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CONTENT

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IMPROVING ECONOMIC EFFICIENCY ON DEGRADED PERMANENT MEADOWS BY VARIOUS MANAGEMENT SYSTEMS

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Abstract

The purpose of this research is to study the possibility of enhancing the multifunctionality of permanent degraded grasslands by overseeding, with special look on economic efficiency. The experience that is the subject of the research was organized in the Research and Development Station for Meadows, Vaslui area, on a Dichanthium ischaemum (L.) Roberty *meadow. In the study area there are large areas of permanent meadows, at different stages of degradation, due to the positioning on surfaces with different degrees of inclination, eroded or subject to erosion process, due to abandonment or non-rational use, with an inappropriate load of animals and failure to apply maintenance or improvement measures. Due to these aspects, the production is small and the floral composition is dominated by species with medium and low fodder value. In order to increase the production of permanent grassland in the area, it was considered necessary to apply organic fertilizers, and their effect was compared to that of abandonment, mulching or simple use, and with overseeding measures. Biological material used (a mixture of: 70% Bromus inermis* Leyss. + *30% Onobrychis viciifolia* Scop. - *30 kg·ha^{-1} + 25 kg·ha^{-1}). Total expenses, net income and profitability rate (rate of return) were calculated. The lowest costs were recorded when the biomass was only harvested, no other action being performed. When overseeding and fertilization were overlapping the costs were the highest, the economic efficiency being carried close to zero, but more likely, the effect of fertilization has been greatly diminished due to poor climatic conditions.*

Key words: *abandonment, mulching, fertilization, biodiversity, productivity*

INTRODUCTION

The International Congress of Grasslands, in Leipzig in 1977, in its 13th edition, defines the term ”grassland” as exploitable agricultural land, used for cultivation for many years or permanently, with perennial grasses dominant in vegetation. In other words, the meadow is seen as a very cheap and accessible source of animals fodder.
Lately, the idea of multifunctionality of the grasslands has been developed, from focusing on the ecological role (wild animals habitats, preventing soil erosion, germplasm stock) to appreciating the importance of aesthetics that they offer to the landscapes. In addition to this, it must also be taken into account that grassland ecosystems seize significant amounts of carbon through the biomass produced, biomass that can be used as a renewable energy source [11], [16], [18].
According to data provided by FAOSTAT, 2023 [12], the estimated land area covered by grasslands in 2021 is 3.54 billion hectares, their area representing about 26.44% of land area, and forests occupy 4.45 billion hectares (33.22 %). This comparison emphasizes the grasslands role as a source of biomass. In

Romania, pastures and hayfields occupy 4,828.5 million ha, as shown by the Romanian Statistical Yearbook for 2022 [20], of which 3,272.2 million ha are pastures and 1,556.3 million ha are hayfields, representing 20.3% of the area total area of the country and 33% of the agricultural area.

Because forests, at the time of harvest provide a large amount of biomass, are seen as more suitable sources than grasslands, but biomass on grasslands regenerates year after year, while forests need tens or hundreds of years for regeneration, and the degree of accumulation of biomass is very small in the first years.

Over 55% of the areas occupied by Moldovan Forest-Steppe grasslands are located on sloping lands, subject to erosion, have a degree of vegetation cover of 60% or less and offer biomass production of 0.5-2 $Mg \cdot ha^{-1}$ DM [10]. To make a comparison, in the temperate zone, in a forest of *Fagus silvatica* L. after 12-24 years of vegetation biomass accumulation varied between 3.4-4.3 $Mg \cdot ha^{-1}$ DM [17].

In Romania, the decline of livestock in recent years has led to the abandonment of large areas occupied by permanent pastures. Simple non-use leads to continuous degradation. Stopping this phenomenon can be done by using the vegetation on these surfaces in order to obtain biofuels. In addition to the rational use, the simplest measure of improvement of grasslands, is represented by the overseeding with valuable species, which through the genetic potential and by the adaptability to the specific conditions of the area, will increase the amount of biomass harvested.

Other changes, such as those to the vegetal carpet's structure and the quality of the feed that can be obtained, must be considered in addition to the rise in biomass. Also, the economic impact of the measures taken must be as small as possible.

In Romania, the studies focused on obtaining biofuels from annual crops (corn, sorghum, etc.) or temporary grasslands. For the Moldovan Forest-Steppe, this study has a novelty character. Globally, there are studies that have focused on analyzing the ability of grasslands to sequester carbon (their ecological role), but there are also studies that have looked at the possibility of using biomass from permanent grasslands to obtain biofuel [6] [14] [13].

The studies carried out in Romania and abroad regarding the effect of overseeding on the degraded permanent grasslands followed, mainly, the effect on the obtained fodder (production and its quality). But, the feed differs from the biomass for fuel, in that is harvested in an advanced stage of vegetation, after the seeds maturation, when the amount of cell walls in the plants is maximum. This is another novelty of the study, namely, increasing the amount of biomass accumulated by overseeding with more productive herbaceous plant species.

In this context, **the purpose of this research** is to study the possibility of enhancing the multifunctionality of permanent degraded grasslands by overseeding, with special look on economic efficiency.

The objectives of the research were:

A. Main objective - Increasing the amount of biomass that can be obtained from permanently degraded grasslands;

B. Secondary objective - Analysis of the influence of overseeding on biodiversity;

C. Secondary objective - Economic efficiency analysis.

MATERIALS AND METHODS

The research from this study took place between March 2022 - August 2023, at the working point from Soleşti locality (46°45' North latitude and 27°48' East longitude) of Research and Development Station for Meadows, Vaslui (RDSM Vaslui). The study area is characterized by temperate climate with the influences of the Russian steppe area.

Description of the experiments

Biological material used (a mixture of: 70% *Bromus inermis* Leyss. + 30% *Onobrychis viciifolia* Scop. - 30 $kg \cdot ha^{-1}$ + 25 $kg \cdot ha^{-1}$) was from Research and Development Station for Meadows, Vaslui, Romania. The cost of overseeding was 1,200 $lei \cdot ha^{-1}$, the work being performed once every 6 years.

The experiment, established in spring 2022, was laid by randomized plots method in three replicates, with a 100 m^2 plot size (10 m x 10 m) and a 81 m^2 harvested area (9 m x 9 m), and the total experimental area will be of 1,600 m^2 (Fig. 1).

Experimental factor - applied management, with five graduations:

v_1 - abandoned;

v_2 - harvested at seed maturation (control variant);

v_3 - overseeded and mulching;

v_4 - overseeded and harvested at seed maturation;

v_5 - overseeded, fertilized with sheep manure (10 $Mg \cdot ha^{-1} \cdot year^{-1}$) and harvested at seed maturation.

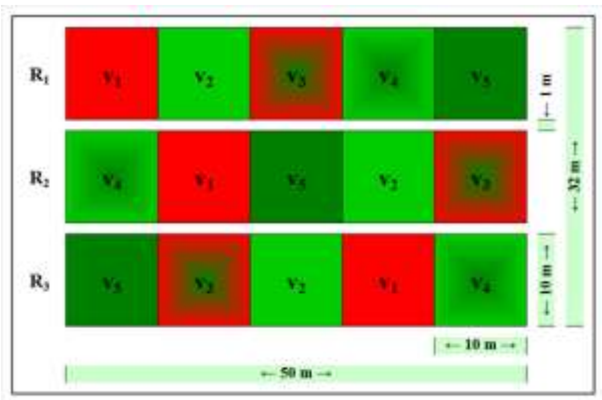

Fig. 1. Experimental design (randomized plots)
Source: Own design.

The overseeding was done mechanically (direct sowing).

Sheep manure was applied in spring at experiment establishment and in the second year of vegetation at the beginning of plant growth, in early spring.

Justification of the working variants chosen:

Abandonment (v_1) is very common on areas occupied by degraded meadows, so this variant serves as a comparison element regarding the improvements that can be made to this situation. The control variant (v_2) involves only the simple harvesting of biomass in the optimal epoch, but the long-term effect can be negative because nutrients in the soil are exhausted [8]. Even in the case of abandonment, the amount of organic matter can be increased by accumulating a larger amount of biomass in the soil by overseeding (v_3). Overseeding and harvesting biomass for biofuel in the optimal era (v_4) may be the best option. Fertilization with moderate doses of manure, where there are livestock, along with overseeding and biomass harvesting for biofuel in the optimal period (v_5), may be the best option [3].

Methodology applied

From the abandoned variants, the production was evaluated by harvesting a sample area of 1 m^2 that was weighed, and from the variants that involve harvesting, the production was evaluated by harvesting 81 m^2. By the halving method was carried to the laboratory a quantity of 1 kg of green mass for performing analyzes. The determination was made in the seed maturation and shaking phenophase for the dominant grass species in the the vegetation structure (to determine the production and quality of biomass that can be used for biofuels).

The analytical methodologies used were in accordance with national and international standards as well as agricultural experimental techniques regulations. The following were determined:

▫ dry matter content (DM) used at determining the amount of biomass that can be obtained ($Mg \cdot ha^{-1}$ DM) was established by drying at an oven at a temperature of 103°C for 3 hours; equipment: Thermo-adjustable Oven - Venticell 111 I; SR ISO 6496/2001;

▫ conducting the floristic study on the vegetation changes using the geobotanical method [23];

▫ the economic efficiency was calculated as follows:

- Total expenses (Ct), with the relation:

$$Ct = Cf + Cs \qquad (1)$$

where:

Cf - fixed technological expenses ($lei \cdot ha^{-1}$);

Cs - represents the amount of expenses incurred for the factors used ($lei \cdot ha^{-1}$);

- Net income (Vn), according to the relation:

$$Vn \text{ (lei)} = (Pv \times Qt) - Ct \qquad (2)$$

where:

Pv = selling price (lei·ha-1);

Qt - total production (kg).

Ct = Total expenses ($lei \cdot ha^{-1}$);

- Profitability rate analysis (rate of return) with the relation:

R (%) = (Vn·Ct^{-1}) x100...........................(3)

Statistical analysis of obtained data it was achieved by calculation of variance analysis, least significant differences (LSD).

The results of this study will help to increase profitability of permanent grassland degraded by overseeding.

RESULTS AND DISCUSSIONS

Permanent meadows, from the perspective of obtaining feed for domestic animals, in different management conditions, have been studied by many authors [1], [2], [4], [9], [19], [22].

The research conducted in 2022-2023 agricultural period at the RDSM Vaslui addresses another perspective of the use of biomass resulting from these ecosystems, in the absence of livestock.

The reason is that in our country the herds of cattle, sheep and goats, horses, decreased from approximately 8.76 million livestock units in 1990, at 4.04-4.4 million livestock units in the period 2010-2021 [20].

Under these conditions there is the possibility of alternative use of biomass from increasingly large areas of abandoned meadows. This biomass can be used rudimentarily on meadows, to prevent degradation and erosion, in the form of mulches. Also, it can be used as a source of organic matter in arable land or for obtaining biofuel (biogas, pellets, or other forms).

The additional amount of nutrients brought by applying fertilizers on degraded permanent grassland is not used optimally by plants existing in the structure of the vegetable carpet. This issue can be remedied by improving the structure of the vegetable carpet and the amount of biomass produced can only be appropriate under over-seeding conditions with valuable species.

In generating the production of meadows and for the most efficient use of mineral or organic fertilizers by plants on these surfaces, the climatic factor plays a very important role.

The vegetation of the meadows in the study area was negatively influenced by the long periods of time with lack of precipitation and higher than normal temperatures.

Figure 1 shows the climate diagram of the period 2022-2023, and where these periods of stress are observed.

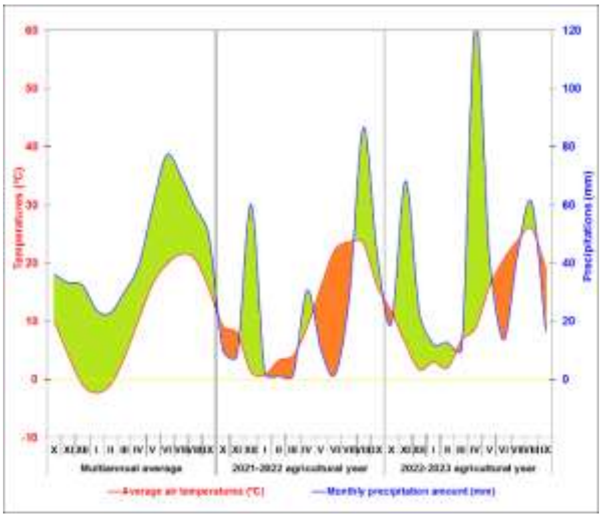

Fig. 2. Climate conditions in the 2022-2023 period
Source: Own data, taken from from RDSM Vaslui weather station (Station II - Soleşti locality) [21].

The experience that is the subject of the research was organized in the Research and Development Station for Meadows, Vaslui area, on a *Dichanthium ischaemum* (L.) Roberty (synonyms: *Bothriochloa ischaemum* (L.) Keng; *Andropogon ischaemum* L.) meadow. In the study area there are large areas of permanent meadows, at different stages of degradation, due to the positioning on surfaces with different degrees of inclination, eroded or subject to erosion process, due to abandonment or non-rational use, with an inappropriate load of animals and failure to apply maintenance or improvement measures. Due to these aspects, the production is small and the floral composition is dominated by species with medium and low fodder value. In order to increase the production of permanent grassland in the area, it was considered necessary to apply organic fertilizers, and their effect was compared to that of abandonment, mulching or simple use, and with overseeding measures.

Dry matter production in the 2022-2023 period (Table 1) varied, on average, between 1.16 Mg·ha^{-1} in abandoned variant and 1.34

$Mg \cdot ha^{-1}$ in harvested at seed maturation variant (control), up to 2.25 $Mg \cdot ha^{-1}$ in the overseeded variant, normally harvested and 2.36 $Mg \cdot ha^{-1}$ in overseeded, fertilized with sheep manure (10 $Mg \cdot ha^{-1} \cdot year^{-1}$) and harvested at seed maturation variant.

In 2022 the obtained productions were much lower due to the extreme drought, especially during the growing season.

Table 1. Dry matter production in the 2022-2023 period

Variant		DM production ($Mg \cdot ha^{-1}$) 2022	2023	Average
v_1 - abandoned;		0.70	1.61	1.16
v_2 - harvested at seed maturation (control variant);		0.99^C	1.68^C	1.34^C
v_3 - overseeded and mulching;		1.23	2.37	1.80
v_4 - overseeded and harvested at seed maturation;		1.31	3.20*	2.25*
v_5 - overseeded, fertilized with sheep manure (10 $Mg \cdot ha^{-1} \cdot year^{-1}$) and harvested at seed maturation.		1.29	3.42**	2.36*
LSD	*0.5*	*0.46*	*0.75*	*0.61*
	0.1	*0.67*	*1.09*	*0.88*
	0.01	*1.01*	*1.64*	*1.32*

Source: Own calculation.

The floristic structure was influenced by the following vectors: vegetation season, management mode (abandonment, mulching, mowing), manure application and overseeding. Their combined effect can be distinguished in Table 2, especially in the case of variants v_4 - overseeded and harvested at seed maturation and v_5 - overseeded, fertilized with sheep manure (10 $Mg \cdot ha^{-1} \cdot year^{-1}$) and harvested at seed maturation, where the degree of vegetation cover was 100% and the percentage of leguminous species increased.

Table 2. Main vegetation changes in the 2022-2023 period

Variant	2022 G	L	F	ga	2023 G	L	F	ga
	Coverage degree (%)							
v_1	71	2	15	12	85	1	10	4
v_2 (C)	68	2	17	13	75	4	21	0
v_3	63	6	24	7	71	2	24	3
v_4	63	10	27	0	73	8	19	0
v_5	66	12	22	0	69	10	21	0
G - grasses; L - leguminous; F - forbs; ga - gaps.								

Source: Own calculation.

In the agricultural field, the cost of any share must be recovered by capitalizing on the production increase obtained. In the case of research carried out in the 2022-2023 period within the RDSM Vaslui the following results were obtained (Table 3):

▫ in case of variant v_1 - abandoned, there is no talk of economic efficiency, because no action is taking place;

▫ in case of variant v_2 - harvested at seed maturation (control variant), the R value was 14.5 %, a very small value, due to the lack of inputs and the small productive potential of the meadow (Ct value includes the expenses related to the mowing, rake and baling works, respectively 125, 75 and 150 $lei \cdot ha^{-1}$, on average);

▫ in case of variant v_3 - overseeded and mulching, also there is no talk of economic efficiency, because the production on this variant remains on the ground, and the activities performed generated only costs (Ct value includes the expenses related to the mowing, rake and overseeding, respectively 125, 75 and 200 $lei \cdot ha^{-1}$, on average);

▫ in case of variant v_4 - overseeded and harvested at seed maturation, the R value was 22.7 %, also a very small value, due to the costs of inputs (Ct value includes the expenses related to the mowing, rake, baling and overseeding works, respectively 125, 75, 150 and 200 $lei \cdot ha^{-1}$, on average);

▫ in case of variant v_5 - overseeded, fertilized with sheep manure (10 $Mg \cdot ha^{-1} \cdot year^{-1}$) and harvested at seed maturation, the R value was only 1.1 %, due to the very high costs of inputs (Ct value includes the expenses related to the mowing, rake, baling, overseeding and fertilization works, respectively 125, 75, 150, 200 and 150 $lei \cdot ha^{-1}$, on average).

Table 3. Economic efficiency in the 2022-2023 period

Variant	Qt (average)	Pv	Pv·Qt	Ct	Vn	R	
	$Kg \cdot ha^{-1}$	$Lei \cdot Kg^{-1}$	$Lei \cdot ha^{-1}$			%	Diffe-rence %
v_1	1160	abandoned					
v_2 (C)	1340	0,3	402	350	52	14,5	100
v_3	1800	0,3	540	400	140	mulching	
v_4	2250	0,3	675	550	125	22,7	153,0
v_5	2360	0,3	708	700	8	1,1	7,7

Source: Own calculation.

Although the differences between the studied variants appeared from the first year of study, the trends obtained may have some changes if the experiment will continue longer, so that it can be included in the study normal years in terms of climatic configurations or even with precipitation surplus. These aspects are highlighted by other studies [5], [7], [15], [24].

CONCLUSIONS

The aspects detached from the study can be concluded in the fact that regardless of the actions performed on the degraded permanent meadows, their costs can be recovered by capitalizing on the production increase obtained.

The lowest costs were recorded when the biomass was only harvested, no other action being performed.

When overseeding and fertilization were overlapping the costs were the highest, the economic efficiency being carried close to zero, but more likely, the effect of fertilization has been greatly diminished due to poor climatic conditions.

As a general recommendation, which can be deduced from this research, overseeding can contribute to increasing the amount of biomass that can be harvested from degraded permanent grasslands.

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THE ATTAINMENT OF THE UNITED NATION SUSTAINABLE DEVELOPMENT GOAL (SDG) NUMBER TWO: ASSESSMENT OF SOME INDICATORS IN NIGERIA

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Abstract

The study examined the journey so far towards achieving the United Nation Sustainable Development Goal (SDG) number 2 ("zero hunger) from the year 2001 to 2022 in Nigeria. Data was gathered from official sources such as the Central Bank of Nigeria (CBN), FAO, and the World Bank, and then analyzed using descriptive tools.The findings revealed that a significant population of Nigerians are still undernourished, representing over 15.00% of the country's population.The fertilizer use rate and water use efficiency in agriculture were found to be very low relative to the other countries in Africa. The finding further showed that agricultural land marginally increase on yearly basis without corresponding increase in factor productivity. In addition, less than 60.00% of the country's population have access to electricity, while 25.46% of the country's rural population has access to electricity in 2022. The agricultural orientation index in Nigeria was low compared to some African countries. The findings revealed that on average Nigeria is rather too slow or better is off track towards achieving the SDG of 'Zero Hunger' by 2030. The country's current efforts, strategies and the general progress towards SDG number 2 are grossly insufficient. The nation must approach the SDG number 2 as a team player collaborating the domestic agenda with the regional and global plans to effectively unlock the potential needed to attain the mandate of 'Zero hunger' in 2030.

Key words**:** *sustainable development goal, undernourished, fertilizer use, Nigeria*

INTRODUCTION

The United Nation Sustainable development Goals (SDGs) was birthed in 2012 at the Rio de Janeiro, Brazil [26], [22]. The major aim of the SDGs was to establish a common global driven mandates to urgently address the basic problems of humanity in areas such as: hunger, poverty, malnutrition, environmental, political, and economic challenges among others. The United Nation (UN) created a 17 SDGs to replace the eight Millennium Development Goals (MDGs) [18]. The adoption of the UN SDGs ushered in, a new era that focused on global collaboration to tackle critical humanity problems. Hence, the SDGs demonstrated an improvement from the MDGs, and emphasized on a larger scope and required a coordinated, monitored and sustainable global actions.

Many African countries have make concerted efforts to achieve the objectives of the SDGs. [18]. The Sub-Saharan African countries still rampage by increasing hunger, malnutrition, starvation, poverty and conflicts in recent years have struggled to achieve the objectives of SDGs especially the number two which focuses on hunger reduction or "zero hunger" [20], [17]. The sub region has enunciated policies, built institutions and implement programmes as well as engaged in regional and international collaborations to strengthen the domestic production of food on both short and long term basis [18]. The attainment of zero hunger is critical in the region given the worrisome statistics on poverty and malnutrition among vulnerable groups in the region. The African continent has a higher proportion of its population facing hunger and poverty compared to other regions of the World [2]. With less than 6 years left until 2030, some countries in Sub-Saharan Africa have made progress towards achieving 'zero hunger' despite the menace of COVID-19 pandemic, conflicts, climate change and political instability [15]. The region needs to strengthen its agricultural research and build a sustainable and climate-resilient food and agricultural practice system. According to SDG report of 2023, the number of people facing hunger and food insecurity has been rising since 2015, with the pandemic, conflict, climate change and growing inequalities exacerbating the situation in the region.

Nigeria is one of the countries in the Sub Saharan Africa. It is the most populous and one of the largest economies in Africa. Following the Global Nutrition Report [23], the country has the second largest population of "stunted" and "wasted" children in the world preferably translated to about 13.90 million and 3.40 million children respectively. According to the SDGs Report [30], the nation was ranked 160 out of the 165 countries with prevailing potentials towards achieving the SDGs in 2030. The report asserted that the country is bewildered with significant challenges concerning the attainment of SDG 2 targets, with insignificant improvement made in reducing the prevalence of stunting and wasting among children under 5 years. Following the UN report archived in the "Our World of Data"[27] and FAO, [21], the share of population with moderate or severe food insecurity in Nigeria stood at 58.50% in 2020. In the same year, it was 19.00% for South Africa, while the figure stood at 36.60% for Ghana. In 2021, the proportion of children under 5 years who were stunted was 31.50%, which was higher than South Africa's 21.40% and Ghana's 17.50%. The report further revealed that the share of children who are wasted (less than 5 years) was 6.50% in Nigeria compared to 3.40% in South Africa. The report also showed that, in Nigeria, the percentage of wasted children (those under five years old) was 6.50%, while in South Africa, it was 3.40 percent and6.8% in Ghana in 2021. The average value of agricultural output produced by the small-scale food farmers/producers in Nigeria was estimated at \$6.35/year, compared to \$18.44/year in Mali, and \$11.06/year in Benin Republic in 2021. The report also revealed an average income for small scale farmers of \$444.92, \$557.58 and \$914.88 in Nigeria, South Africa and Ghana respectively. Further analysis revealed an estimated 0.23; 0.16 and 0.08 agriculture orientation index for government expenditures in Nigeria, Ghana and Mali respectively. In 2021, about \$257.22m, \$30.38m, \$183.24m worth of total official inflows including development assistance to the agricultural sector in Nigeria, South Africa and Ghana respectively. The indicator of food price anomalies (IFPA) stood at 0.62, 0.82, and 2.04 for Nigeria, Ghana and Zambia respectively.

The brief literature provided revealed that, Nigeria is really struggling to achieve the UN SDG number 2 in many target areas. For instance, the country is a major importer of rice and wheat in the World including some livestock commodities[28], [24]. This is a strong indication that the agricultural sector is not a preferred sector relative to other economy sectors in the country. Also, many researchers in the country have reported poor farm factor productivity and low farm returns among rural farmers [29], [3], [12], [13], while the average per capita meat consumption is insufficient and is far lower than some African countries and the standard recommended by the World Health Organization (WHO)[4], [9], [8]. Literature also abounds on the high level of poverty among farmers, frequent conflicts between farmers and herders, seasonal flooding, increasing desertification in the northern region of the country, and increasing rural-urban migration among others [12], [6], [25], [1], [16]. This implies that the country still needs to scale up all aspects of development in the agricultural sector in order to holistically achieve the SDG number 2. With a huge population of over 200 million, the country is seriously challenged in areas such as food security, adequate nutrition and rural infrastructures provision among others [10], [11], [7]. It is thought that the country has made some progress in accomplishing SDG 2 in certain target areas compared to other African countries, there is still a need to critically examine other parameters or indicators to further expose the position of the country in tackling SDG number 2. Since achieving a "zero hunger" in the country requires a broad based approach, it therefore means that additional parameters would be appropriate to further explore the country's developmental efforts in achieving UN SDG number 2 in different target areas. Premised on this assertion, the study was designed to first substantiate some of the SDG number 2 reports on Nigeria and secondly, provide additional parameters/indicators and information on the country's effort towards achieving the SDG number 2 and its targeted areas so far.

MATERIALS AND METHODS

The study used time series information and applied descriptive tools to analyze the objectives of the study. Data were obtained from official sources including the Food and Agricultural Organization (FAO), World Bank and Central Bank of Nigeria. The data frame covered the period from 2001 to 2022.

Definition of Variables

The variables used in the analysis are defined in Table 1. The variable were categorized based on the target areas of SDGs number 2. Indices such as the mean, maximum, minimum, coefficient of variability, standard error and exponential growth rate of these variables were calculated for easy comparison and discussion.

Table 1. Sustainable Development Goal 2 ('Zero Hunger') – targets and indicators for Nigeria

Assessment variables	unit	SDG 2 target
Prevalence of undernourishment in Nigeria	Percentage of the population	Access to safe and balance diet in the country
Number of undernourished people in Nigeria	Number (million)	
Fertilizer use rate in Nigeria	(kg/ha)	Increase the productivity and incomes of small-scale famers
Water use efficiency in Agriculture in Nigeria	Naira/m^3	
Agricultural land availability in Nigeria	Percentage of the total land area	Sustainable food production and resilient agricultural practices
Agricultural share of central government total expenditure in Nigeria	Percentage	Rural infrastructure development
Access to electricity in the population	Percentage of population	
Access to electricity in the rural areas	Percentage of rural population	
Agriculture value added share of the country's GDP	Percentage	
Agricultural Orientation Index in Nigeria	No unit	

Source: prepared by the authors.

The exponential growth rate of variables

The explicit form of an exponential trend equation for a given variable is represented in equation 1:

$$lnY_t = \delta_0 + \delta_1 t + \varepsilon_t \ldots\ldots\ldots\ldots.\ldots\ldots\ldots (1)$$

The "Y" represent all the variables specified in Table 1. Therefore, the exponential growth rate is expressed in equation 2 ([14], [5]):

Exponential growth rate) =

$$\left(e^{\delta_1} - 1\right) * 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots. (2)$$

Definition of Variables

(a)Agriculture Share of Government Expenditures (AEG)

This variable measures the federal government sum of expenditures in agricultural sector relative to the total expenditure in the economy in period t. The higher the percentage or the closer the percentage to 100, the better the federal government expenditure on agricultural sector. Mathematically, it is expressed as thus:

$$\text{AEG} = \sum_{i=1}^{n} \frac{Govt\ expend.on\ agric.sector}{total\ govt\ expenditure} * 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots. (3)$$

(b)Agriculture value added share of GDP (AVS)

The variable measures the sum of agricultural sector's value addition as a percentage of the economy's gross domestic product in period t.

The higher the percentage or the closer the percentage to 100, the better the agricultural sector's value addition. The mathematical form is shown in equation 4.

$$\text{AVS} = \sum_{i=1}^{n} \frac{\text{Agric. value added}}{\text{GDP}} * 100 \ldots\ldots(4)$$

(c)Agriculture Orientation Index (AOX)

The Agricultural Orientation Index (AOX) is the ratio of the agriculture share of Government Expenditure (AEG) and the Agriculture value added share of GDP (AVS). Note Agriculture refers to the agricultural sector consisting of livestock sub-sector, forestry sub-sector, fishery and wild life sub sectors.

$$A\text{OX} = \sum_{i=1}^{n} \frac{(\text{AEG})}{(\text{AVS})} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(5)$$

An Agriculture Orientation Index (AOX) greater than unity shows a higher orientation towards the agriculture sector expenditure by government compared to the sector's monetary worth of its value-added. When the AOX is lower than one, it implies a lower index, while an AOX equal to one indicates neutrality or indifference in government's orientation to the agriculture sector expenditure.

RESULTS AND DISCUSSIONS

The descriptive tests of variables are shown in Table 2. The results present the minimum value, maximum value, standard deviation, coefficient of variability and annual exponential growth rate of the specified variables.

Table 2. Descriptive test of variables

Indicators	Min.	Max.	Mean	Std. dev.	CV (%)	Exp. G %
Number of undernourished people (million)	9.500	34.000	16.850	7.399	0.439	5.93
Prevalence of undernourishment (%)	6.400	15.900	9.621	2.636	0.274	3.20
Fertilizer use rate (kg/ha)	4.300	20.300	10.395	5.702	0.549	7.30
Access to electricity (% of population)	43.900	59.500	52.230	4.641	0.089	1.22
Agricultural land (% of the total land area)	72.101	75.369	73.796	1.045	0.014	0.22
Water Use Efficiency (Agriculture) USD/M^3	0.080	0.250	0.184	0.042	0.225	3.59
Access to electricity, rural (% of rural population)	21.804	33.970	26.237	3.596	0.137	0.61
Agric. share of Government Expenditure %	1.290	5.290	3.0398	1.197	0.394	-2.59
Agriculture value added share of GDP %	19.990	36.970	24.344	4.168	0.171	-1.55
Agriculture orientation index	0.040	0.210	0.126	0.044	0.349	-1.08

Source: computed by authors. Exp. G is exponential growth rate (%).

(i) Undernourished population (million)

According to statistics, Nigeria has a maximum of 34 million of undernourished people, with a minimum of 9.50 million from 2001 to 2022. Specifically, the sum total of undernourished Nigerian in 2021 was about 34 million. Within the period of study, the statistics showed an average undernourished population of about 16.90 million, with the coefficient of variability of 43.90%. This means that, the number of undernourished people in Nigeria experienced a variation of about 43.90% annually.The result indicates that the total undernourished people in Nigeria varies significantly on yearly basis. The result also showed an exponential growth rate of 5.93%, implying that the variable grew positively with increase in time. Otherwise, the variable grew at the rate of 5.93% per year.

The graph represented in Figure 1 shows the trend in the yearly total of undernourished population in Nigeria from the 2001 to 2022. The graph portrayed a steady growth rate in the population of undernourished in Nigeria.

The findings indicate that, the country is not doing enough to tackle the problem of undernourished among vulnerable groups and UN SDG on global access to safe and nutritious food might not be achieved in Nigeria in 2030. This result is substantiated by the UN-SDGs [30] reports on Nigeria.

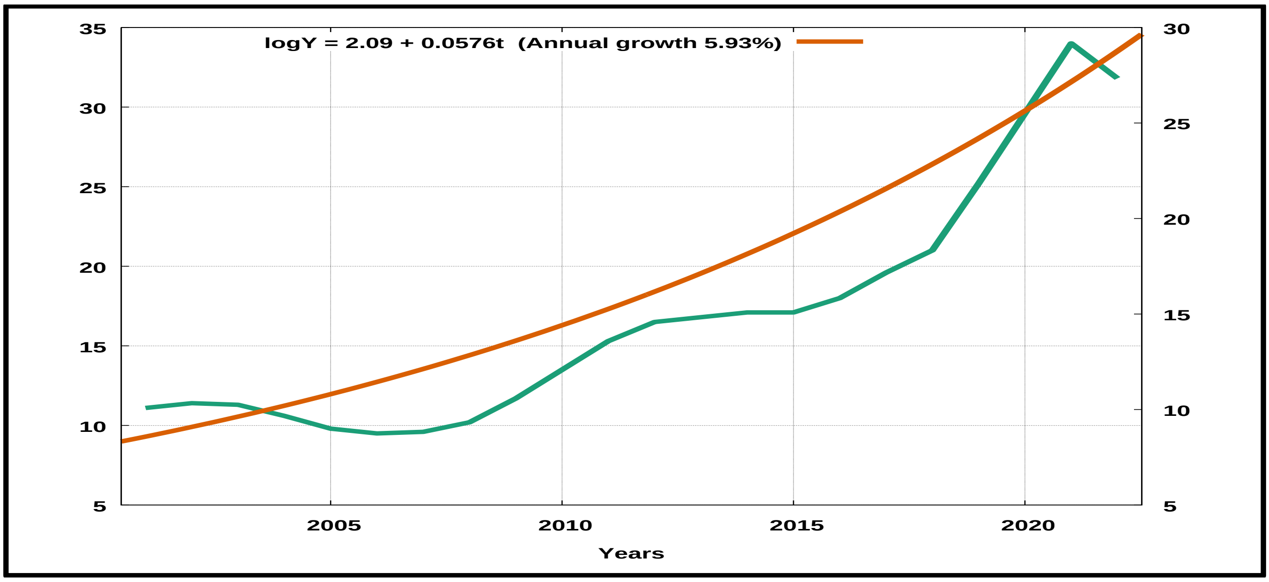

Fig.1. Trend in number of undernourished people in Nigeria (2001 - 2022)
Source: from data analysis, 2024.

(ii)Prevalence of undernourishment (%)

The percentage prevalence of undernourished population revealed an average percentage distribution of 9.62 with the coefficient of variability of 27.40% from the year 2001 to 2022. The country experienced the minimum percentage prevalence of undernourished population of 6.40 and maximum of 15.90 within the time frame of the study.

The result suggests that the percentage prevalence of undernourished population in Nigeria varies at 27.40% per year (Fig. 2).

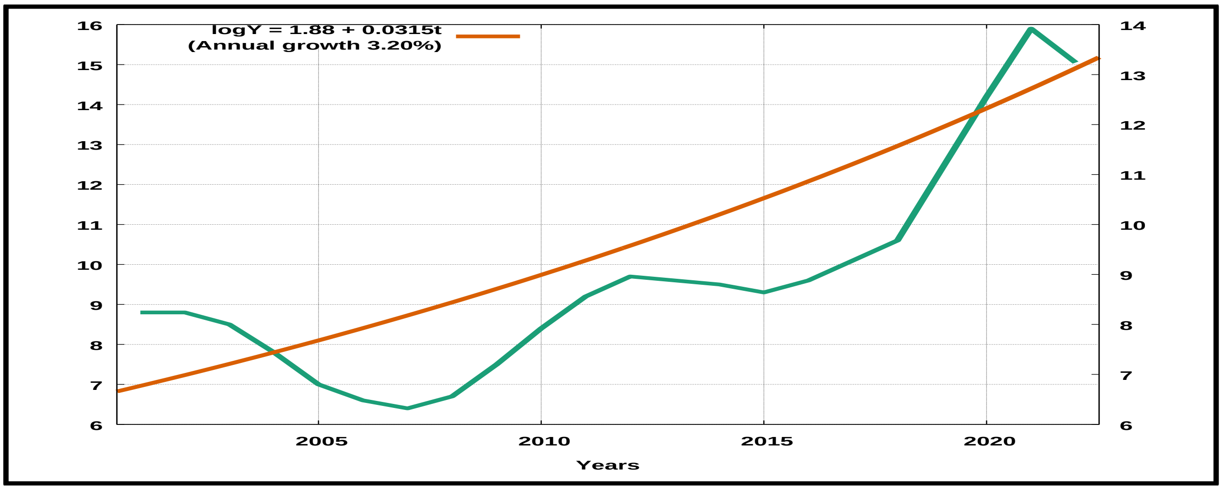

Fig. 2. Trend in the prevalence of undernourishment in Nigeria (2001 - 2022).
Source: from data analysis, 2024.

In 2022, the percentage of undernourished Nigerian was 15.08%. The finding also revealed a compound growth rate of 3.20% in the percentage prevalence of undernourished population. This revealed that the variable grew positively as time increases.

The percentage prevalence of undernourished populations in Nigeria is depicted pictorially in Figure 2.The graph which starts from 2001 to 2022 shows distinct troughs and peaks with an average progressive or positive growth within the time of study. The results depicts the fact that the undernourished population is mounting despite attempts by the country to meet the SDGs target. By implication, the country is not doing enough to tackle the problems of undernourished population and the universal access to safe and nutritious food among vulnerable groups. This result is substantiated by the UN-SDGs[30] reports on Nigeria.

(iii)Fertilizer use rate (kg/ha)

The statistics for fertilizer use rate showed that the minimum use rate in recent time was 4.30kg/ha while the maximum use rate stood at 20.30kg/ha within the period of the study. The analysis showed an average use rate of 10.39kg/ha, with the coefficient of variability of 54.90% within the study period. In 2022, the annual fertilizer use rate in the country stood at 18.60kg/ha. The finding suggests that fertilizer use rate varies significantly on yearly basis in Nigeria. Moreover, the finding revealed a compound growth rate of 7.30%. This means that the fertilizer use rate has seen a significant positive growth rate in recent time in the country.

The Figure 3 shows the trend in the fertilizer use rate in Nigeria from the year 2001 to 2022.

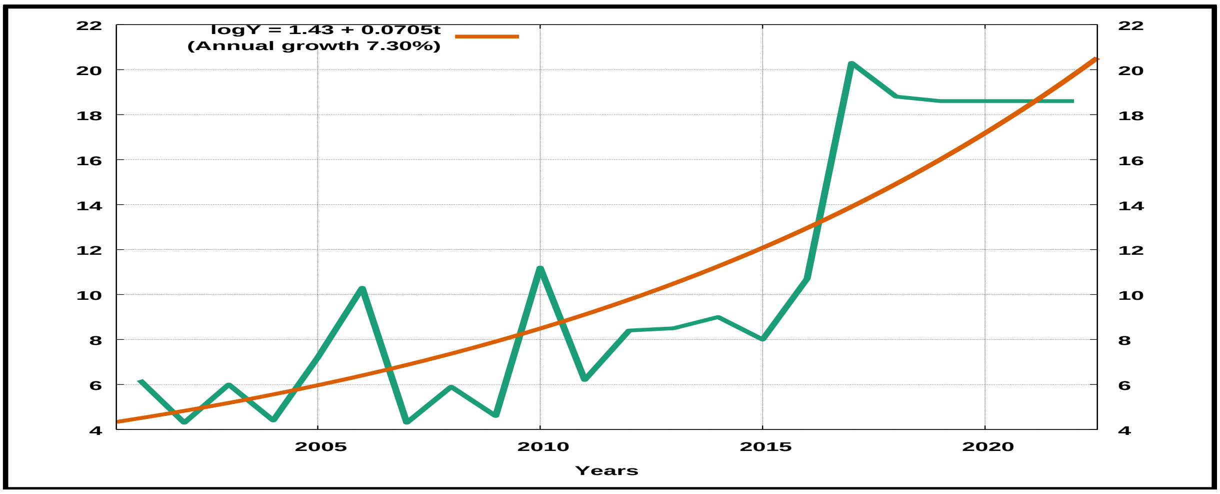

Fig. 3. Trend in Fertilizer use rate in Nigeria (2001 – 2022).
Source: from data analysis, 2024.

The graph revealed a rippled trend in fertilizer use rate across the study period. However, the trend on average indicates a steady rise in fertilizer use rate in the country. The use of fertilizer is very critical in attainment of the increase productivity and sustainable income of small-scale farmers who are mostly resource poor.

Contrary to the recent improvement in fertilizer use in the country, the country's average annual fertilizer use is still far behind some countries in Africa. For instance in 2021, Egypt, South Africa, Zambia and Mali used fertilizer at the rate of, 414.16kg/ha, 91.04kg/ha, 63.25kg/ha and 28.12kg/ha respectively compared to 18.60kg/ha in Nigeria. The use of fertilizers in Africa averaged at around 25.6kg/ha of cropland area, a very low figure compared to the world average of about 118.6kg/ha that same year. The findings implies that, the country is making positive improvement in fertilizer use rate, but the improvement is not sufficient to trigger double productivity and sustainable income for resource–poor farmers in the country. Based on this finding, it is obvious that the SDG target of increasing the productivity and incomes of small-scale farmers in the country in 2030 is seriously jeopardized.

(iv)Access to electricity (% of population)

The percentage of Nigeria's population that have accessed to electricity averaged at 52.23% from the year 2001 to 2022, with the coefficient of variability of 8.90%. In 2022, about 57.45% of the country's population had access to electricity. The country experienced only 1.22% growth in electricity consumption from 2001 to 2022. Though the country's witnessed a positive growth in electricity consumption within the period of this study, however with the population of over 200 million, the level of consumption was grossly inadequate. From this finding it is so clear that the country has a serious issue in electricity consumption which is very critical in attaining

SDG target of doubling productivity and income of farmers. Electricity is an important resource in agro-processing. Its sufficiency and availability would help to reduce the cost of farm production and encourage farmers to use modern technologies in processing.

Figure 4shows the trend in electricity access among Nigerians from the year 2001 to 2022.

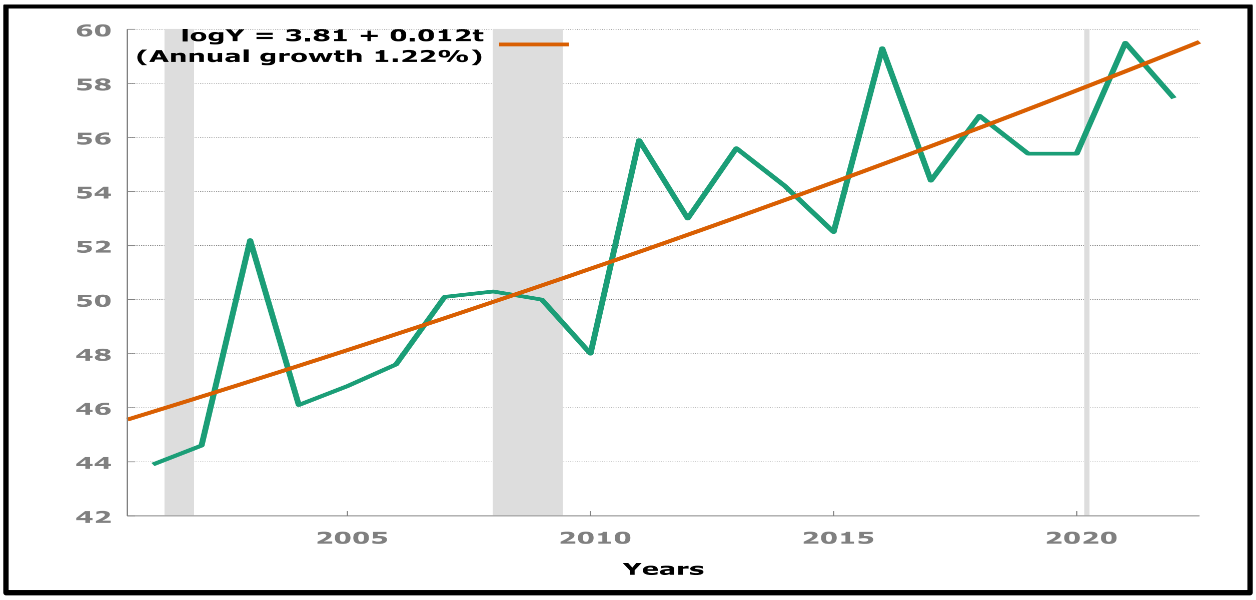

Fig. 4. Trend in the percentage of population that have access to electricity in Nigeria (2001 - 2022).
Source: generated from analysis, 2024.

The graph revealed a progressive increase in the percentage of population that have access to electricity in Nigeria. The findings indicate that, though the country is making progress in electricity consumption, but is far from achieving the UN SDG on sustainable infrastructural development and enhancing agricultural sector's productivity in 2030. The observations noticed in the analysis aligned with the report of the SDGs [30] on Nigeria.

(v)Agricultural land (% of the total land area)

The distribution of the annual share of agricultural land in the total land area revealed an average agricultural land area of about 73.80% of the total land from the year 2001 to 2022. Judging from the duration of the study, the ountry has experienced gradual expansion of agricultural land which grew at the exponential rate of 2.20% per annum. In 2021, the percentage of agricultural land use stood at 75.29% of the total land mass in the country. The result shows a coefficient of variability of 1.40%. This suggests that agricultural land is expanding slowing.

By implication, the forest land and other land reserves are degrading annually probably creating potentials for other problems like climate change issues, erosion and desertification among others.

The pictorial trend in agricultural land area is presented in Figure 5.

The graph revealed a steady progressive trend from the year 2001 to 2022 in Nigeria. Given a huge population of Nigeria (above 200 million), the continuous rise in the agricultural land area is not a good indication, but rather remind the nation that farm–factor productivity is inadequate. The country should rather opt for land saving technologies and adopt actions that will promote farm-factor productivity in the country. Hence given the current agricultural land use method, it is pertinent that, the attainment of a sustainable food production and resilient agricultural practices in the country might not be achieved in 2030 as enshrined in the SDG number 2, unless proactive actions are urgently taken.

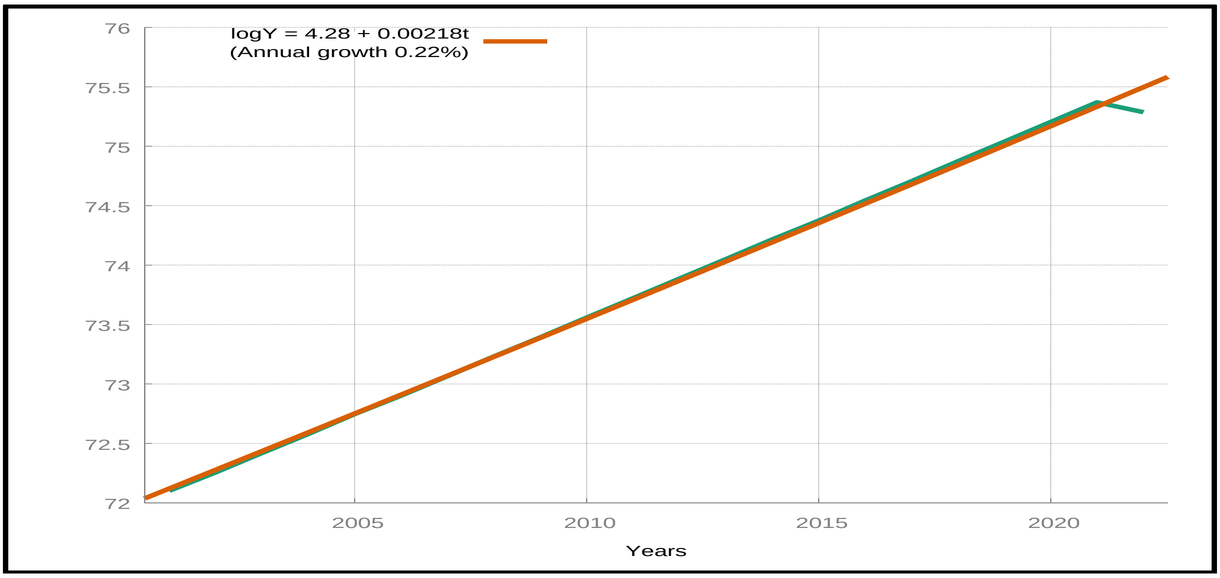

Fig. 5. Trend in Agricultural land availability in Nigeria (2001 - 2022)
Source: from data analysis, 2024.

(vi)Water Use Efficiency (Agriculture) Naira/M³

Water use efficiency measures the total accumulated biomass per unit used of water. According to Cui et al., [19], improved water use efficiency of crops would result in a higher yield. From 2001 to 2022, the country's average water use efficiency was 0.184 USD/m^3 and coefficient of variability of 22.50%. In 2020, Nigeria average water use efficiency was 0.23USD/m^3 compared to 0.75 USD/m^3 in Egypt and 0.18USD/m^3 in Ethiopia. However, within the period of this study, the water use efficiency grew at the rate 3.95%, implying that the country is making progress in enhancing water use efficiency in agriculture relative to other African countries. The trend in agricultural water use efficiency is shown in Figure 6.

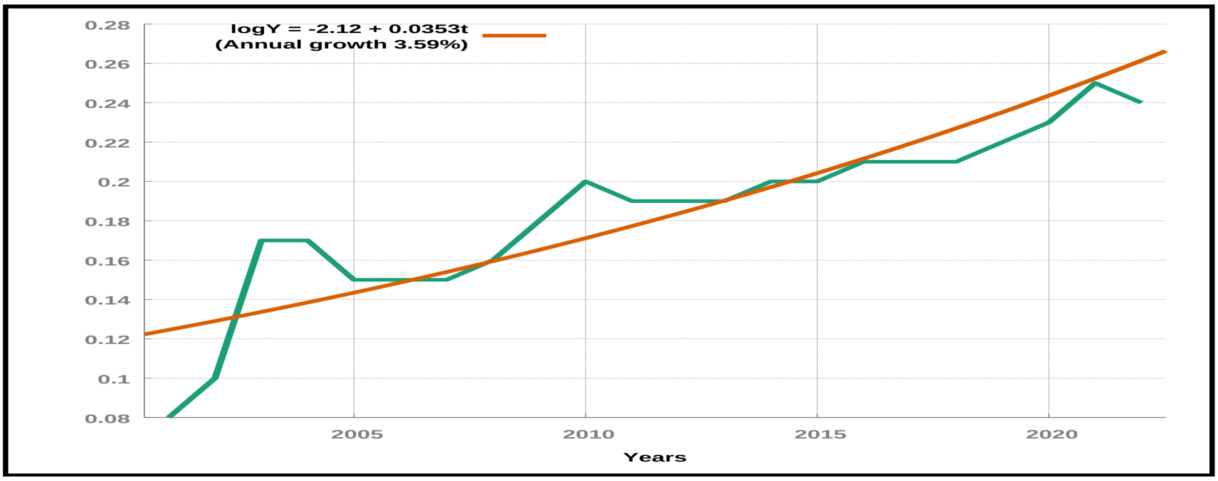

Fig. 6. Trend in water use efficiency (Agriculture) in Nigeria (2001 - 2022).
Source: from data analysis, 2024.

The graph showed evidence of positive growth in water use efficiency in agriculture from the year 2001 to 2022 in Nigeria. Since there is a positive relationship between total biomass and water use efficiency, the current level of water use efficiency in agriculture in the country is not sufficient to maintain a sustainable food production as envisage by the SDG number 2. Water use efficiency is critical in enhancing farm factor productivity and yield of farmers. The majority of farmers in the Sub Saharan region of Africa are resource-poor, government need to subsidize some factors of production in order to enhance farm income generation. Hence, achieving a sustainable water use efficiency in agriculture in Nigeria in 2030 would require a more practical policy embedded in sound and adaptable modern technologies.

(vii)Access to electricity, rural (% of rural population)

The percentage of Nigeria's rural population that have accessed to electricity averaged at 26.34% from the year 2001 to 2022, with the volatility index of 13.70%. In 2022, the result showed that about 25.46% of the country's rural population has access to electricity. The country experienced only 0.61% growth in the rural electricity consumption from 2001 to 2022. Though the country's witnessed a marginal positive growth in electricity consumption in the rural areas within the study period, but it is also observed that in 2022, about 74.54% of the rural population did not have access to electricity. This statistic is very worrisome as sustainable agricultural production cannot be achieved in 2030 with this magnitude of poor rural infrastructure such as electricity which is very critical in agricultural production and processing.

The graph represented in Figure 7shows the trend in electricity access among rural population in Nigeria from the year 2001 to 2022.

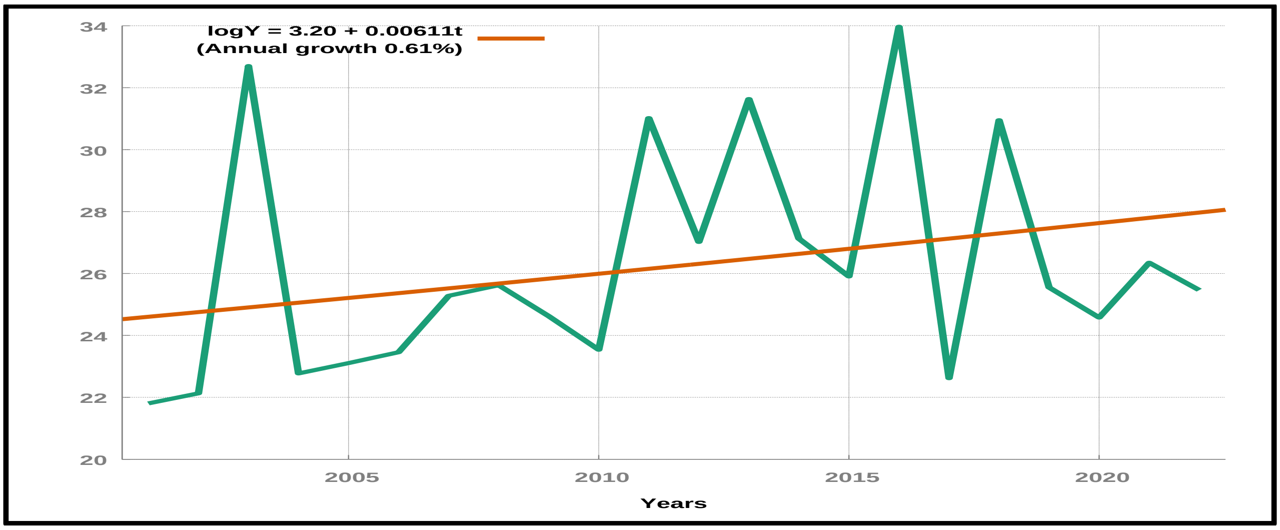

Fig. 7. Trend in the rural population access to electricity in Nigeria (2001 - 2022)
Source: generated from data analysis, 2024.

The graph showed a slight increase in Nigeria's rural population's access to electricity.The findings indicate that, though the country is making a marginal progress in electricity consumption in the rural areas, but it is far behind the standard required by the SDGs targets for the agricultural sector. The observations noticed in the analysis aligned the report of the SDGs [30] on Nigeria.

(viii)Agricultural share of Government Expenditure (%)

The agricultural share of government expenditure measures the percentage share of agricultural expenditure in the government total expenditure at period t. The variable measures the government's commitment to infrastructural development and research in agricultural sector. The statistics for this variable revealed the mean value of 3.04%, minimum and maximum values of 1.29% and 5.29% respectively. The coefficient of volatility of the variable stood at 39.0% and an exponential growth rate of -2.59%. The result suggests that, the country has not been consistent in advancing the course of agricultural expenditure over the years. For instance, the country's budgetary allocation to the agricultural sector has been persistently less than 10.0% which is in deviant with the Maputo declaration of 2003. The declaration demanded African Union member nations to commit at least 10.0% of their annual budgetary allocation to the development of agricultural sector. However, in Nigeria the achievement of this declaration was just a mirage as the declaration demands were not met at any time. In 2022, the agricultural share in the central government total expenditure was only 2.29%. This is far below the standard needed by the UN SDG number 2 target on rural infrastructure development and stimulation of agricultural researches among others.

The graph in Figure 8 shows the trend in agricultural share of the central government expenditure from the year 2001 to 2022.

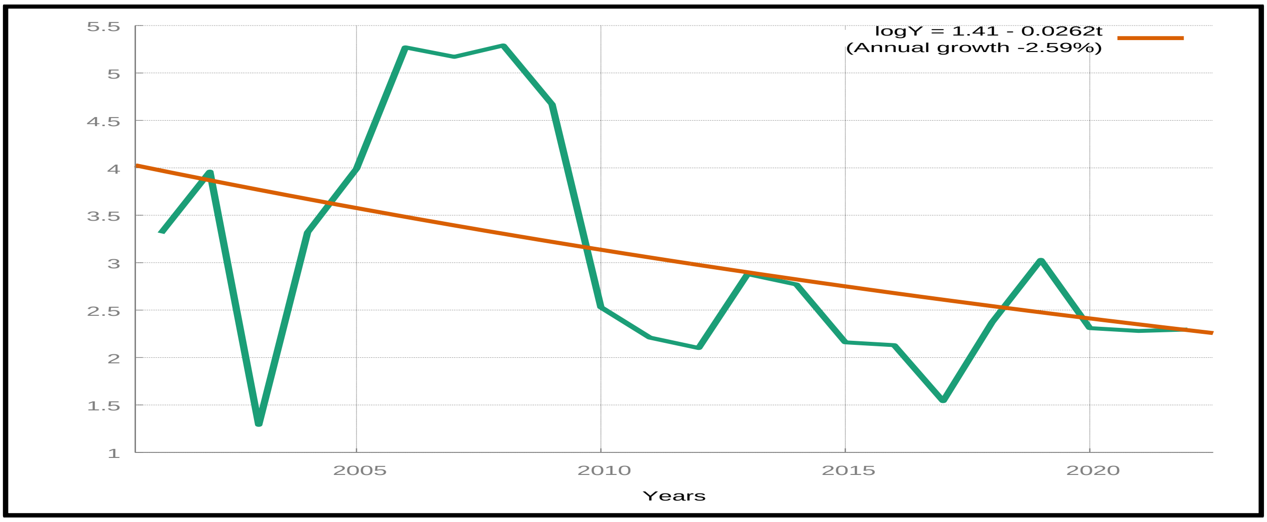

Fig. 8. Trend in agricultural share of government expenditure in Nigeria (2001 - 2022).
Source: from data analysis, 2024.

The graph revealed a conspicuous negative growth in agricultural share of the central government expenditure. The findings indicate that, the country in recent time has persistently reduce the capital allocation to the agricultural sector, thereby stiffening its investment potentials. This trend structure do not align with the purpose of the SDG 2 which emphasizes on the provision of sustainable rural infrastructures as one of the prerequisites to manifest “zero hunger” and sustainable development in the agricultural sector. The findings from the analysis of the agricultural share in the central government's expenditure are consistent with the SDGs report[30] on Nigeria.

(ix) Agricultural sector’s value added share of GDP % in Nigeria

This index represents the proportion of the agricultural sector’s value addition in monetary terms in the country’s GDP expressed as a percentage in period t. The index is larger in agrarian based economy. A greater index implies potent, efficient and sustainable agricultural sector’s production, processing and marketing. Otherwise, an industrialized economy which built its GDP outside agriculture will have a lower index of agriculture value share of GDP. However, the information for this variable revealed the mean value of 24.34%, minimum and maximum values of 19.99% and 36.97% respectively. The coefficient of variability is 17.10% and an exponential growth rate of -1.55%. In 2021, the index was 23.36% in Nigeria, 2.47% in South Africa, 19.17% in Ghana and 11.44% in Egypt. The result suggests that, the country’s value addition in agriculture is depreciating. Increase in agricultural researches and expenditure as well as a stable macroeconomic environment are some of the prerequisites for the upsurge of this variable.

The graph in Figure 9 below shows the trend in the agricultural value added share of the GDP (as a percentage) from the year 2001 to 2022. The graph revealed a noticeable negative growth in the agricultural value added share of the GDP. Given the nature of trend in the agricultural value added share of the GDP, it implies that the country is not doing enough in technology application and processing of agro-products. This is contrary to the aim of SDG number 2 and the finding corroborates the report of the SDGs [30] on Nigeria.

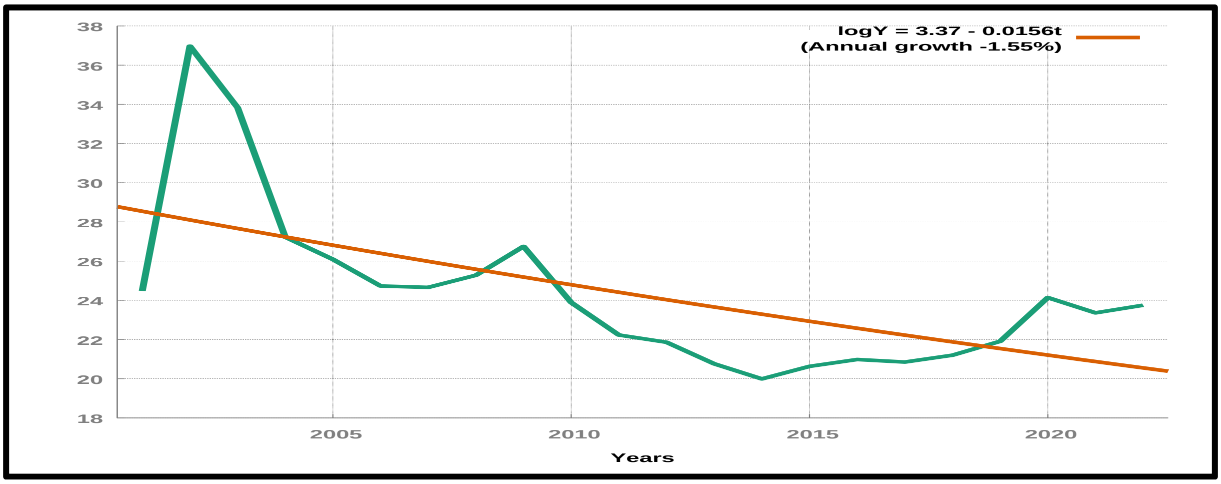

Fig. 9. Trend in Agricultural value added share of the GDP (%) in Nigeria (2001 - 2022).
Source: from data analysis, 2024.

(x)Agriculture orientation index

The agricultural orientation index for government expenditures is referred to as the proportion of agriculture share of government expenditure divided by the agriculture value added share of the economy GDP in period t. The descriptive statistics for this variable revealed the mean value of 0.126, minimum and maximum values of 0.04 and 0.21 respectively from the year 2001 to 2022. The coefficient of variability is found at 34.90% and exponential growth rate of -1.08%. In 2021, the index was 0.10 in Nigeria, 0.56 in South Africa, 0.06 in Ghana, 0.10 in Kenya, and 0.12 in Egypt. The result suggests that, the country's agricultural orientation index is low relative to some African countries. The finding implies that, the agricultural sector receives a lower share of government spending relative to its contribution to economic value-added. The result contradict the intention of the SDG number 2 target for the country in 2030 (Fig.10).

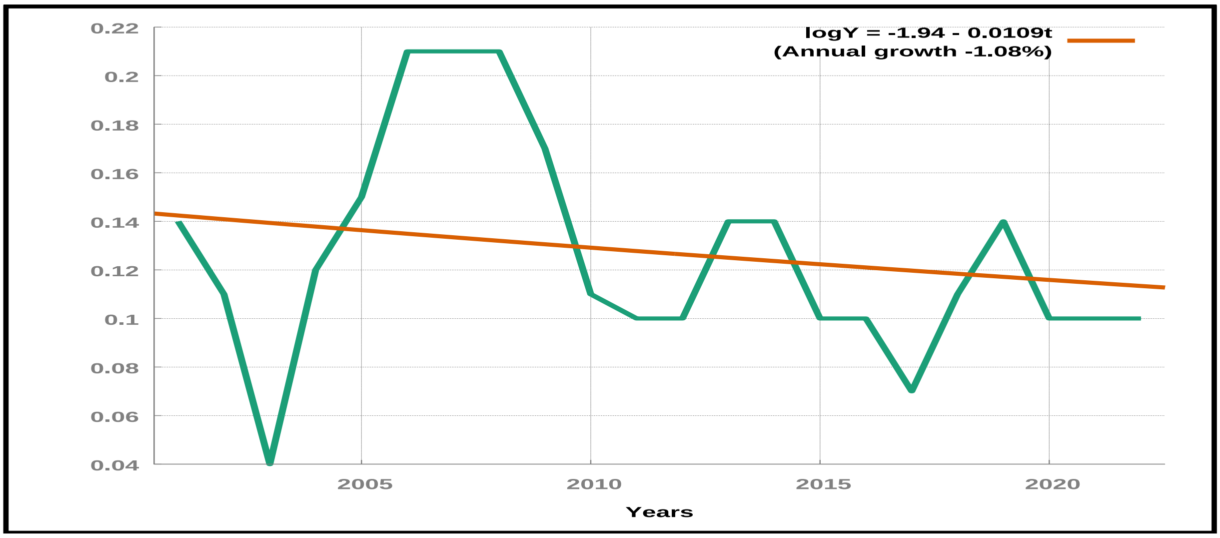

Fig. 10. Trend in the Agricultural Orientation Index in Nigeria (2001 - 2022)
Source: from data analysis, 2024.

Figure 10 shows the trend in the agricultural orientation index for government expenditures from the year 2001 to 2022. The graph displayed a fluctuating trend with distinct peaks and troughs, all of which were characterized by an average negative growth throughout the period. Considering the nature of the agricultural orientation index trend for government expendituresin Nigeria, it is obvious that the country is far from achieving the SDG Number 2 in 2030.

Beckoned on such facts as: majority of farmers in the country are poor, plenteous of moribund projects in agricultural sector, dilapidated infrastructures in agricultural sector and frequent farmers-herders conflicts as well as mounting insecurity, the country need to invest heavily in all facets of agriculture in order to make meaningful improvement in the sector. The finding is contrary to the aim of SDG number 2 and it corroborates the report of the SDGs [30] on Nigeria.

CONCLUSIONS

The study assessed several indicators of the United Nation Sustainable Development Goal (SDG) number 2 in Nigeria. The aim was to examine the success the country has achieved from the year 2001 to 2022. Time series data were used for the analyses. The finding revealed that significant population of Nigerians are still undernourished representing over 15.00% of the country's population. This means that the target of SDG number 2 concerning universal access to safe and nutritious food in 2030 might be an illusion if proactive actions are not taken by the country. The fertilizer use rate in Nigeria was found to be very low relative to the other countries in Africa, the average in Africa continent and the world. Also, the water use efficiency in agriculture was relatively low and cannot generate sustainable agricultural practices as envisage by the UN SDG number 2.

The findings suggests that the SDG target of doubling productivity and incomes of small-scale food producers Nigeria would not be achieve unless the fertilizer use level and water use efficiency is deliberately upsurge. The finding further showed that agricultural land marginally increase on yearly basis without corresponding increase in factor productivity. The finding contradict the requirement for achieving the SDG on sustainable food production and resilient agricultural practices.

In addition, the percentage of the country's population that have access to electricity is less than 60.00%, while only 25.46% of the country's rural population has access to electricity in 2022. The agricultural share of government expenditure is persistently low and less 10.00% of the Maputo declaration for African Union member nations.

The agriculture value added share of GDP of Nigeria is low and it grew negatively from 2001 to 2022.

Agricultural Orientation Index in Nigeria is low compared to some African countries. The index was 0.10 in 2022. The index grew at the rate of -1.08% from 2001 to 2022 implying that, the agricultural sector receives less or insignificant share of the federal government spending relative to its contribution to economic value-added.

The findings revealed that on average Nigeria is rather too slow or better is off track towards achieving the SDG of 'Zero Hunger' by 2030. The country's current efforts, strategies and the general progress towards SDGs are grossly insufficient.

The nation must approach the SDGs as a team player collaborating the domestic agenda with the regional and global road maps to effectively unlock the potential needed to attain the mandate of 'Zero hunger' in 2030.

Based on the findings, it is recommended that, Nigeria should increase its budgetary expenditure on agricultural sector in order to meet the SDG number 2 and its targets in 2030.

The country should invest in fertilizer production and irrigation system so as to increase fertilizer consumption per hectare and water use efficiency in agricultural sector. Also, the nation should focused on achieving higher farm factor productivity instead of expanding the current agricultural land area.

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TREND ANALYSES AND MACROECONOMIC VARIABLE DETERMINANTS OF OIL PALM FRUIT AND ITS DERIVATIVES PRODUCTION IN NIGERIA

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Abstract

The production of oil palm fruit and its derivatives was once the prime mover of the Nigeria's economy a few decades ago, but currently, the country is a net importer of these commodities. The sub-unit holds great potential in terms of job creation, poverty reduction, raw materials for agro-based industries and overall growth of the country's economy. In recent times, the governmenthas articulated and implemented numerous policies, programs and institutions to re-brand the sub-unit but to no avail. Beckoned on these evidences, the study was developed to examine the production trends in this sub-unit and investigate its link with some selected macroeconomic variables as alternative ways of examining the problems of the sub-unit. The research utilized secondary data from the years 1981 to 2023. The data were gathered from the United State Department of Agriculture (USDA), Food and Agricultural Organization (FAO), World Bank, and Central Bank of Nigeria (CBN). The properties of the series were tested to confirm their stability. The co-integration of the series was establish by autoregressive distributed lag (ARDL) bound F-test. The trends analyses revealed a 1.68%, 3.50%, 4.63%, 4.83%, and 2.19% annual exponential growth in oil palm fruit, palm kernel, palm kernel oil, palm kernel meal and palm oil respectively. The study found significant relationship between the outputs of oil palm fruit, palm kernel, palm kernel oil, palm kernel meal and palm oil and the domestic credit injected in the economy, per capita income, nominal exchange rate, and inflation rate in the short and long run periods. To upsurge the sub-unit production, it is strongly recommended among others that adequate credit facilities should be provided for the production of the primary product (oil palm fruit) and the expanding value chain.

Key words: *Palm oil, Palm kernel oil, palm fruit, Macroeconomics, Trend, Nigeria*

INTRODUCTION

The *Elaeis guineensis* popularly known as oil palm tree is among the prominent cash crops grown in the southern region of Nigeria [32], [29], [24], [8]. The crop has been integrated in the cultural fabric of the inhabitants of the south eastern and south-south regions of Nigeria [10]. The history of the crop is well rooted in the country and dates back to the 1950s when Nigeria control almost half of the global export. In the mid-1960s, Nigeria owned a global market share of 43% [32]. Though the dominant position of Nigeria in palm oil production and export was relinquished to Malaysia and Indonesia following the diversification of the revenue source due to the commencement of the commercial drilling of crude oil in the early 1970s in the country [26], [12]. Both countries currently controlled about 80% of the global palm oil production and exports. Currently, Nigeria is ranked 5th in the global palm oil production, with an annual production of about 1.40 million metric tons which is below 2.0% of the global output in 2022 [16].

Despite the abysmal performance of Nigeria in oil palm fruit and its derivatives production, the relevance of the sub-unit has continued to upsurge given its importance in job creation, industrialization drive and its multiple chains of income generation and livelihood sustenance [10], [38]. The crop is rich and has a long chain of derivatives namely: palm oil, palm kernel oil, palm kernel cake, palm kernel, palm kernel meal and sludge among others. Palm oil is the most widely used oil palm fruit processing derivative. It is a major component in the daily dietary intake of the majority of Nigerians. According to Gonzalez-Diaz and García-Núñez [18], palm oil is a rich source of carotenoids, vitamins, tocopherols, fatty acids, vitamin E, and emulsifiers among other chemicals.

Nigeria's demand for oil palm fruit and its derivatives have increased progressively over the years. For example, palm oil domestic demand (i.e. used as food) was at 1.65 million metric tons in 2020 and rose to 1.71 million metric tons in 2021 [39]. The domestic production stood at 1.275 million metric ton in 2020 and 1.400 million metric tons in 2021 creating supply deficits of 0.375 million metric tons and 0.310 million metric tons in 2020 and 2021 respectively [39]. The supply deficit generated import demand with a huge financial implication for the country's economy. If this trend continues without appropriate interventions, other sectors might suffer gross neglect and this can further worsen Nigeria's poverty situation [35]. Currently, with an estimated population (demand capacity) of over 200 million, the demand capacity is expected to expand with expanding deficiency in supply. According to the report from the USDA [39], Nigeria is the biggest consumer of palm oil in Africa with an annual consumption of 1.79 million metric tons followed by Egypt with a yearly consumption of 1.225 million metric tons in 2022. In 2020, the Sub-Saharan Africa production level stood at 6 million metric tons of oils and fats while domestic consumption was 11.2 million metric tons, thereby creating an import demand of 7.4 million metric tons. In 2018, it was reported that Nigeria's total fats and oil consumption rose to about 3 million metric tons, with 44.7% share derived from palm oil consumption [33].

The government of Nigeria has put forward several attempts to revive the dwindling fortune in the oil palm fruit production and agricultural sector in general that is predominated by the small-scale farmers [38], [1]. The interventions manifested in import policies, financial assistance to stakeholders, infrastructural development among others [9]. For instance, the Federal Government (FG) in 2015 added palm kernel and palm oil products to the list of items it prohibits from accessing foreign exchange for importation [13]. In 2019, the FG closed its land borders to guarantee the enforcement of bans on the imported palm oil derivatives. In addition, the FG released about N30 billion loan to oil palm farmers to enhance their productivity. In 2015, the CBN launched the anchored borrower programme to provide indirect funds to small scale oil palm farmers in the country to boost aggregate production. The CBN in 2020 disbursed ₦34.3 billion to major palm oil enterprises in the country with an intention to expand cultivated area to 100,000ha in 2025 from 20,000ha in 2020, increase productivity and generate jobs for the teeming youth population. However, these interventions have not yielded the expected outcomes as the country's commanding position in the global oil palm fruit and its derivatives production is still a mirage. The yearly output growth rate is still at the marginal level [16]. In 2019, the major palm oil producing firms quoted in the Nigerian stock exchange (NSE) market recorded a revenue decline. In addition, the global activities played down on the objective of the FG to boost oil palm fruit and its derivatives production. For example, the mean crude palm oil price in 2017 stood at US$751/metric ton compared to US$601/metric ton in 2019; a 19.97% decline [40].

Though many economists have attributed the weakening production capacity of the palm oil fruit and it derivatives to the over reliance of the country's economy on petroleum production, poor processing techniques and poor policy implementation, but the volatility in the macroeconomic fundamentals also played a major role [29], [1], [27], [28], [41], [11], [25]. Oil palm fruit production is an economic activity likely to be influence by the uncertainties in the macroeconomic policy environment in areas such as: production, research capability, marketing, export and import drives among others [3], [1], [27], [28], [25], [5]. The macroeconomic policies is an embodiment of the exchange rate regulations, fiscal, monetary and trade policies tended to control the economic (production) activities in the economy. Sound and sustainable macroeconomic policies are prerequisites for sustainable agricultural development [15], [7], [1], [27], [22], [2], [4], [5]. A stable macroeconomic environment has a severe economic and development implications for the attainment of smart and sustainable agricultural production and expansion of export [7], [37]. For instance, import restrictions, exchange rate regulation and trade barriers can be used as tools to boost domestic production [15]. Moreover, high rate of inflation can trigger cost of production and dampened the domestic supply. As note by Ziaei and Issa [41] a surge in palm oil production would possibly lead to an increase in farmers' income, private capital stock or assets, government revenue, improved human capacity, an stimulate other economic activities. Hence, with these assertions, there is a need to critically examine the roles macroeconomic fundamentals had played in the production of oil palm fruit and its derivatives over the years as an alternative strategy to boost production and extend the borderline of value addition system of the sub-unit in the country.

Surprisingly very scanty literature have explored the association between the oil palm fruit and its derivative production versus macroeconomic variables. However, Akpan and Patrick [3] in Nigeria found a significant impact of selected macroeconomic variables on the outputs of palm oil and palm kernel in the short and long run periods. Among the macroeconomic variables identified were, the per capita income and lending interest rate. Also, [26] identified the exchange rate (N/$) and the price of palm oil among the determinants of oil palm production in both short and long run periods. In a similar vein, Akpan [1] found the price of oil palm fruit, value addition and consumers' income as long and short runs determinants of oil palm fruit production in Nigeria. Moreover, Hasibuan and Nurdelila [20] identified the negative influence of inflation rate on oil palm fruit production in both short and long run periods in Indonesia. Recently, Busari et al., [12] found the nominal exchange rate, the interest rate on the agricultural loan, export tax, and the inflation rate as significant negative determinants of the Nigeria's market share of palm oil in the global market.

From the few literature available, it is palpable that most of the studies focused specifically on palm oil neglecting other palm oil fruit derivatives. The appropriate intervention in the sub-unit needs to be holistic by considering a wide range of important derivatives. Again, information on this issue need to be updated following the high volatility of macroeconomic environment in the country.

Hence, this study was designed to fill this identified research gaps and generate alternative variables to tackle the problem of low output/supply deficit in oil palm fruit and its derivatives production in Nigeria.

To achieve this major objective; the study specifically: (i) examined the trends in the annual outputs of the oil palm fruit, palm kernel, palm kernel oil, palm kernel meal and palm oil in Nigeria and, (ii) identify the macroeconomic variables that influence the outputs of oil palm fruit, palm kernel, palm kernel oil, palm kernel meal and palm oil in both short and long run periods in Nigeria.

MATERIALS AND METHODS

Study area and data Source

The study was conducted in Nigeria. The country is located in the Sub-Saharan region of West Africa. Nigeria is the most populous country in Africa. It is rich in agricultural resources.

The country is a major player in the global oil palm fruit production. About 60% of the country's population are engaged in agricultural production [17].

The land mass is 923,769km^2 and more than 70% of the land mass constitute arable crop land. The population of the country is over two hundred (200) million [36].

Secondary information or data were gathered from official sources including; United State Department of Agriculture (USDA), World Bank publications; Food and Agricultural Organization (FAO) and Central Bank of Nigeria (CBN). The time frame stretches from the year 1981 to 2023.

Theoretical Framework

The study used the concept of a classical production theory framework which assumed that a firm output is determined by the use of certain factors of production suh as labour and capital. Basically, the classical production theory describes a unilateral production function depicting the relatonsip between output of a firm and factors of production. Implicitly, in a typical factor- factor relationship, a firm output is determined as thus:

$$Q = f(W, B) \dots\dots\dots\dots\dots..(1)$$

where: Q represent a firm or farm output, and W and B connotes capital and labour factors respectively. The amount of Q produced at any point is a function of the various combinations of W and B while other inputs are held constant. Production being an economic activity is affected by other economic variables. The quantities of W and B inputs available is equally affected by the market prices, wages, and interest paid among others. Hence, economic production is is a function of a multilateral factors such as; macroeconomic factors, climatic factors, price factors etc. The production relationship in a holistic form connotes that, a firm output at any point in time depends on the physical inputs and non-physical factors alike. Implicitly, this assertion can be illustrated and examplified as thus:

$$Q = f(W, B, E, C) \dots\dots\dots\dots\dots\dots..(2)$$

where: E an C are economic and climatic factors. Therefore, equation 2 forms the structural framework in which we derive our behvioural function employ in this study.

Model Specification

The analyses of trends in oil palm fruit and its derivative

The study estimated the exponential trend equation to analyze the trends in annual oil palm fruit and its derivatives outputs. The trend equation is explicitly showed in equation 3.

$$log_e Output_t = \delta_0 + \delta_1 t + U_t \dots (3)$$

where "t" represents the time variable measured in years. According to Akpan et al., (2022), the compound growth rate or exponential (r) growth rate is given as:

$$(r) = (e^{b1} - 1)\, x\, 100 \dots\dots\dots\dots\dots..(4)$$

Note, euler's number (e ≈ 2.71828). The quadratic trend equation as shown in equation 5 was also estimated to test the acceleration, deceleration and stagnation of oil palm fruit and it derivatives outputs over doubling of time [6], [5].

$$log_e Output_t = \vartheta_o + \vartheta_1 T_1 + \vartheta_2 T_2^2 + u_t \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots.(5)$$

If $\vartheta_2 > 0$; the oil palm fruit production for instance is increasing at a decreasing rate or is increasing at increasing rate depending on its sign. When $\vartheta_2 < 0$, it means the growth rate in palm oil fruit is not significant, hence stagnated over a doubling period. Note the trend equation was also estimated for the oil palm fruit derivatives (namely; the palm kernel, palm kernel oil, palm kernel meal and palm oil).

The macroeconomics factors influencing oil palm fruit and it derivatives production

An oil palm fruit equation is modeled using variables at their level to identify its determinants. The general production relationship used is explicitly demonstrated in a double –log form in equation 6.

$$LnY_t = \alpha_0 + \alpha_1 LnINF_t + \beta_2 LnEXC_t + \beta_3 LnPER_t + \beta_4 LnCRE_t + \mu_t \dots\dots\dots\dots\dots \quad (6)$$

where:

Y_t represents group of dependent variables defined as:

PFU_t = Oil palm fruit in tons

PKE_t = Palm kernel in tons

PKO_t = Palm kernel oil in tons

PKM_t =Palm kernel meal in tons

PAO_t = Palm oil in tons

Where:

INF_t = annual inflation rate (that proxy factor price fluctuation)

EXC_t = annual nominal exchange rate(₦/$) (proxy influence of external World)

PER_t = Gross Domestic Product per capita (naira/person) (represents demand capacity of the population)
CRE_t = domestic credit disbursed to the private sector in the economy used as a proxy to credit injected in the agricultural sector (% of GDP)
U_t = error term; $U_t \sim$ IID $(0, \delta^2_U)$.

The Autoregressive Distributed Lag (ARDL) bound test

To avoid spurious regression following the result of the unit root test of series; it is strongly recommended that the series should be tested for cointegration. The ARDL bound test was used to validate the cointegration relationships among variables in the specified equations [30], [31]. The ARDL bound test is designed to solve issues with variables having mixture of stationary. The ARDL test generates relatively more efficient estimates compared to other techniques (such as cointegration and Engle-Granger two step method) especially when dealing with small sample size. Besides, the test produced unbiased, best and stable estimates of the long-run model as noted by Harris and Sollis, [19]. The ARDL bound test modelled for equation (6) is expressed explicitly as thus:

$$\begin{aligned}\Delta LnY_t &= \theta_0 + \theta_1 \sum_{i=1}^{n_1} \Delta LnY_{t-1} + \theta_2 \sum_{i=1}^{n_2} \Delta LnINF_{t-i} \\ &+ \theta_3 \sum_{i=1}^{n_3} \Delta LnEXC_{t-i} + \theta_4 \sum_{i=1}^{n_4} \Delta LnPER_{t-i} \\ &+ \theta_5 \sum_{i=1}^{n_5} \Delta LnCRE_{t-i} + \delta_1 LnY_{t-i} \\ &+ \delta_2 LnINF_{t-i} + \delta_3 LnEXC_{t-i} + \delta_4 LnPER_{t-i} \\ &+ \delta_5 LnCRE_{t-i} \\ &+ U_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots . (7)\end{aligned}$$

The ARDL bound test model assumes endogeneity of the specified variables. In equation 7, the short run elasticities coefficients are symbolized by θ_1 to θ_5 while δ_1 to δ_5 are the long-run coefficient elasticities. The θ_0 represents the drift factor; "n" is the maximum lag length determined by the decision criteria; U_t is the regression error term. The bounded F-values were generated with restricted constant and no trend for K = 4. The decision rule is that, if the ARDL F-value exceed the upper bound critical value; then co-integration exist, hence the null hypothesis is rejected. Besides, when the estimated F-value is found to be below the lower bound critical value, the null hypothesis of no cointegration cannot be rejected, indicating the absence of no co-integration. Otherwise, if the F-value lies between the lower and upper critical bound values; then the results is inconclusive [31]. When the ARDL bound test upheld the presence of cointegration, then the long and the short runs equations are explicitly specified as thus:

The long run model:

$$\begin{aligned}LnY_t = \delta_0 + \delta_1 \sum_{i=1}^{q_1} LnY_{t-i} + \delta_2 \sum_{i=1}^{q_2} LnINF_{t-i} \\ + + \delta_3 \sum_{i=1}^{q_3} LnEXC_{t-i} \\ + \delta_4 \sum_{i=1}^{q_4} LnPER_{t-i} \\ + + \delta_5 \sum_{i=1}^{q_5} LnCRE_{t-i} \\ + \varepsilon_t \ldots\ldots\ldots\ldots\ldots\ldots (8)\end{aligned}$$

The short run model (ECM model):

$$\begin{aligned}\Delta LnY_t = \beta_0 + \beta_1 \sum_{i=1}^{n_1} \Delta LnY_{t-1} + \beta_2 \sum_{i=1}^{n_2} \Delta LnINF_{t-i} \\ + \beta_3 \sum_{i=1}^{n_3} \Delta LnEXC_{t-i} \\ + \beta_4 \sum_{i=1}^{n_4} \Delta LnPER_{t-i} \\ + \beta_5 \sum_{i=1}^{n_5} \Delta LnCRE_{t-i} + \forall ECM_{t-1} \\ + U_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (9)\end{aligned}$$

From the ECM, "$\forall$" is the error correction term that depicts the speed of adjustment towards the long-run equilibrium.

RESULTS AND DISCUSSIONS

The Summaries of variables

The series' summary tests are shown in Table 1. The data indicated that the GDP per capita and exchange rate skewness and coefficient of variability indices are larger than one. This indicates that during the specified period, the variables under consideration exhibited significant annual volatility and continued annual increases. A marginally positive skewness and the lowest coefficient of variability were observed in the annual production of oil palm fruit. The sub-unit witnessed about 23.00% variability while the skewness index suggests that the output grew at a marginal positive rate. In addition, the volatility index of annual palm kernel, palm oil, palm meal, palm oil production and domestic credit was 45 per cent, 53 per cent, 53 per cent, 30 per cent, and 38 per cent respectively. This means that the annual variations in these variables were moderate; but with persistent positive annual growths. However, the variations in inflation rate revolved around unity but with consistent positive annual growth.

Table 1. The major summaries of data

Variable	Min.	Max.	Average	Std. deviation	CV	Skewness
Oil palm fruit (tons/10,000)	475.00	1,271.80	793.67	183.37	0.23	0.71
Palm kernel (tons/10,000)	20.00	90.00	51.18	23.19	0.45	0.25
Palm kernel oil (tons/10,000)	6.80	39.30	21.59	11.38	0.53	0.14
Palm oil (tons/10,000)	50.00	140.00	81.17	24.62	0.30	0.97
Palm kernel meal (tons/10,000)	7.60	47.20	26.23	13.81	0.53	0.06
Inflation rate (%)	5.39	72.84	19.07	16.28	0.85	1.87
Exchange rate (%)	0.62	638.70	127.82	142.23	1.11	1.53
GDP/capita	1,853.10	1,026,900	244,440	295,060	1.21	1.08
Domestic credit/GDP	4.96	19.63	9.62	3.63	0.38	0.86

Source: This is computed by the authors, data are derived from FAO, CBN, USDA and World Bank, 2024.

This means that these variables witnessed high level of fluctuations marked with consistent increase in the growth rates within the specified period. An average of 7.93 million metric tons, 0.51 million metric tons, 0.21 million metric tons, 0.81 million metric tons and 0.26 million metric tons of oil palm fruit, palm kernel, palm kernel oil, palm oil and palm kernel meal respectively was produced from 1981 to 2023 period.

Trends in the oil palm fruit output and its derivatives

The estimated exponential trend equation for oil palm fruit and its derivatives is shown in Table 2 an 3. The results show that annual production of oil palm fruit and its derivatives in Nigeria is positively related to time. In other words, the annual production of palm oil fruit and its derivatives (palm kernel, palm kernel oil, palm kernel meal and palm oil) increases with the increase in the time factor.

The results show that in Nigeria, the average positive exponential growth rate is 1.68 per cent, 4.63 per cent, 3.50 per cent, 4.83 per cent, and 2.19 per cent for oil palm fruit, palm kernel oil, palm kernel, palm kernel meal and palm oil respectively.The findings revealed that the oil palm fruit and its drivatves on average wtnessed persisitent annual positve increment from 1981 to 2023.

Further analyses of the quadratic trends revealed that the time squared coefficients related to the palm kernel, palm kernel oil and palm kernel meal equations are negative and significant at the conventonal levels. This suggests that the production of these outputs over doubling time assumed a deceleration pattern. Alternatively, over a doubling time, the annual production of palm kernel, palm kernel oil and palm kernel meal increase at a decreasing rate in Nigeria. The result for the palm oil fruit production revealed stagnation over doubling of time, while the production of oil palm showed acceleration in output over doubling of time. The behaviours observed in these variables has a lot of policy implications. From the analyses, it is obvious that the oil palm fruit production and its rich value chain in Nigeria cannot be describe as being efficient but just struggling to stay afloat within the period of analysis. This is an indication of long neglect of the oil palm sub–unit and perhaps the agricultural sector at large in the country. The neglect and non-prioritizing of the agricultural sector and the conscious violation of the Afrıcan Union, Maputo 2003 Declaration on agricultural investment in Africa has contributed to the result obtained [7], [22].

The pictorial representation of the estimated trend lines for the oil palm fruit and its derivatives are shown in Figure 1 to 5. The trends in palm kernel oil, palm kernel meal and palm kernel production are somehow similar while trends in oil palm fruit and palm oil production displayed similar pattern with minor variations. However, from 1981 to 1985, the output trends in all the five commodities assumed undulated patterns following the policies of the then pre-structural Adjustment Programme (PSAP). The structure of the trend could partly be attributed to the instability in the macroeconomic environment that prompted the enunciation of economic stabilization acts in 1985 [7], [2].

Table 2. Thetrend analyses of oil palm friuts and its derivatives

Variable	**Oil palm fruit**		**Palm kernel oil**		**Palm kernel**	
	Coeff	t-value	Coeff	t-value	Coeff	t-value
Constant	6.284	214.1***	1.916	35.19***	3.071	49.52***
Time	0.017	14.33***	0.045	21.02***	0.034	14.02***
Fcal. (1,41)	205.3*		441.8*		196.5*	
Exp. growth (%)	**1.68**		**4.63**		**3.50**	
	Quadratic trend analysis					
Constant	6.229	140.1***	1.799	22.03***	3.222	35.08***
Time	0.024	5.16***	0.061	7.11***	0.014	1.49
Time Squared	-0.0002	-1.63	-0.0004	-1.87*	0.0005	2.15**
Fcal.(2, 40)	108.1***		236.1***		109.3***	

Note: asterisks *** represent a 1% significance level. Exp is exponential growth rate.

Table 3. Thetrend analyses of oil palm friuts derivatives

Variable	**Palm kernel meal**			**Palm oil**		
	Coeff.	Std error	t-value	Coeff.	Std error	t-value
Constant	2.062	0.055	37.75***	3.879	0.026	148.0***
Time	0.047	0.002	21.2***	0.022	0.001	20.86***
Fcal. (1,41)	475.9*			435.12*		
Exp. growth (%)	**4.83**			**2.19**		
	Quadratic trend analysis					
Constant	1.846	0.073	25.37***	3.999	0.033	123.1***
Time	0.076	0.008	9.96***	0.006	0.003	1.64
Time Squared	-0.0007	0.0002	-3.89***	0.0004	0.00008	4.87***
Fcal.(2, 38)	327.8***			349.7***		

Note: asterisks *** represent a 1% significance level. Exp is exponential growth rate.

In 1986, the Structural Adjustment Programme was enunciated being engulfed by several policies that decline the roles of government in agricultural production and accelerating privatization programmes [5]. During this period, importation of oil palm fruit derivatives was discouraged in order to boost domestic production. Also, the marketing board of palm oil was abolished to enhanced farmers earnings and reduced government participation and subsidy in the oil palm production among other policies [34].This period which spanned from 1986 to 1993 witnessed an improvement in outputs of oil palm fruit and its derivatives. The trends in oil palm fruit and its derivatives production in this period was majorly influenced by the policies and programmes embedded in the structural adjustment programme (SAP) era. [7], [35]. From 1994 to 1999, privatization and commercialization policies was emphasized in the agricultural sector through public-private partnership agenda (PPP). This period was characterized by the emergence of mega agro enterprises in oil palm production. This period also witnessed a tremendous increase in the production of oil palm fruit and its derivatives in Nigeria. This period is considered as the boom period in the post Sap era in oil palm fruit and its derivatives production in Nigeria. The notable feature of this period was the privatization and commercialization of state-owned palm oil companies. During this period, private investment in oil palm fruit production and processing increased significantly, but subsequent improvements in the sub-sector was significantly hampered by increasing macroeconomic fundamental volatility in the country. Between 1999 and 2007, series of President Initiatives were enunciated and targeted on specific agricultural commodities to upsurge food production in line with Vision 2020 agenda. From 2007 to 2010, the agricultural policies of the "seven point agenda" attempted to create a conducive macroeconomic environment to stimulate greater agricultural production [23].

From 2010 to 2015, the agricultural transformation agenda was birthed to strengthen private investment in the oil palm production. Following the implementation of these policies, the oil palm fruit and its derivative outputs continued to upsurge till 2009. From 2010 to 2015, the sub-units witnessed a general decline in outputs. As a response in 2015, the Central Bank of Nigeria (CBN) launched the Anchor Borrowers Programme (ABP), among other intervention schemes, to provide loans to majors, small and medium scale oil palm enterprises in the country. The overall policy objective of the programme was to meet the local demand for palm oil and its derivatives and at the same time improve local processing quality and standards. In addition, the (ABP) was aimed at protecting the foreign exchange reserves; create more jobs and enhance the entrepreneurial skills of Nigerians along the oil palm value chain. Also, in 2015, the CBN intentionally excluded palm kernel and palm oil products from being procured with foreign exchange from the Nigerian foreign exchange markets or platforms with the aim of boosting domestic production.

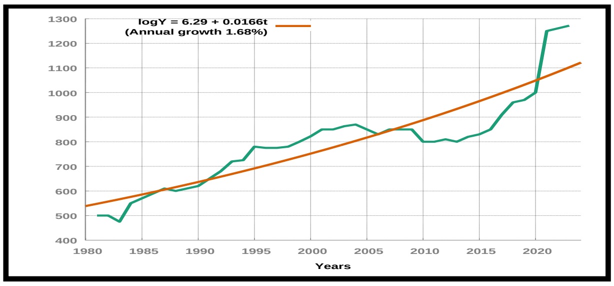

Fig. 1. Trends in Oil Palm Fruit in Nigeria (1981 - 2023)
Source: Own results.

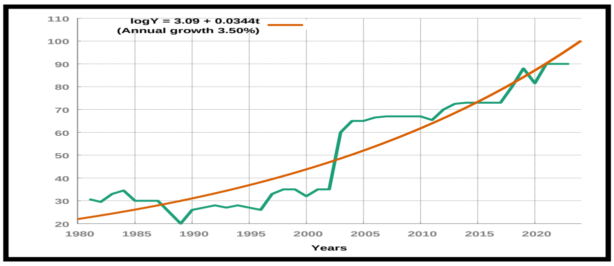

Fig. 2. Trends in Palm Kernel nut in Nigeria (1981 - 2023)
Source: Own results.

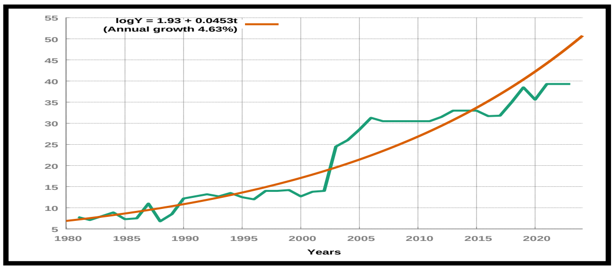

Fig. 3. Trends in Palm Kernel Oil in Nigeria (1981 - 2023)
Source: Own results.

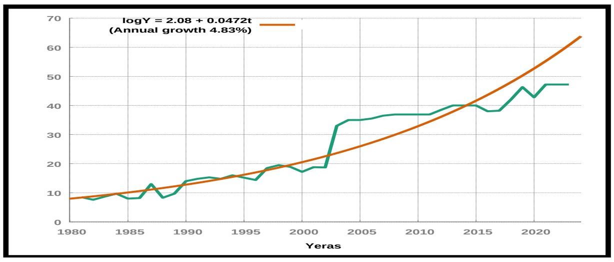

Fig. 4. Trends in Palm Kernel Meal in Nigeria (1981 - 2023)
Source: Own results.

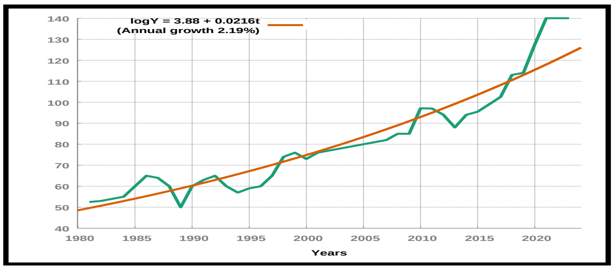

Fig. 5. Trends in Palm Oil in Nigeria (1981 -2023)
Source: Own results.

These interventions yielded positive impact with insurgence of positive growth in outputs of oil palm fruit and its derivatives from 2017 to 2019 though inconsistent. In 2019, the CBN enunciated partnership agreement with the oil palm producing States to nurture the long term investments in oil palm production and its value chains. The partnership aimed at expanding the oil palm plantation by 100,000 hectares. Though the implementation of some of these policies are on-going, the global lock-down caused by the emergence of COVID-19 pandemic in 2020 and persistent increase in inflation rate slow down the activities in the sub-units from 2019 to 2021. In summary, the trend in oil palm fruit and its derivatives production has shown undulating behaviours from 1981 to 2023, which mostly were predicated by the implementation of programmes and policies targeted at increasing the capacity utilization in the sub-sector. However, the overall growth patterns have been uninspiring considering the domestic deficit imposed by production shortages.

Unit root test

The study used the Augmented Dickey Fuller [14] unit root test to verify the stationarity of series. The results as presented in Table 4 showed that inflation rate is stationary at level 1(0); while other series are shown to be stationary at the first difference 1(1) level. Given the unit root test results, some methods of testing the presence of the cointegration among series is inappropriate. For example, the Engle-Granger two step method and Johansen cointegration method required that all series must be stationary at the same level. Therefore, following the mixed level of stationarity of variables, it infers that the ARDL bound test technique is the most suitable to test for the presence of cointegration in the specified models compared to other methods. The justification of using ARDL bound test warrant the determination of the appropriate lag length for the specified series. This was conducted by using the information criteria. The next step was the estimation of the F-values of the ARDL models. The calculated ARDL F-values and the tabulated F-values representing the critical bound are presented in Table 5.

Table 4. ADF unit root tests for variables

Variable	ADF (constant)				ADF (constant and Trend)			
	Lag	**Level**	**1st Diff.**	**Decision**	**Lag**	**Level**	**1st Diff.**	**Decision**
Oil palm fruit (tons)	0	-0.2373	-6.1731	1(1)	0	-1.3403	-6.0980	1(1)
Palm kernel oil (tons)	0	-0.988673	-8.1273	1(1)	0	-3.0523	-8.0500	1(1)
Palm kernel (tons)	0	-0.39667	-6.3634	1(1)	0	-2.3567	-6.3159	1(1)
Palm oil (tons)	0	0.11179	-6.0389	1(1)	0	-2.3491	-6.0487	1(1)
Palm kernel meal (ton)	0	-1.12547	-8.2573	1(1)	0	-3.0497	-8.2299	1(1)
Inflation rate (%)	0	-3.5251**	-	1(0)	0	-3.4907*	-	1(0)
Exchange rate (%)	0	-1.94252	-5.5056	1(1)	0	-1.62125	-5.7462	1(1)
GDP/capita	0	-1.51375	-3.5098**	1(1)	0	0.139674	-3.7539**	1(1)
Domestic credit/GDP	0	-1.49744	-5.8990	1(1)	0	-3.05837	-5.8277	1(1)
Critical values								
1%	0	-3.5966	-3.6009		0	-4.1923	-4.1985	
5%	0	-2.9332	-2.9350		0	-3.5208	-3.5236	
10%	0	-2.6049	-2.6058		0	-3.1913	-3.1929	

Note: Asterisks*, ** and *** indicate 10%, 5% and 1% probability levels respectively. Variables in in natural logarithm. Table prepared by authors.

The results of the ARDL F-values with respect to oil palm fruit, palm kernel, palm kernel oil, palm kernel meal and oil palm equations connote presence of cointegration. The estimated F-value for each of the estimated equation exceed the tabulate upper critical value bound at 5% probability level. The finding implies the presence of co-integration.

Following the establishment of co-integration among series, the long run and the ECM models were generated.

Table 5. Cointegration test (ARDL Bound Test; unrestricted intercept and no trend)

Equations	**Lag**	**F-Statistic**	**Decision**
$F_{PFU}(PFU \mid INF_t, EXC_t, PER_t, CRE_t)$	ARDL(1, 2, 0, 3, 2)	3.5153	Co-integration
F_{PKE} $(PKE \mid X\ INF_t, EXC_t, PER_t, CRE_t)$	ARDL(1, 4, 4, 1, 1)	5.5479	Co-integration
$F_{PKO}(PKO \mid INF_t, EXC_t, PER_t, CRE_t)$	ARDL(1, 4, 4, 0, 4)	4.0959	Co-integration
$F_{PKM}(PKM \mid INF_t, EXC_t, PER_t, CRE_t)$	ARDL(1, 4, 4, 0, 4)	5.5123	Co-integration
$F_{PAO}(PAO \mid INF_t, EXC_t, PER_t, CRE_t)$	ARDL(1, 3, 1, 3, 0)	3.6274	Co-integration
Critical Values (at K = 4 and Asymptotic: n=1,000)			
	Lower	Upper	
10%	2.20	3.09	
5%	2.56	3.49	
2.5%	2.88	3.87	
1%	3.29	4.37	

Note: Table arranged by authors and generated from data analysis from Eview 12.

The long run determinants of the ARDL model for oil palm fruit and its derivatives

The results in Table 6, 7 and 8 present the estimates of the long run ARDL bound test generated for oil palm fruit, palm kernel, palm kernel oil, palm kernel meal and palm oil equations.

(a) Oil Palm Fruit

The long- run results for oil palm fruit equation revealed that inflation rate has a significant negative inelastic correlation with output of oil palm fruit in Nigeria. This connotes that as the inflation rate increases, the output of oil palm fruit shrinks. The possible reason for the result could be the fact that increase in inflation will trigger increase in the cost of factors of production and subsequently increase in the production cost. Farmers will intentionally cut down production following increase in production cost. The finding corroborate Hasibuan and Nurdelila [20] and Busari et al., [12].

The coefficient of the nominal exchange rate and per capita GDP exhibited a positive significant association with the oil palm fruit production in Nigeria. This implies that as these variables increase, the oil palm fruit production increases too. A unit increase in the nominal exchange rate and per capita income will result in a 0.089 unit and 0.011 unit increase in oil palm fruit production respectively.

Table 6. The ARDL long- run Coefficients for palm fruit and its derivatives

Variable	**Oil palm fruit**				**Palm kernel nut**			
	Coeff.	Std error	t-value	p-value	Coeff.	Std error	t-value	p-value
Constant	5.777	0.721	8.01***	0.000	5.320	1.668	3.190***	0.004
Inflation rate	-0.476	0.276	-1.73*	0.096	-0.315	0.121	-2.600**	0.016
Exchange rate	0.068	0.017	3.95***	0.004	0.262	0.209	1.250	0.224
GDP/capita	0.102	0.035	2.94***	0.007	-0.036	0.006	-5.737***	0.000
Domestic credit/GDP	0.563	0.113	4.98***	0.001	0.377	0.193	1.955*	0.056

Note: The asterisks: ***, **, and * indicate 1%, 5% and 1% probability level respectively. Variables are expressed in natural logarithm.

An increase in the nominal exchange rate (₦/$) means the devaluation of the Naira with respect to US dollars thereby constraining importation of oil palm products or derivatives. This policy has a tendency of boosting domestic production. Similarly increase in the per capita income will likely increases the citizen demand capacity. This in turn would stimulate domestic demand for oil palm fruit. The increase in demand would incentivize farmers to produce more. The result is in agreement with the submission of [26].

Similarly, the domestic credit has a significant stimulating impact on the production of the oil palm fruit in the country. This means that, as the domestic credit increases by a unit, the quantity of palm fruit produce increases proportionally by 0.624 unit. Nevertheless, credit is known to stimulate production at the farm level considering the fact that most farmers in the developing countries are resource-poor.

(b) Palm kernel

The long run relationship showed that inflation rate and per capita income have a significant negative relationships with the palm kernel production in the country. This means that as these variables increase, the quantity of palm kernel produce decreases. The relationship with respect to the per capita GDP could be attributed to the fact that, the palm kernel is not directly consumed by people but are demanded for by firms who use it as a raw material. On the other hand, the domestic credit has a significant positive relationship with the production of palm kernel in the country. This implies that increase in the domestic credit would upsurge palm kernel output in the country.

Table 7. The ARDL long- run Coefficients for palm fruit and its derivatives

Variable	**Palm Kernel Oil**				**Palm kernel meal**			
	Coeff.	Std error	t-value	p-value	Coeff.	Std error	t-value	p-value
Constant	3.563	1.582	2.252**	0.035	3.016	0.903	3.341***	0.003
Inflation rate	-0.143	0.044	-3.224***	0.005	-0.101	0.043	-2.353**	0.039
Exchange rate	0.474	0.251	1.885*	0.073	0.388	0.550	0.705	0.762
GDP/capita	-0.284	0.080	-3.552***	0.003	0.173	0.185	0.945	0.862
Domestic credit/GDP	-0.624	0.276	-2.260**	0.036	0.471	0.348	3.183***	0.007

Note: The asterisks: ***, **, and * indicate 1%, 5% and 1% probability level respectively. Variables are expressed in natural logarithm.

(c) Palm Kernel Oil

The long run coefficient of inflation, per capita income and the domestic credit showed negative significant relationships with the palm kernel oil production in Nigeria. For instance, a unit increase in inflation rate, the per capita GDP and domestic credit will cause about 0.143, 0.284 unit and 0.625 unit decrease in the palm kernel oil production respectively in the country. The conceivable reasons for the result is the fact that palm kernel oil is not a household consumable (neither a normal good) among Nigerians. It is mostly used by industries for secondary production and sometimes by the households for medicinal purposes as such increase in the household per capita income will not directly influence its production. Moreover, palm kernel oil is one of the secondary derivatives of oil palm fruit and so credit is mostly tight to the production of the primary product which is palm fruit instead. Another reason for the result could be the fact that the volume of credit in the economy that actually goes into agricultural sector is small and palm oil production being a tree crop is rarely considered by donors' banks for credit disbursement. This is due to its peculiar nature such as long gestation period, slow rate of returns and risks involved in its production among others. Also, increase in the rate of inflation would impose a higher cost during value addition and would likely restrain production volume. On the contrary, the slope coefficient of the exchange rate has a significant positive inelastic relationship with the palm kernel oil in the country.

Table 8. The ARDL long- run Coefficients for Palm oil

Variable	Coefficient	Standard error	t-value	p-value
Constant	3.6233	0.9472	3.8253	0.0007
Inflation rate	-0.5061	0.2765	-1.8307	0.0782
Exchange rate	0.2691	0.1166	2.3076	0.0318
GDP/capita	0.1739	0.0713	2.4382	0.0287
Domestic credit/GDP	0.4613	0.2010	2.2947	0.0426

Note: The asterisks: ***, **, and * indicate 1%, 5% and 1% probability level respectively. Variables are expressed in natural logarithm

Increase in the nominal exchange rate will impose constraints to importation and rather encourage domestic supply of palm kernel oil. The finding agrees with [26].

(d) Palm Kernel meal

The long run coefficients of inflation and domestic credit showed negative significant correlation with the palm kernel meal production in Nigeria. By implication, a 10% increase in the inflation rate and domestic credit will result to 1.01% and 4.71% decline in palm kernel meal production respectively. Similar reasons discussed above also are applied in this case. Palm kernel meal is a derivative and would not be a preferred area of credit investment among the value chains. Also, a rise in inflation rate is known to negatively impact on all stages of production. The finding agrees with [26].

(e) Palm oil

In the long run, the inflation rate has a significant negative relationship with the palm oil production in Nigeria. A unit increase in the inflation rate will decrease palm oil production by 0.506%. Increase in inflation rate causes increase in the general price level including the cost of production. This has a deteriorating effect on palm oil production in the long run. On the contrary, an increase in the nominal exchange rate relates positively to the palm oil production in the country. Besides, the per capita income and domestic credit impacted positively on palm oil production in the long run in Nigeria. Palm oil is consumed by almost all households in Nigeria. It is a normal good whose consumption or demand increases with an increase in household income. Also, palm oil production is a primary derivative from palm fruit processing with a good potential to attract credit sources due to its high demand and ability to yield persistent revenue. The finding is similar to the reports of [26], [20], [12].

The short run coefficients of ARDL model for oil palm fruit and its derivatives

The estimates presented in Table 9, 10 and 11 represent the short – run dynamics of the ARDL model for the specified equations. The ECM coefficients in each of the equation possessed the required sign and are statistically significant at the conventional level of probability.

For instance, the oil palm fruit equation has the ECM coefficient of 0.163 which shows that about 16.30% of the short-run disequilibrium in the oil palm fruit production is adjusted towards the long-run equilibrium annually.

The interpretation is also applicable to other equations (i.e. palm kernel, palm kernel oil, palm kernel meal and oil palm production). The diagnostic tests for all the ECM equations indicated structural rigidity following the non-rejection of the null hypothesis concerning the RESET tests.

The Breusch-Pagan and the normality test of residuals upheld the null hypotheses of no presence of heteroscedasticity and the normality of residuals. This justifies the used of the Ordinary Least Squares estimation method. The Durbin-Watson values for all the equations revolved around 2.00 unit mark showing minimal autocorrelation of the error terms. However, as noted by Laurenceson and Chai [21], the ECM model is shown to be robust against residual serial autocorrelation. Hence, the presence of serial autocorrelation does not affect the stability of the short run estimates. This means that, the estimated ECM models have structural rigidity, absent of heteroscedasticity, normally distributed error terms and is stable over time. The estimated cumulative sum (CUSUM) statistics derived from the recursive estimation of the ARDL ECM models denote stability in the coefficients of the ARDL ECM within the time frame. The empirical results are discussed below:

(a) Oil palm fruit

The results for the short run model for the oil palm fruit equation revealed a statistically significant negative connection between inflation rate and the production of oil palm fruit in the short run in Nigeria.

This means that in the short run, as the rate of inflation keep on rising, the production of oil palm fruit shrinks correspondingly.

The result satisfies a *priori* expectation since increase in inflation will likely snowball to increase in production cost.

Table 9. The ARDL short - run coefficients for oil palm fruit and palm kernel outputs

Variable	Oil palm fruit				Palm kernel				
	Coeff.	Std error	t-value	p-value	Variable	Coeff.	Std error	t-value	p-value
D(INF)	-0.028	0.014	-1.998*	0.056	D(INF)	-0.053	0.033	-1.615	0.120
D(INF(-1))	-0.023	0.013	-1.703*	0.100	D(INF(-1))	-0.123	0.041	-2.996***	0.007
D(PER)	-0.063	0.088	-0.716	0.479	D(INF(-2))	-0.143	0.034	-4.191***	0.000
D(PER(-1))	-0.199	0.085	-2.329**	0.027	D(INF(-3))	-0.093	0.031	-2.978***	0.007
D(PER(-2))	-0.199	0.087	-2.286**	0.030	D(EXC)	0.039	0.051	0.751	0.460
D(CRE)	0.043	0.042	1.027	0.313	D(EXC(-1))	-0.167	0.062	-2.699**	0.013
D(CRE(-1))	0.104	0.043	2.404**	0.023	D(EXC(-2))	-0.317	0.071	-4.457***	0.000
ECM(-1)	-0.163	0.033	-4.999***	0.000	D(EXC(-3))	-0.147	0.065	-2.250**	0.034
					D(PER)	-0.410	0.135	-3.036***	0.006
					D(CRE)	0.008	0.091	0.084	0.934
					ECM(-1)	-0.425	0.067	-6.366***	0.000
R-Squared		0.400983			R-Squared		0.685624		
RESET test		1.496470(0.2322)			RESET test		1.055255(0.3028)		
Breusch-Pagan test		0.391673(0.9547)			Breusch-Pagan test		0.796596(0.6703)		
Normality of residual		2.945066(0.0710)			Normality of residual		1.641720(0.2175)		
CUSUM test		-1.0929 (0.2828)			CUSUM test		-0.813185(0.4223)		
Durbin-Watson		2.160306			Durbin-Watson		2.504841		
Selected Model		ARDL(1, 2, 0, 3, 2)			Selected Model		(1, 4, 4, 1, 1)		

Note: The asterisks: ***, **, and * indicate 1%, 5% and 1% probability level respectively. Note, variables are expressed in log. Difference. ARDL lag (1, 2, 0, 3, 2) for oil palm fruit and ARDL lag (1, 4, 4, 1, 1) for palm kernel.

Since most of the oil palm fruit producers are small-scale farmers and are resource poor, an increase in inflation in the short run might induce diversification and or alternative allocation of farm resources. The result also showed that the per capita income at lag 1 and lag 2 correlate negatively with the production of oil palm fruit in the short run. The finding also revealed a significant positive relationship between domestic credit and oil palm fruit production in the short run. Busari et al., [12] has reported similar result.

(b) Palm kernel

The short run result indicates that the lags of inflation rate and exchange rate (i.e. lags 1, 2, and 3) impacted negatively on the palm kernel production. Also, the per capita GDP at level also showed a negative correlation with the palm kernel production in the short run.

(c) Palm kernel oil

The short run coefficients of the palm kernel oil equation revealed that the lags of inflation rate (i.e. lag 1, 2 and 3) relate negatively with the palm kernel oil production. This means that the rise in the previous first, second and third year inflation rate decreased the output of palm kernel oil in the current year.

Similarly, the rise in the previous first, second and third year exchange rate decline the output of the palm kernel oil in the current year. However, the relationship between the current year exchange rate and palm kernel oil was found to be positive. In the same vein, the lag 2 and lag 3 of the domestic credit exhibited a positive influence on the palm kernel oil production.

(d) Palm kernel meal

The short run coefficients of the palm kernel meal equation showed that the lags of inflation and exchange rates (i.e. lag 1, 2 and 3) has a negative correlation with the palm kernel meal production. This means that the rise in the previous first, second and third year inflation and exchange rates decrease the output of palm kernel meal in the current year. On the contrary, the level value of the exchange rate has a positive significant impact on the current value of the palm kernel meal output. In the same vein, the lag 2 and lag 3 of the domestic credit exhibited a positive influence on the palm kernel meal production.

Table 10.The ARDL short - run coefficients for oil palm kernel oil and palm kernel meal

Variable	**Palm Kernel Oil**				**Palm kernel meal**				
	Coeff.	Std error	t-value	p-value	Variable	Coeff.	Std error	t-value	p-value
D(INF)	-0.011	0.047	-0.230	0.821	D(INF)	-0.024	0.045	-0.532	0.601
D(INF(-1))	-0.107	0.049	-2.182**	0.041	D(INF(-1))	-0.079	0.046	-1.739*	0.097
D(INF(-2))	-0.159	0.050	-3.166***	0.005	D(INF(-2))	-0.128	0.046	-2.757**	0.012
D(INF(-3))	-0.121	0.045	-2.695**	0.014	D(INF(-3))	-0.101	0.042	-2.419**	0.025
D(EXC)	0.220	0.075	2.936***	0.008	D(EXC)	0.176	0.071	2.485**	0.022
D(EXC(-1))	-0.231	0.087	-2.667**	0.014	D(EXC(-1))	-0.256	0.084	-3.031***	0.006
D(EXC(-2))	-0.313	0.097	-3.228***	0.004	D(EXC(-2))	-0.352	0.093	-3.799***	0.001
D(EXC(-3))	-0.253	0.092	-2.752**	0.012	D(EXC(-3))	-0.289	0.088	-3.296***	0.003
D(CRE)	0.108	0.137	0.786	0.441	D(CRE)	0.085	0.129	0.659	0.517
D(CRE(-1))	0.113	0.131	0.857	0.401	D(CRE(-1))	0.136	0.125	1.084	0.291
D(CRE(-2))	0.346	0.135	2.566**	0.018	D(CRE(-2))	0.355	0.126	2.826***	0.010
D(CRE(-3))	0.310	0.133	2.327**	0.030	D(CRE(-3))	0.295	0.126	2.340**	0.029
ECM(-1)	-0.556	0.101	-5.516***	0.000	ECM(-1)	-0.807	0.126	-6.399***	0.000
R-Squared	0.650000				R-Squared				
RESET test	0.917913 (0.3696)				RESET test	1.046187 (0.3080)			
Breusch-Pagan test	1.426479 (0.2180)				Breusch-Pagan test	1.961986 (0.0720)			
Normality of residual	10.339(0.0056)				Normality of residual	10.3555 (0.0056)			
CUSUM test	-1.01489 (0.3053)				CUSUM test	-1.028919 (0.2839)			
Durbin-Watson	2.607100				Durbin-Watson	2.512477			
Selected Model	ARDL(1, 4, 4, 0, 4)				Selected Model	ARDL(1, 4, 4, 0, 4)			

Note: The asterisks: ***, **, and * indicate 1%, 5% and 1% probability level respectively. Note, variables are expressed in log. difference. ARDL lag (1, 4, 4, 0, 4) for palm kernel oil and ARDL lag (1, 4, 4, 0, 4) for palm kernel meal.

(e) **Oil palm**

The short run results for oil palm equation revealed that the previous years of inflation rate (i.e. lag 1 and 2) has a significant negative connection with the current year production of palm oil. On the opposing side, the per capita GDP at lag 1 and 2 and the domestic credit at level has a significant positive relationship with the output of palm oil in the short run. The finding corroborates Busari et al.,[12], Akpan and Patrick [3].

Table 11. The ARDL short - run coefficients for oil palm oil output

Variable	Coeff.	Std error	t-value	p-value
D(INF)	-0.0270	0.0164	-1.6477	0.1110
D(INF(-1))	-0.0965	0.0166	-5.8153***	0.0000
D(INF(-2))	-0.0383	0.0160	-2.3941**	0.0239
D(EXC)	0.0298	0.0287	1.0373	0.3088
D(PER)	0.0809	0.1058	0.7647	0.4511
D(PER(-1))	0.3682	0.1085	3.3935***	0.0021
D(PER(-2))	0.3405	0.1199	2.8406***	0.0085
D(CRE)	0.0631	0.0192	3.2830***	0.0092
ECM(-1)	-0.1995	0.0414	-4.8252***	0.0000
R-Squared		0.572865		
RESET test		1.083053 (0.2887)		
Breusch-Pagan test		0.588831 (0.83120)		
Normality of residual		1.6975(0.42795)		
CUSUM test		-0.9829 (0.3333)		
Durbin-Watson		2.452571		

Note: The asterisks: ***, **, and * indicate 1%, 5% and 1% probability level respectively. Note, variables are expressed in natural logarithm. ARDL lag (1, 2, 0, 3, 2) selected based on decision criteria.

CONCLUSIONS

The study has shown that the oil palm fruit and its major derivatives growth rates are insufficient to restore the leading position Nigeria had previously in the global production map. Considering the commodities production over a long time, the study has also revealed that their productions shrinks implying increasing supply deficit in the future. Given the rich value chain and the magnitude of jobs oil palm fruit and its derivative production is capable to generate; the country needs an urgent policy direction to boost production to the required level that will help to reduce poverty and unemployment. Focusing on the roles of macroeconomic variables as an alternative strategy to upsurge production in the sub-unit, the study found a significant relationship between some key macroeconomic fundamentals and the annual production of palm oil fruit, palm kernel, palm kernel oil, palm kernel meal and palm oil in both short and long run periods in Nigeria. The study confirmed the impact of inflation rate, nominal exchange rate, per capita income and domestic credit on the production of oil palm fruits and their derivatives in both short and long run periods. Based on this study, by improving the per capita income of Nigerians, an increase in the production of palm oil fruits, palm kernel oil, palm kernels, palm kernel meal and palm oil in the country can be achieved. Providing adequate credit facilities for the production of the primary product (oil palm fruit) and growing value chain are critical to increasing production in the sub sector. Furthermore, a reduced and stable inflation rate in the country is necessary and highly recommended for the survival of the sub-unit. Maintaining an appropriate exchange rate policy is also an important prerequisite for improving the production of palm oil fruits, palm kernel oil, palm kernels, palm kernel meal and palm oil in the country

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TRENDS IN ROMANIA'S TRADE WITH WALNUTS IN THE PERIOD 2010-2022

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Abstract

The paper aimed to follow the recent developments regarding the production and Romanian trade with fresh or dried walnuts in shell or shelled. Both statistical and specific indicators of international trade are used. The results indicated that Romania increased its production of walnuts and performed well in trade with shelled walnuts, and the trade balance was positive in the entire analysed period. Is not the case of the trade with walnuts in shell, where the trade balance was consistently negative. Most part of the Romanian trade with walnuts is either with EU countries or with the neighbour countries which are not EU members.

Key words: *walnuts in shell or shelled, trade, Romania, World*

INTRODUCTION

The international exports of walnuts include fresh or dried walnuts which can be also in shell or shelled. Besides their contribution to the food and wood industry, the walnut trees which have powerful root system can help against soil erosion and can limit human negative activities effects [10]. Walnuts have demonstrated health and nutritional effects and their lipid contribution and bioactive apport is essential [9]. Some research showed the role of walnuts on brain, with positive effects on learning and memory [3], while other studies underlined the role of nuts as antioxidant, or their contribution in reducing atherosclerosis risk [11]. The papers focused on economic aspects related with nuts, are focused on various topics as: developing methods of walnuts production [6], evaluating aspects from the phase of production [12] until the walnuts are delivered to export [1].
Walnut trees growing is a profitable business [13].
The evolution of walnuts trade, which is the main topic of this paper, was also considered at national level and in world context by several authors, in their countries which are specialized in walnuts production like Turkey [2], Afghanistan [8] or Iran [4].

In this context, the study aimed to analyse Romania's production and trade with raw or dehydrated walnuts in shell or shelled in the period 2010-2022.

MATERIALS AND METHODS

Within this research we analysed the evolution of the walnut's surfaces and production in Romania and its international trade with raw or dehydrated walnuts. For this study we calculated statistical indicators as: the mean, the standard deviation, the coefficient of variation, the annual growth rate, and specific trade indicators as: evolution of quantitative and value of export and import and trade balance. The data were provided of Romanian National Institute of Statistics and the main provider of trade data is International Trade Center.

RESULTS AND DISCUSSIONS

An analyse of the evolution of walnuts tress in Romania indicated that in the last decade the number of walnuts trees had a positive evolution, reaching a peak of 2.3 million walnuts trees in 2022, while the minim for this period was recorded in 2011 when Romania had only 1.8 million walnuts trees.

If we take in consideration the trend of the entire number of walnuts trees in the all number of the trees with fruits in Romania, we can see that if in 1990 the share of walnuts trees was lower than 2%, in 2022 the walnuts trees over 3% of the total number of fruits trees cultivated in Romania (Fig. 1).

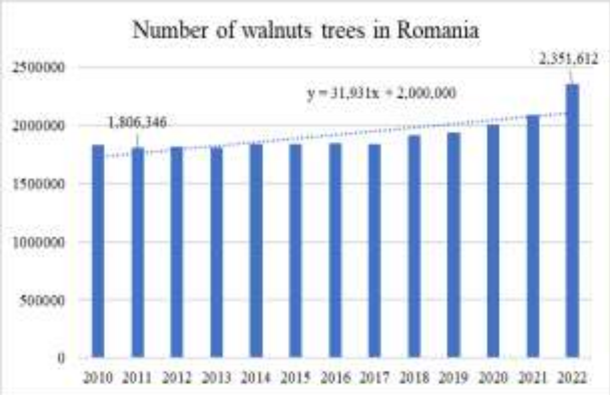

Fig. 1. Number of walnuts tree in Romania, 2010-2022
Source: NIS, 2023 [7].

The increase of the number of walnuts trees led to the increase in the same period of time, of the walnuts production from a minimum of over 30.5 thousand to in 2012 to a maxim of over 56.2 thousand to in 2022. When we analysed the evolution of the total walnuts production in the total fruits production in Romania, the results indicated that, if in 1990 the share of walnuts production was only 1.79%, in 2022 the walnuts production represented 3.72% of the total fruit production in Romania (Fig. 2). The increase of production can be related both with intern and extern increase in demand for both in shell and shelled walnuts.

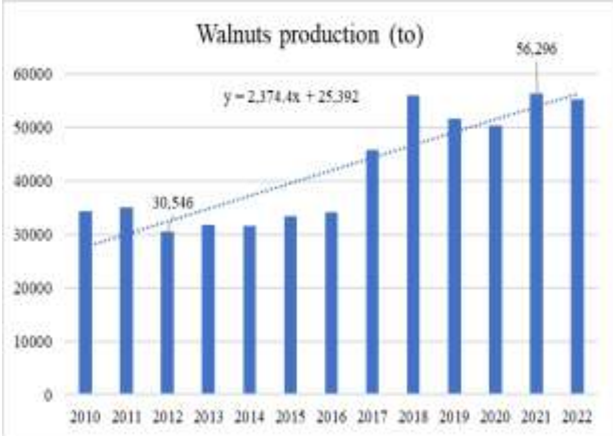

Fig. 2. Walnuts production in Romania (to)
Source: NIS, 2023 [7].

An analyse of the total exports of fresh or dried walnuts shelled in Romania, showed that Romanian imports for this product increased from 1,563 to in 2018 to 6,203 to in 2023 (Table 1). For the period 2018-2022, Romania imported in average 3,401 to of walnuts shelled. The Czech Republic was the main exporter of walnuts shelled in 2022 in Romania, followed by Ukraine and Moldova.

Table 1. Top exporters of fresh or dried walnuts shelled in Romania (to)

Crt. no.	Exporters	2018	2019	2020	2021	2022	Average	St. Dev.	Coef. of variation (%)	Annual growth rate (%)	Evolution 2022/2018 (%)
	World	1,563	2,199	2,320	4,718	6,203	3,401	1,765	0.52	41.14	396.87
1.	Czech Republic	39	15	97	1078	2053	656	804	1.23	169.36	5,264.10
2.	Ukraine	979	1,133	817	1,501	1,420	1,170	259	0.22	9.74	145.05
3.	Moldova	60	235	633	361	574	373	212	0.57	75.87	956.67
4.	Belgium	57	15	6	5	547	126	211	1.68	76.01	959.65
5.	Austria	159	102	163	518	406	270	162	0.60	26.41	255.35

Source: own calculation based on INTRACEN data base [5].

While the Czech Republic had the highest annual growth rate from the countries that exported walnuts shelled in Romania, of 169% per year, Belgium, which increased its shelled walnuts exports to Romania from 57 to in 2018 to 574 to in 2022 had the biggest coefficient of variation, of 1.68% for this period of time. We can also notice that even if Czech Republic was the main exporter of walnuts shelled in Romania in 2022, in each year of the analysed period, significant share of the walnuts shelled imports in Romania were from countries that are not part of the European Union, as Ukraine and Moldova, but the quality of neighbour of this countries, can be a significant reason for the level of imported quantities, which are brought in Romania with a low delivery cost, which compensates the customs duties between these countries. Romania imported even a small quantity of raw or dehydrated walnuts in shell between 2018 and 2022 (Table 2). In average Romania imported over 2.7 thousand to of fresh or dehydrated walnuts in the analysed period. From 2018 to 2022 the annual growth rate of imported quantities was almost 3%, but the standard deviation was high, related with the small level of imports from 2020. Belgium was the main exporter of raw or dehydrated walnuts in shell in Romania, followed by Poland and France, but only the first two mentioned countries delivered important quantities in Romania during this time. In the case of the imports of walnuts in shell we can notice that the main part of imports was from EU countries.

Table 2. Top exporters of fresh or dried walnuts in shell in Romania (to)

Crt. no.	Exporters	2018	2019	2020	2021	2022	Average	St. Dev.	Coef. of variation (%)	Annual growth rate (%)	Evolution 2022/2018 (%)
	World	3,101	2,647	715	3,589	3,489	2,708	1,050	0.39	2.99	112.51
1.	Belgium	1,265	942	461	2,440	2,761	1,574	882	0.56	21.55	218.26
2.	Poland	605	399	118	268	223	323	168	0.52	-22.08	36.86
3.	France	82	161	-	126	214	146	48	0.33	-	260.98
4.	Ukraine	50	122	10	340	113	127	114	0.90	22.61	226.00
5.	Spain	53	77	19	-	73	56	23	0.41	-	137.74

Source: own calculation based on INTRACEN data base [5].

The price per tonne of walnuts imported in Romania made some changes in the ranking of top exporters of fresh or dried walnuts shelled in Romania. In average, Romania imported walnuts shell worth 16,368 thousand Euro for the period 2018-2022 (Table 3). The annual growth rate in terms of value was lower than the annual growth rate in terms of quantities, which means that the imports prices were attractive for Romanian market, putting pressure on the domestic producers, even if the quality of the imported walnuts shelled could be a topic for the consumers, which often take in consideration only the price.

Table 3. Export value of fresh or dried walnuts shelled in Romania registered by the top exporters (thousand Euro)

Crt. no.	Exporters	2018	2019	2020	2021	2022	Average	St. Dev.	Coef. of variation (%)	Annual growth rate (%)	Evolution 2022/2018 (%)
	World	8,349	9,787	10,968	22,799	29,935	16,368	8,511	0.52	37.61	358.55
1.	Czech Republic	343	136	587	5,553	11,348	3,593	4,371	1.22	139.83	3,308.45
2.	Ukraine	4,491	4,901	3,610	6,401	5,820	5,045	982	0.19	6.70	129.59
3.	Germany	834	1,807	2,074	2,117	2,910	1,948	668	0.34	36.67	348.92
4.	Moldova	415	1,085	2,735	1,649	2,435	1,664	853	0.51	55.64	586.75
5.	Austria	1,082	424	758	3,137	2,154	1,511	999	0.66	18.78	199.08

Source: own calculation based on INTRACEN data base [5].

The top exporters regarding the value of raw or dehydrated walnuts in shell in Romania are EU countries: Belgium, Poland and France. We could notice that in the top 5 of raw or dehydrated walnuts in shell exporters in Romania between 2018 and 2022 are only countries members of the European Union. The annual growth rate of the imports of walnuts in shell was by only 2.02%. The average exports in terms of value for this period reached 4,055 thousand Euro, while the highest value was recorded in the year 2022, of over 5,2 million Euro. Belgium was the main exporter of walnuts shell in Romania, the value of the export reaching a peak of 4.3 million Euro in 2022, from a total value of 5.2 million Euro recorded in the World in that year by Romania (Table 4).

Table 4. Export value of fresh or dried walnuts in shell in Romania registered by the top exporters (thousand Euro)
Source: own calculation based on INTRACEN data base [5].

Crt. no.	Exporters	2018	2019	2020	2021	2022	Average	St. Dev.	Coef. of variation (%)	Annual growth rate (%)	2022/2018 (%)
	World	4,866	3,620	1,393	5,124	5,271	4,055	1,453	0.36	2.02	108.32
1.	Belgium	2,152	1,795	1,079	3,590	4,365	2,596	1,205	0.46	19.34	202.83
2.	Poland	437	518	86	276	269	317	150	0.47	-11.42	61.56
3.	France	124	218	-	150	243	147	85	0.58	-	195.97
4.	Spain	55	91	24	-	81	63	26	0.41	-	147.27
5.	Slovakia	-	-	43	90	76	42	37	0.89	-	-

Source: own calculation based on INTRACEN data base [5].

Romania exported in average 5,637 to of walnuts shelled between 2018 and 2022. In 2021 Romania exported the highest quantities of walnuts shelled, of over 7.1 million to. Most part of the Romanian exports went to the EU countries, mainly in Germany, Austria and France. The annual growth rate of walnuts shelled exports from Romania reached in average 11.18%, while the highest increase of walnuts shelled exports was to Austria, from 120 to in 2018 to 1,425 to in 2022, which corresponded with an annual growth rate of over 85%. From the top 5 export destinations countries, only Netherlands recorded a negative annual growth rate during the analysed period (Table 5).

Table 5. Top importers of fresh or dried walnuts shelled from Romania (to)

Crt. no.	**Importers**	**2018**	**2019**	**2020**	**2021**	**2022**	**Average**	**St. Dev**	**Coef. of variation (%)**	**Annual growth rate (%)**	**Evolution 2022/2018 (%)**
	World	4,376	4,724	5,252	7,148	6,687	5,637	1,092	0.19	11.18	152.81
1	Germany	673	384	839	1,578	1,739	1,043	526	0.50	26.79	258.40
2	Austria	120	171	395	1,138	1,425	650	532	0.82	85.63	1,187.50
3	France	765	531	1,063	1,193	871	885	231	0.26	3.30	113.86
4	Netherlands	758	1,053	922	798	681	842	131	0.16	-2.64	89.84
5	Italy	337	447	252	735	344	423	168	0.40	0.52	102.08

Source: own calculation based on INTRACEN data base [5].

The quantities of walnuts in shell exported by Romania are very low. Some exports are destined to Türkiye, which is high consumer of walnuts, due to its national food specialties (Table 6).

Romania exported raw or dehydrated walnuts shelled which worth in average 28,597 thousand Euro for the period 2018-2022. The highest value was recorded, in 2022, of 35,505 thousand Euro. Germany is the main destination of Romanian exports of raw or dehydrated walnuts shelled. In 2022, exported in Germany walnuts shelled worth 9,489 thousand Euro. The highest annual growth rate of the value of raw or dehydrated walnuts shelled exported was recorded to Austria, of 81% (Table 7).

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Table 6. Top importers of raw or dehydrated walnuts in shell from Romania (to)

Crt. no.	Importers	2018	2019	2020	2021	2022	Average	St. Dev	Coef. of variation (%)	Annual growth rate	Evolution 2022/2018 (%)
	World	192	196	79	57	78	120	61	0.50	-20.16	40.63
1	Türkiye	91	107	66	42	54	72	24	0.33	-12.23	59.34
2	Georgia	-	-	-	-	21	21	-	-	-	-
3	Germany	-	-	11	12	3	9	4	0.46	-	-
4	Belgium	-	-	-	1	1	1	-	-	-	-
5	France	-	81	-	-	-	81	-	-	-	-

Source: own calculation based on INTRACEN data base [5].

Table 7. Top importers of fresh or dried walnuts shelled from Romania (thousand Euro)

Crt. no.	Importers	2018	2019	2020	2021	2022	Average	St. Dev	Coef. of variation (%)	Annual growth rate (%)	Evolution 2022/2018 (%)
	World	24,893	22,837	25,088	34,665	35,505	28,598	5,362	0.19	9.28	142.63
1	Germany	4,077	1,691	4,038	7,447	9,489	5,348	2,766	0.52	23.52	232.74
2	Austria	737	753	1,941	5,781	7,917	3,426	2,908	0.85	81.04	1,074.22
3	France	4,248	2,436	5,008	5,555	4,592	4,368	1,060	0.24	1.97	108.10
4	Netherlands	4,630	5,318	4,220	3,844	3,626	4,328	602	0.14	-5.93	78.32
5	Slovenia	1,803	1,218	1,356	997	1,694	1,414	298	0.21	-1.55	93.95

Source: own calculation based on INTRACEN data base [5].

Table 8. Top importers of raw or dehydrated walnuts in shell from Romania (Euro)

Crt. no.	Importers	2018	2019	2020	2021	2022	Average	St. Dev	Coef. of variation (%)	Annual growth rate	Evolution 2022/2018 (%)
	World	288	163	92	138	169	170	65	0.38	-12.48	58.68
1	Türkiye	75	101	75	109	119	96	18	0.19	12.23	158.67
2	Georgia	-	-	-	-	43	43	-	-	-	-
3	Germany	-	-	13	23	5	14	7	0.54	-	-
4	Belgium	-	-	-	1	2	2	1	0.33	-	-
5	France	1	42	3	2	-	12	17	1.44	-	-

Source: own calculation based on INTRACEN data base [5].

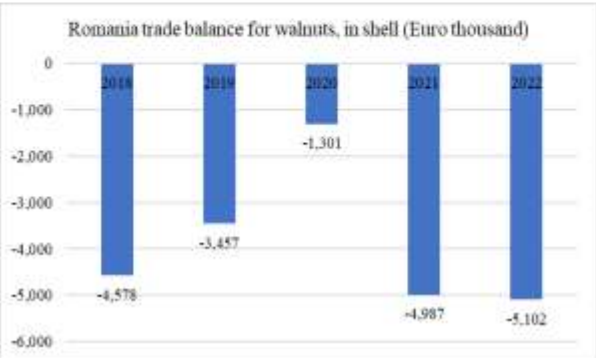

Fig. 3. Evolution of the Romanian trade balance for walnuts in shell in the period 2018-2022
Source: INTRACEN data base [5].

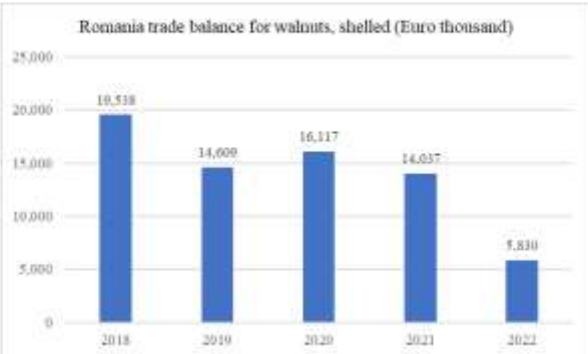

Fig. 4. Evolution of the Romanian trade balance for walnuts in shelled in the period 2018-2022
Source: INTRACEN data base [5].

The value of the exports of raw or dehydrated walnuts from Romania is very low. Most parts of the value exported by Romania is destined to countries that are not part of EU, as Türkiye and Georgia (Table 8).

The analyse of the Romanian trade balance for walnuts indicated opposite situation for the two types of exports: shell and shelled walnuts.

While the trade balance for walnuts in shell was negative for the entire period 2018 – 2022, the trade balance for walnuts shelled was positive, also for the entire analysed period (Fig. 3 and Fig. 4).
The highest deficit of the Romanian trade balance for the walnuts in shell was recorded in 2022, of over 5.1 million Euro, while the highest surplus was recorded at the beginning of the analysed period, in 2018, of 19.5 million Euro.

CONCLUSIONS

Romania is performing well in the trade with shelled walnuts, were recorded a positive balance in the entire analysed period. Is not the case of the trade with walnuts in shell, where the trade balance was consistently negative. Most part of the Romanian trade with walnuts is either with EU countries or with neighbours which are not yet part of the EU. Correlating the increase of the walnut's surfaces and production in Romania with the decrease of exports for this product, we can conclude that the intern consumption had increased during the analysed period, which a positive sign, in relation with the benefits which this product, as we mentioned in introduction, it brings to the human health insurance.

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HOW DID THE RISE IN FERTILISER USAGE IMPACT ROMANIAN TRADE IN THIS PRODUCT?

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Abstract

The paper aimed to analyse how the increase in the fertiliser usage in Romania in the last years, 2010-2022, made change in the imports value of these products. For this purpose, it was analysed first the recent evolution of fertiliser usage in Romanian agriculture, and then the impact on imports, using data provided by the European Commission and the International Trade Centre. The results of the quantitative analyse indicated that Romania is highly dependent of external markets in order to cover its internal needs for the usage of these products in agriculture. Both usage of natural and chemical fertilisers increased in the analysed period, and the poor internal production conducted to a very high annual growth rate of the imports.

Key words: *fertiliser usage, trade, Romania, European Union*

INTRODUCTION

The fertilisers play a role key in increasing agriculture productivity. Many studies were focused on determining the optimal level of fertilisers that can be used, by applying modelling computing corelated with the EU strategies in this field [3]. While some authors were focused on the doses of fertilisers that should be applied [4] others are dedicated to the effect of some types of fertilisers [12] as foliar, which brought improved yields for specific crops [2]. The necessity to know if some fertilisers have negative effects [11] conducted to complex studies that reveals different effects on soil and water. Relative with the economic impact of using fertilisers, have to be mentioned some studies that analyse the farmers reaction on fertilisers price changes [1] or the effect of fertilisers increased prices on European farmers [9]. The subject of trade with fertilisers was approached in relation with its impact on EU dependence in some key fertilisers as phosphorous [10], or in relation with the main players that controlled the world trade with fertilisers [6]. In this paper it was underlined the evolution of the Romanian demand for fertilisers in agriculture and the impact of the increased usage of fertilisers on Romanian trade in this product.

MATERIALS AND METHODS

The data provided by Romanian National Institute of Statistics were used to determine the evolution of Romanian production of different type of fertilisers, by applying statistic indicators. Both statistic and trade indicators were used in evaluating the Romanian trade with fertilisers, following the data provided by International Trade Centre. The data provided by the European Commission, through FADN Public Database were used in the comparative analyse of the average fertiliser usage at the EU and Romanian farm level.

RESULTS AND DISCUSSIONS

Romania used in 1990 over 25.8 million to of chemical and natural fertilisers, from which most part were natural fertilisers: over 24,7 million to of active substance. From 1990 to 2008 the usage of fertilisers dramatically decreased to only 13.7 million to of active substance, from which over 13.2 million to were natural fertilisers. Then the degree of usage increased again, to over 18.9 million to of active substance in 2022, from which 18.2 million to, represented natural fertilisers (Fig 1).

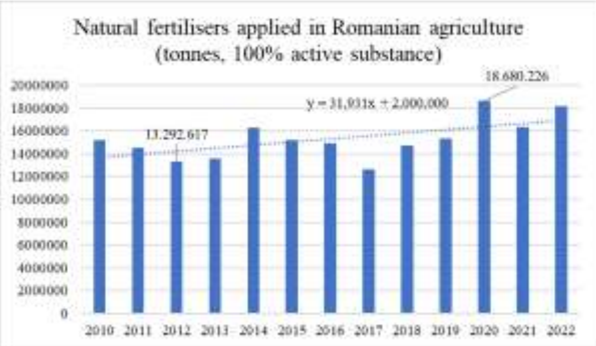

Fig. 1. Evolution of natural fertilisers applied in Romanian agricultrure between 2010 and 2022
Source: National Institute of Statistic [7].

The applied chemical fertilisers decreased from 1,1 million to of active substance in 1990 to 326 thousand to in 2002. Then the usage of chemical fertilisers started to increase yearly, up to 844 thousand to in 2022 (Fig 2).

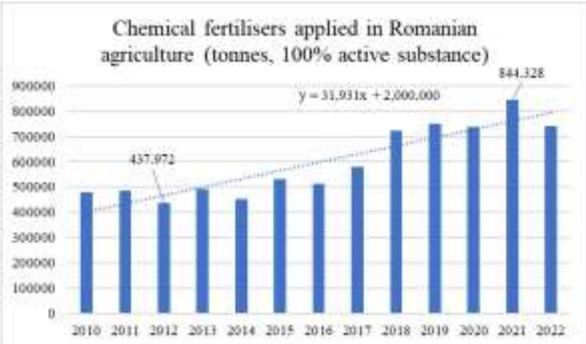

Fig. 2. Evolution of chemical fertilisers applied in Romanian agricultrure between 2010 and 2022
Source: National Institute of Statistic [7].

From the chemicals fertilisers most part of usage during this period were represented by Nitrogenous, followed by Phosphatic and Potassic (Fig 3). In 2012 from the total usage of 437 thousand to of chemical fertilisers, 66.21% were represented by nitrogenous, and 25.81% by phosphatic, both recording the highest, respectively the lowest percent of usage from the entire period 2010-2022. In 2021 the usage of nitrogenous was only 60.5% from the entire chemical fertilisers, while phosphatic was 28.1%, that represented the lowest, respective the highest percent of usage for each from the entire period (Fig 3). The usage of Potassic varied between 2010 and 2022 from a minim of 6.66 % in 2014 to a maxim percent of 12.31 % in 2019.

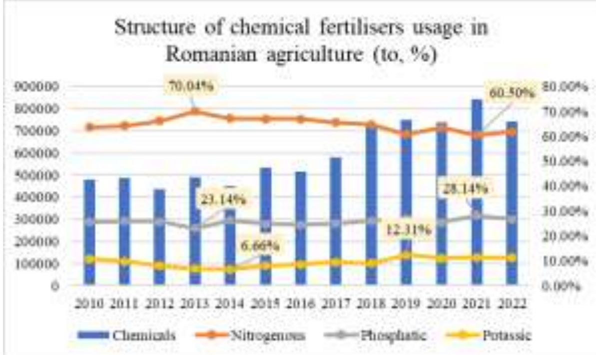

Fig. 3. Structure of chemical fertilizers applied in Romanian agricultrure between 2010 and 2022
Source: National Institute of Statistic [7].

In the crops production, at the EU level the cost of fertilisers per crop farm increased from 10.2 hundred Euro in 2019 to 15.7 hundred Euro in 2022. The fertilisers represented an important part of the total inputs cost at EU level, which also increased from 71.9 hundred Euro in 2019 to 79.5 hundred Euro in 2022 (Table 1).

In the same period of time in Romania, the cost of fertilisers per crop farm increased from 8.1 hundred Euro in 2019 to 14.7 hundred Euro in 2022 (Table 2), while the total inputs cost increased from 55.6 hundred Euro in 2019 to 71.5 hundred Euro in 2022. The cost increase can be associated both with the increase of the fertiliser quantity usage per ha and the increase of the cost of purchasing fertilizers by farmers.

Table 1. The average cost of inputs by farm in EU and particularly in Romania

Year	Average cost of inputs by farm in EU (Euro)	Average cost of inputs by farm in Romania (Euro)
2019	71,936	55,646
2020	70,823	53,203
2021	68,173	57,901
2022	79,513	71,573

Source: FADN Public Database [5].

In Romania professional press released that [13] from 11 producers of fertilisers that had a combined production of 2.5 million to of chemical fertilisers, three decades ago, only two are still active on the market, but produce expensive fertilisers due to significant increase in the recent years in the price of natural gas.

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Table 2. The average cost of fertilisers by farm in EU and particularly in Romania

Year	Average cost of fertilisers by farm in EU (Euro)	Average cost of fertilisers by farm in Romania (Euro)
2019	10,217	8,106
2020	9,943	7,823
2021	10,274	9,482
2022	15,763	14,772

Source: FADN Public Database [5].

Most part of the imports of fertilisers that get in Romania, arrived from countries that are geographically close to Romania as Bulgaria and Russian Federation. The price of the fertilisers that come from these countries are attractive for Romania market. Since the consume of methane gas is high in the producing of fertilisers, Russian Federation has a big advantage due its huge resources of methane gas which allow her to produce fertiliser at very low prices. We can notice that Romania imported most part of its fertilisers from countries that are not part of the EU. The annual growth rate of 43% between 2018 and 2022 of the imports of fertilisers in Romania (Table 3) is a result of increased demand of fertilisers on the internal market, combined with a poor offer provided by Romanian producers of fertilisers. Romania is a net importer of fertilisers and only a small part of its internal production go the neighbour countries. While Bulgaria is the main exporter of fertilisers in Romania, Hungary is the main importer. Even in the case of exports, Romania recorded a positive annual growth rate of 16.37% for the period 2018-2022.

Table 3 Top exporters of fertilisers in Romania (thousand Euro)

No. crt	Exporters	2018	2019	2020	2021	2022	Average	St. Dev.	Coef. of variation (%)	Annual growth rate (%)	2022/2018 (%)
	World	484,897	610,013	490,588	906,585	2,050,864	908,589	591,301	0.65	43.41	422.95
1.	Bulgaria	102,393	126,856	87,478	129,898	264,617	142,248	63,169	0.44	26.79	258.43
2.	Russian Federation	47,252	84,049	49,592	84,314	246,840	102,409	73,969	0.72	51.18	522.39
3.	Türkiye	14,772	7,751	10,988	48,665	204,226	57,280	74,927	1.31	92.83	1,382.52
4.	Egypt	18,946	25,321	14,930	63,977	187,431	62,121	65,041	1.05	77.35	989.29
5.	Georgia	6,045	10,451	12,234	54,163	183,745	53,328	67,486	1.27	134.80	3,039.62

Source: own calculation based on INTRACEN data base [8].

Table 4. Top importers of fertilisers from Romania (thousand Euro)

No. crt	Exporters	2018	2019	2020	2021	2022	Average	St. Dev.	Coef. of variation (%)	Annual growth rate (%)	Evolution 2022/2018 (%)
	World	124,809	141,637	168,485	148,819	228,861	162,522	36,007	0.22	16.37	183.37
1.	Hungary	29,623	38,797	30,329	37,577	97,717	46,809	25,722	0.55	34.77	329.87
2.	Bulgaria	15,762	27,450	17,988	35,311	48,116	28,925	11,867	0.41	32.18	305.27
3.	Republic of Moldova	4,614	5,732	5,777	9,480	19,375	8,996	5,444	0.61	43.15	419.92
4.	Croatia	496	7,869	1,546	3,560	14,782	5,651	5,217	0.92	133.65	2,980.24
5.	Ukraine	3,691	11,546	6,052	5,076	13,124	7,898	3,733	0.47	37.32	355.57

Source: own calculation based on INTRACEN data base [8]

While Georgia started to be an important exporter of fertilisers on Romanian market, with an annual growth rate of 134.8%, in the case of the exports the small exported quantities cannot lead to significant conclusions, excepting the idea that Romanian exports are focused to neighbour countries. Türkiye, with an annual growth rate of export of fertilisers in Romania of 92.83% for the period 2018-2022 and Egypt with an annual growth rate of export of fertilisers in Romania of 77.35% can increase their share of exports of fertilisers on Romanian market in the next years, since the imports from the Russian Federation are banned now in the EU and not too many other options are available for Romania, due to high delivery freight cost from countries situated at long distances from our country.

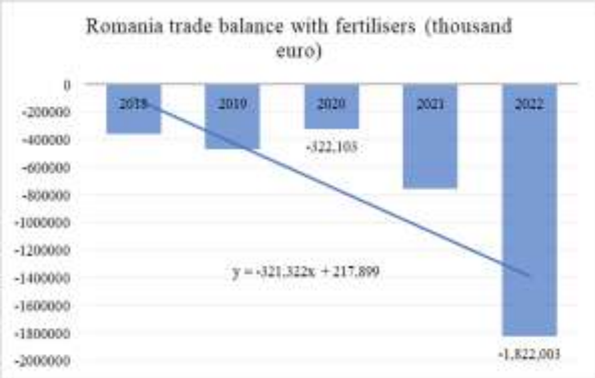

Fig. 4. Romania trade balance with fertilisers (thousand euro)
Source: INTRACEN data base [8]

The deficit of the Romanian trade balance for the fertilisers increased between 2018 and 2022 from a minim of 322,103 Euro deficit in 2020 to a record of 1,822,003 Euro deficit in 2022 (Figure 4).

CONCLUSIONS

Romania has an internal usage of fertilisers that cannot be cover in the next years by the internal production. The constantly increase of fertilisers imports conducted to a high deficit of Romanian trade balance with these products. The usage of fertilisers in Romania increased within the analysed period, and the necessity of finding replacement of the imports from the Russian Federation will be high in the next years. The internal production is affected by the cost of methane gas, and has few options to recover in the next period of time. The replacement of chemical fertilisers with natural fertilisers can be a solution, but should be correlated with the existing situation in the animal sector, which is not also very favourable. Romania is obliged to increase its imports of fertilisers from countries that are not part of the EU, and the customs duties should be analysed, and negotiated at the EU level, since Romania is not the only affect country by the existing tensions on the World fertiliser market.

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ANALYSIS OF THE SUPPLY OF THE NUMBER OF CATTLE HEADS IN THE PRODUCTION OF BEEF IN THE REPUBLIC OF SERBIA

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Abstract

From a global point of view, the Republic of Serbia has favorable conditions for cattle breeding and beef production, because there are favorable soil and climatic conditions, high production of roughage and fodder, available workforce, installed capacities of meat processing industries (for the production of beef and meat products) etc.. However, it is not the only, or exclusive, parameter of the development of cattle production, because there are significant differences in the racial composition and production potential of cattle in certain production districts of the Republic of Serbia. The paper shows the period of the movement of the number of cattle, as one of the potentials for the production of beef, and the heifers that provide new heads for fattening. In the observed time period from 2012 to 2022, it is in permanent decline. According to the obtained data of the calculated value of base and chain indices for the observed time period of ten years, there is no hint of stabilization of breeding and increase in the number of cattle for slaughter. The average number of cattle in the Republic of Serbia was 898 thousand head with a tendency to decrease from 2.5% to 3.0%. At the end of 2022, the estimate of slaughter outside slaughterhouses in December was reduced to 16 thousand heads, however, the number of slaughtered heads increased from May and reached its maximum in October with 20.61 thousand heads and in November when there were 26.45 thousand heads. From this data, it can be seen that the total number of heads has been decreasing since December, which means that there has been stagnation in the number of slaughtered heads.

Key words**:** *beef, number of cattle, beef production, supply analysis*

INTRODUCTION

Livestock farming represents one of the most important branches of agricultural production and is of great importance for breeders, producers and consumers. According to Stevanović et al. [18] the driving force behind the development of agriculture is precisely animal husbandry. The increase in livestock production is the basis for improving nutrition with high-value animal products necessary for the population. Meat is an irreplaceable component in a proper and well-balanced human diet [4]. Beef meat is particularly important due to its exceptional nutritional value, high biological value and content of minerals and vitamins necessary and important for human nutrition (B complex vitamins, minerals magnesium, zinc, potassium and phosphorus, but also proteins and fats), [5]. Also, meat is an important export product, which is why highly developed countries pay special attention to the development of livestock production with various incentive measures of agrarian policy, placing livestock in a dominant place in the structure of total agricultural production [2].

The Republic of Serbia has favorable agroecological conditions for cattle production and high and stable meat production [7]. Despite this fact, in the Serbian livestock industry, a way to increase and stabilize production is constantly being sought [12], because in the last 10 years of the 20^{th} century, the livestock industry in Serbia almost halved due to the decrease in the number of animals and the total production of all types of meat. According to Sredojević et al., [16], the number of cattle in Serbia has decreased to the level of the beginning of the 20th century.

Meat production is conditioned by genetic factors and the action of a complex of exogenous factors, primarily of an ecological and economic nature. Meat plays an important role in nutrition, as it provides energy and protein value. The long-term improvement of meat production implies the timely adoption of appropriate macroeconomic measures in order to increase production and stabilize the domestic market and increase exports. The awareness of producers in the livestock industry must rely on market demand and gradually introduce breeds that give a larger amount of meat into their herds. The following racial composition is represented in Serbia: 60% of the Simmental breed and the combined type, 35% of mixed breeds (Hereford, Limousin, Charolais) and 5% of the Holstein-Friesian breed.

Beef production is based mostly on domestic colored beef in the Simmental type (56.6%) and Simmental (25.3%), and to a lesser extent on cattle of the Holstein-Friesian breed (6.5%) and other breeds and crossbreeds (17.8%). A positive fact is that a large population of the Simmental breed of cattle has been preserved, which ranks well in terms of production characteristics, so it is to be expected that in the future beef producers in the Republic of Serbia could once again find a significant place and position in the European and other traditional markets previously had [2].

MATERIALS AND METHODS

In the article for the review and calculation of the structure, tendency and realized values of the effects of the work, the existing statistical material in our country was used, namely: data from the Statistics Office the Republic of Serbia for the observed period, the library of the Institute for Agricultural Economics, its own scientific research activity and other scientific material. Given the character of the topic, content and structure, the formation of the database and the processing of individual indicators were carried out using appropriate computer programs.

The cause-and-effect interdependence of phenomena will be determined by relational-regression analysis.

The balance method, structural changes in production will be used to determine the surplus and deficit of certain agricultural and food commodities, specifically veal and june meat, which is the subject of the paper. The obtained results will be tabulated and analyzed in time periods.

RESULTS AND DISCUSSIONS

According to Table 1, the largest number of cattle is represented in the region of South Serbia with an average of about 600 thousand cattle, which is 66% of the total cross-section of Serbia, and in the observed period it shows a tendency to decrease. The north of Serbia has a smaller number of cattle, 246 thousand, but in the observed period it recorded a slight increase at a rate of 0.69% per year, which is a consequence of the emergence of more organized farming units than in other areas of the Republic of Serbia and attempts to harmonize the potential of cattle production and installed processing capacities .

Data about the total number of cattle in the Republic of Serbia, for the period from 2012 to 2022 [17] are given in Table 1. Also, the calculated values of base and chain indices are given.

Table 1. Movement of the number of cattle in the Republic of Serbia and calculation of the base and chain index (thousands).

Republic of Serbia - total				North Serbia			South Serbia		
Year	Cattle	Base index	Chain index	Cattle	Base index	Chain index	Cattle	Base index	Chain index
2012	921	–	–	307	–	–	614	–	–
2013	913	99.1	99.1	306	99.7	99.7	607	98.8	98.8
2014	920	99.9	99.9	323	105.2	105.5	597	97.2	98.3
2015	916	99.5	99.6	306	99.6	94.7	610	99.3	102.2
2016	893	97.0	97.5	299	97.4	97.7	594	96.7	97.4
2017	899	97.6	100.6	307	100.0	102.6	591	96.2	99.5
2018	878	97.6	97.6	305	99.4	99.5	573	97.0	96.9
2019	898	97.5	102.3	310	100.9	101.6	588	95.7	102.6
2020	886	96.2	98.6	306	99.7	98.7	580	94.5	98.6
2021	860	93.4	97.0	303	98.7	99.0	556	90.5	95.8
Avrg.	898	2,5	–	246	–	–	591	96.2	–

Source: RZS Statistical yearbooks from 2012 to 2021, Belgrade and author's calculation.

The calculated coefficients show cyclicity in the number of cattle as well as a decreasing trend of cattle for the observed period, and there is no hint of stabilization of breeding and an increase in the number of cattle for slaughter.

The movement of the number of heads of cattle is subject to cyclical movements, which are also called "cattle cycles". These cycles in the world last five to six years on average. Almost no country is immune to this phenomenon. They are felt by producers and consumers over a longer period of time. In countries with a significant production of beef, such phenomena bring great difficulties to the entire cattle industry. This is especially true for those countries that export this type of meat. Since cattle production is also important for other branches of production, especially the meat processing industry, the leather industry, etc. such depressions lead to great difficulties in that activity.

Cattle breeding in the Republic of Serbia is organized through two types of production: agricultural enterprises and family households. Thus, it is possible to perform an analysis of the total number of cattle in the observed period that are located in agricultural enterprises and family households.

The production of beef in the Republic of Serbia is shown in Table 2, where a decline in production can be seen in the observed period. The biggest drop was recorded in 2013 compared to the base year 2012, by as much as 14.6%. However, there is a slight increase or stagnation of production in the other observed years as well [3].

Table 2. Production of beef in the Republic of Serbia and calculation of the base and chain index, in thousands of tons

Republic of Serbia				
Year	Beef	Base indices	Chain indexes	Meat consumption/ inhabitant
2012	82	Base year	–	11.4
2013	70	85.4	85.4	9.7
2014	73	89.0	104.3	10.2
2015	77	93.9	105.5	10.7
2016	77	93.9	100.0	10.7
2017	71	92.7	92.2	9.9
2018	76	86.6	107.0	10.6
2019	71	92.7	93.4	9.9
2020	75	91.5	105.6	10.5
2021	75	91.5	100.0	10.5
Average	75	90,8	99,3	10,4

Source: Author's calculation based on statistical data from statistical yearbooks for the analyzed period, RZS, Belgrade.

Both in the number of cattle and in the production of beef, there is cyclicality and there is no hint of stabilization or increase of beef in the Republic of Serbia. Such cycles negatively affect the quality of cattle breeding. Small farms are the most vulnerable, which in the period of contraction completely abandon production, and in the period of expansion, they include cows of untested quality in breeding. In order to achieve production growth, it is necessary to build a set of anti-cyclical measures and instruments, in order to mitigate the cycles that are inherent in livestock production. Primarily, we are referring to regulatory - intervention measures on the market, which would be calculated to eliminate market disturbances. The primary prerequisite is reserves, both of animal products and animal feed.

Number of cattle for slaughter in family households

Family households are by far the largest breeders of cattle for slaughter, but unfortunately this sector recorded a decline in the observed period at an annual rate of 1.30%, which especially applies to central Serbia. One of the reasons for this decrease in the number of cattle is that agricultural companies adapt to unfavorable economic conditions by reducing livestock, while family households in these conditions produce more naturally, for their own needs, by extending production cycles, which adversely affects the quality achieved. meat. The largest number of cattle is located in the territory of South Serbia (Central Serbia) with 68.0%, while 32.0% is located in the territory of Northern Serbia (Vojvodina).

According to the 2012 Census of Agriculture [15], there are a total of 908,000 head of cattle in 177,252 agricultural holdings. About 50% of farms have 1-2 head of cattle, 40.0% of farms have 3-9 head of cattle, the share of all other farms is 10% with 10 or more head of cattle. Small share in the total number of farms are those farms that have a little more than 30 heads and participate with 1.6% [14].

Nastić [11] states in his dissertation that in the region of Serbia-North there is a greater number of farms engaged in cattle production compared to the Republic of Serbia, namely 42.2% of farms with 3-9 head, while the share of farms from 1-2 heads of only 32.1%. However, the share of farms with a larger number of heads (about 30 heads) compared to the level of the Republic of Serbia has a significantly higher share, which amounts to 6.0%. The analysis determined that the largest number of farms engaged in cattle production is in the area of Serbia-South, which is 84.5% of the total number of farms in Serbia. Farms with 1-2 heads are the most numerous and amount to 53.2%, while farms with 3-9 heads amount to 39.6%, and compared to the Republic of Serbia and the region of Serbia-North, farms with more than 30 heads have a smaller share of everything 0.8%.

In the Region of Western Serbia and Šumadija, according to the number of head of cattle per 1 ha of used agricultural land, there are 0.41 head/ha, and the lowest number of head in the Region of Vojvodina is 0.15 head per hectare of land. With over two years of age, there are an average of 491,000 cattle, which make up 54.5% of the total number of cattle. Heads of cattle between one and two years of age have a tendency to decline, and precisely those heads represent the potential for beef production in the country [8]. The average number of heads in family households in central Serbia accounts for more than 4/5 of the total number of heads in the structure.

Advantages in family households are reflected in the following:

- In family households, investment per product unit (calves, steers, tons of live mass for slaughter or beef) are several times lower than in the social sector. It should be added that with individual producers, any existing building, regardless of what it was used for before, can be equipped for modern cattle production with very little investment;
- Smaller farms more easily solve the problems of location, infrastructure, removal and use of manure, pollution of the human environment and nature in general;
- The possibility of greater employment of people in the countryside, which would increase the income of the agricultural population, etc.

Since family households are responsible for the production of cattle for slaughter, it is necessary to pay special attention to their lending, so that it goes in the direction of improving the racial composition, then obtaining financial resources faster based on the delivery of cattle to the meat processing industry, the price of cattle for slaughter, etc.

The relationship between the price of feed and the price of cattle for slaughter is a very significant moment for the breeding of cattle for slaughter, because the price of cattle for slaughter - on the income side and the price of feed - on the side of expenditure, i.e. costs, have a dominant influence on the realization of the financial result of production [1]. Subsidies awarded by the Ministry of Agriculture, Forestry and Water Management per fattened head have a significant share in the formation of income (12.3%) [6].

In the developed countries of the world, and especially in the European Union, rural households (farmers) are given strong support for their survival and development, primarily for production and economic reasons, but also for demographic, social and political reasons [10].

Number of cattle for slaughter in agricultural enterprises

In all areas of the Republic of Serbia, the number of cattle in agricultural enterprises has a decreasing trend. It is characteristic for these producers that they have a trend of decreasing the number of head in breeding at a rate of over 4.0%, which has a direct consequence of reducing production, that is, supply. Considering that all production from these companies is directed to the meat processing industry, this results in a reduced number of slaughtered heads and a lower percentage of capacity utilization, which is reflected in higher costs per unit of production.

It is noticeable that in the same economic conditions, family households have a smaller decline than agricultural enterprises, which indicates the reason that family households are small market producers who primarily produce for their own needs and individual sales, which is why they are less affected by changes in the market, while agricultural enterprises are more difficult to bear crisis strikes.

According to Table 3, we can see that the lowest number of slaughtered cattle was in 2012 (143 thousand head), while every subsequent year there is an increase in the number of slaughtered cattle.

Table 3. Cattle slaughtered in slaughterhouses for the period from 2012 to 2022.

Year	Number, thousand throats	Base index	Chain index
2012	143	Base year	–
2013	147	2.8	2.8
2014	151	5.6	+ 2.7
2015	162	13.3	+ 7.3
2016	170	18.9	+ 4.9
2017	178	24.5	+ 4.7
2018	173	21.0	-2.7
2019	173	21.0	-
2020	172	20.3	-0.6
2021	181	26.6	+5.3
2022	164	14.7	-9.9

Source: Search of the desemination database, Republic office of statistic of the Republic of Serbia.

Compared to 2012 (the base year), an increase in the number of slaughtered heads can be observed, so that the largest increase in 2017 was by 24.5% and in 2021 by 26.6%, when there was also the largest increase in the number of slaughtered heads. If we look at the percentage of increase in 2021, compared to 2020, more cattle were slaughtered by 5.3%. According to the chain calculation, it can also be observed that every year there is an increase of 3.0% to 5.0%, while the largest was in 2015 of 7.3% compared to the previous year 2014. However, in 2022, compared to 2021, we have about 10% (9.9%) fewer slaughtered cattle, which means that the stock of cattle and thus the cattle offered for slaughter has decreased. In our country, the supply of fattened beef is decreasing, because many farmers gave up this business due to low prices and expensive plant nutrients, so they did not see the possibility of making money, as well as covering production costs with a premium of 15,000 dinars per delivered beef to a slaughterhouse or exporter [13].

The production of cattle for slaughter is an essential condition for obtaining stable meat production and depends on the influence of a whole series of factors such as the production of coarse and concentrated feed. The price parity between beef and milk is also extremely important, because it depends on whether cattle producers will focus more on the meat or milk production line. Cattle breeding and meat production are influenced by the production of breeding material, as well as the average weight of the head at slaughter and the slaughter structure [19]. The basis of production is the demand on the domestic market, i.e. supply, the degree of connection of all participants in the repro-chain of production from producers of animal feed, reproductive material, through cattle breeders, meat processing industry and the like.

Meat production in 2021 was an average of 75 tons, while Serbia used to be a traditional exporter of beef, i.e. baby beef, meat products and fattening beef in many even the most developed countries. Today, there are several slaughterhouses with an EU certificate, and the approved quota of 8,000 tons for the export of meat and beef cannot be realized. Therefore, cattle production is expected to provide quality products for export, especially beef of defined origin and quality [9].

In order for production to be as good as possible, better state support is needed in incentive measures such as: rebates, premiums, loans and beneficial interest, then in systemic measures that include prices, foreign exchange policy and the reserve mechanism, support in protective measures is also important. measures that include tax policy, customs measures and levies, as well as development measures that include scientific and research work and professional and advisory services. The implementation of all measures will significantly contribute to the overall development of beef production. Therefore, in the following period of development of cattle breeding, the basic subject should be peasant farms united in cooperatives and individual companies intensively engaged in the production of beef.

CONCLUSIONS

The paper provides an analysis of the total number of cattle and production of beef (beef and veal) for the period from 2012 to 2022 in the Republic of Serbia. According to the data issued by RO of statistic of the Republic of Serbia, the current situation in cattle breeding is considered very unfavorable.

The results and analysis according to the base and chain indexs, for the observed period, showed that there is a certain cyclicality in the number of cattle and beef production and that there is no hint of stabilization and increase in beef production in the Republic of Serbia.

The results and analysis according to the base and chain indices, for the observed period, showed that there is certain cyclicality in the number of cattle and beef production and that there is no hint of stabilization and increase in beef production in the Republic of Serbia.

Based on the analysis of the current state of the number of cattle for beef production, the obtained results should draw attention to the elements that are important for increasing domestic production, perspectives and possible destinations for export.

It is necessary to stop the negative trend in livestock production with appropriate measures, first of all, macroeconomic policies, in order to fully satisfy the domestic market and create the necessary market surpluses for export. In order to revive animal husbandry, it is necessary to provide financial resources for the stimulation of this production, which will serve as a function of the overall agricultural development.

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NAVIGATING DIGITAL FRONTIER: FACTORS INFLUENCING SUPPLY AND DEMAND OF FRESH MILK IN PAKISTAN

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Abstract

Understanding market forces that shape up supply and demand of fresh milk. This research study is essential for smooth milk production and its consumption particularly in case of emerging economies. Therefore, this study analyzes those factors that influence the market forces: consumption and production of fresh milk in Faisalabad, Pakistan. To achieve the objective, we used multiple linear regression technique to determine the effect of determinants influencing production and consumption. Results of this research article revealed that the fresh milk demand was positively influenced by consumer's educational background, fresh milk price, consumer income, family size, and family expenditures along with use of ICTs. Our study also depicted that the fresh milk production was influenced by factors such as credit facility, the strength of milking animals, sale price, concentrate value, farming experience, labor costs, fodder value, and ICTs. The study concluded that any intervention that aimed at smooth milk production and consumption should facilitate consumers and producers' access to ICTs, reduce prices of fresh milk and provide access to credit. Furthermore, while devising policies, the government should focus more on consumers with large family sizes and illiterate households to overcome the problem of food security.

Key words: *market forces, ICTs, milking animals, emerging economies, food security*

INTRODUCTION

Pakistan is an agrarian country where agriculture plays a significant role in the economy. The livestock sub-sector is the largest contributor to the agricultural sector, accounting for 55.1 percent of the total contribution. Livestock in Pakistan primarily includes buffaloes, goats, and cows, which provide various products such as milk, hides, and other raw materials [37; 46].

Milk is the most important product of Pakistan's economy as it is the third-largest milk-producing country in the world. Over 10 billion farm families in Pakistan produces nearly 40 billion liters of milk annually, equating to 11.3% of total GDP production. Despite this, the production of milk is not to the level of Pakistan's actual potential which is US$5.64bn in 2023. According to CAGR 2023-2028, this market is projected to raise by 6.50% per annum [41]. Local businesses deliver nearly 80% of the milk, while urban one's form only 20% of the milk-producing sector.

The key limitation in Pakistan's milk production is the uneven milk distribution in rural and urban regions due to the non-existence of organized dairy farming [44; 45]. It is estimated that nearly 3% of the milk is supplied with the help of an organized channel, whereas 97 % continues to be distributed through traditional distribution channels involving middlemen [40].

The 'Katcha dodhies' use to gather milk from rural regions and sell it to domestic businesses or 'pakka dodhies.' The 'pakka dodhies' then distribute milk to retailers, dairy processors, and merchants in urban cities. The 'glass specifically supply milk to the countryside and urban regions. In Pakistan, such milk distribution and production strategy desperately need a makeover, since, nearly 15-19% of the marketed milk is wasted due to an ineffective cold chain storage systems and supply facilities [36]. Moreover, per capita milk utilization in Pakistan is imperfect due to a mismatch between the vested interests of milk production and supply [38; 23].

Dairy products are an essential part of the Pakistani diet, and milk is considered a major dairy product. Milk offers numerous long-lasting benefits, including promoting bone health, reducing the risk of cardiovascular and blood pressure diseases, aiding in weight management by combating obesity, and being effective against type 2 diabetes, cancer, and dehydration [42; 17; 47]. The consumption of dairy products, including milk, meat, and eggs, is widespread in Pakistan and plays a crucial role in meeting nutritional needs and maintaining a balanced diet for people of Pakistan.

Furthermore, the milk production levels are substantially affected by diverse interests during low production time. Low milk yield may be the result of multiple factors, including poor administration. Several scholars [19; 18; 7; 4; 15; 16] have provided an insight on the reasons that affect production and consumption of livestock and agricultural merchandises, generally.

However, limited researches [18; 20; 3; 48] has solely been conducted on the milk sector. Critical factors such as mulching animal's number, i.e., source of milk supply, price of milk produced and a product substitute have been unclear considered. Also, not enough studies have been conducted to understand the supply and demand for milk in Pakistan.

Literature review

Dairy and Livestock Production in Rural Areas of Pakistan is Segregated. Small-holder subsistence (1-5 animals), small-holder market oriented (5-15 animals), and rural commercial with more than 50 animals (typically 90% buffaloes & 10% cows) are the three dairy and livestock production systems commonly employed in rural areas [35;11].

Farming families drink milk and sell excess milk to other consumers, i.e. milk left over after household consumption. In the animal herd, male and female calves typically nurse the dams and are held during the lactation phase. Male calves with the best breed qualities are traditionally preserved for breeding, while other male calves are slaughtered and considered for beef production. Because the sector is un-organised and dispersed, it is difficult for farmers to receive technical help and business development services connected to enhanced livestock production [35].

The increase in milk production in Pakistan in recent years is primarily attributed to an increase in the total number of animals rather than improvements in productivity per animal. There are several reasons for the lower productivity levels [1].

Consumers, now a days, especially in big cities of Pakistan are ready to pay more for pasture-raised milk than for conventional milk, suggesting a trend towards goods with additional benefits exceeding organic and fresh milk [19]. At this point, there's currently no in-depth understanding of the mindsets that lead to this behavior. For marketing, the main purpose is to successfully contact consumers. But it is critical to understand their values, psychology and motivations [42; 29].

Greater consumer knowledge about the environment, livestock welfare, and human health impacts traditional and unconventional dairy production systems. It may influenced consumer attitudes and motivated them to choose pasture-raised milk products. A possible technique for increasing milk sales is to enhance consumer interest in production systems and their desire to understand more about the source of their food and its effect on environment they belong to [10; 2; 20; 39].

Purchase patterns are beneficial in analyzing customer behavior. Customers are typically devoted to the most easily accessible locations that meet their food and milk needs. Furthermore, multiple categories of consumers can be reached at the same location. As a result, marketing efforts for milk related products should be customized to the mood of the retail location while conveying a message broad enough to reach the majority of buyers [12; 10;14].

The food market is changing around globally, specifically in developing nations. This variation improves consumer`s quality of life, which influences lifestyle evolution and global consumption trends. It is significant to discover a link among environmental factors and personal factors that determine milk consumption. Therefore, dairy companies have useful solutions and strategic plans to grow their business digitally [30; 28].

More than 6 billion milk and dairy products consumer`s live in developing countries. Therefore, milk production must increase by about 22% every year, if we want to sustain demand. An estimated 150 million households are involved in milk production, universally. Small farmers lived in most developing countries produce milk which result in contributing food security, nutrition and domestic income. For small producers, Milk generates swift revenue comparatively. Hence, result in an imperative cash flow. In last thirty years, Global milk production has grown up by 50% or more. It is on record that in 1983 milk production increase from 500 million tons to 769 million tons in 2013 [13; 26; 31]. "

The purpose of the paper

In this context, this study aims to understand factors related to the production and consumption of milk in Pakistan, which will help devise policies to reform the demand and supply framework in the future. This study can be seen as a good standpoint to begin research in the region and contribute strategies to enhance milk production and distribution in Pakistan.

MATERIALS AND METHODS

The current study is based on data collected by concluded a pretested survey that involve 100 dairy farmers and 100 customers of dairy from Tehsil Faisalabad. A convenient sampling method was used to collect samples. Survey for checking Demand was accompanied in rural, semi-urban and peri-urban areas of Lyallpur and Madina Town. The supply survey was conducted in rural, semi-urban and peri-urban since livestock rearing is restricted in urban regions. Statistical double log regression analysis was deployed to understand key factors influencing new milk demand and supply.

The relationship between dependent and independent variables is given as:

$$Y = f(X_i, D_k) \;\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

where:

Y = Quantity consumed of fresh milk (kg/month)

Xi = Vector of quantitative variables i = 6

Dk = Vector of qualitative variables k = 1

In a more specific form, equation 1 can be written as:

$$Y = \beta o \, X_i^{\beta i} \, D_j^{\beta k} e^{\mu} \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

The equation 2 can be further explained as:

$$Y = \beta o \, X_1^{\beta 1} X_2^{\beta 2} X_3^{\beta 3} X_4^{\beta 4} X_5^{\beta 5} X_6^{\beta 6} D_1^{\beta 7} e^{\mu} \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

By taking natural log on both sides, equation 3 can be written as:

$$\ln Y = \beta o + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + \beta_6 \ln X_6 + \beta_7 D_1 + \mu \ldots\ldots\ldots(4)$$

where:

Xs are the independent variables in which,

X_1= Number of family members/family size (Persons)

X_2 = Purchase price of milk (Rs. /kg)

X_3= Monthly household income (Rs.)

X_4 = Education of the family head (Years of schooling)

X_5 = Age of the family head (Years)

X_6 = Monthly expenditure on food (Rs.)

D_1 = Dummy variable (ICTs)

D_1=1, if the consumer was employing ICTs

D_1=0, if otherwise

βo is the intercept, βs are the elasticity's and μ is the random error

ln = Natural log.

On the other hand, the relationship between dependent and independent variables is given as:

$$W = f(Z_i, D_j) \;\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

where:

W = Quantity of milk produced (Kgs/month)

Zi = Vector of quantitative variables i = 6

Dj = Vector of qualitative variables j = 2

In a more specific form, equation 5 can be written as:

$$W = \beta o\ Zi^{\beta i}\ Dj^{\beta j}\ e^{\mu} \ldots\ldots\ldots\ldots \quad (6)$$

The equation 6 can be further explained as:

$$W = \beta o\ Z_1^{\beta 1}\ Z_2^{\beta 2}\ Z_3^{\beta 3}\ Z_4^{\beta 4}\ Z_5^{\beta 5} Z_6^{\beta 6}\ D_1^{\beta 7}\ D_2^{\beta 8}\ e^{\mu} \ldots\ldots\ldots\ldots \quad (7)$$

By taking natural log on both sides, equation 7 can be written as:

$$\ln W = \beta o + \beta_1 \ln Z_1 + \beta_2 \ln Z_2 + \beta_3 \ln Z_3 + \beta_4 \ln Z_4 + \beta_5 \ln Z_5 + +\beta_6 \ln Z_7 + \beta_7 D_1 + \beta_8 D_2 + \mu \ldots\ldots\ldots\ldots \quad (8)$$

where:
Zs are the independent variables in which,
Z_1= Number of mulch animals (No.)
Z_2 = Farming experience (Years)
Z_3= Value of fodder consumed by farm animals in a month (Rs.)
Z_4= Value of concentrates consumed by farm animals in a month (Rs.)
Z_5 = Monthly expenditures on labour (Rs.)
Z_6 = Sale price of fresh milk (Rs. /kg)
D_1 = Dummy variable (Credit)
D_1=1, if the farmer was availing credit facility
D_1=0, if otherwise
D_2 = Dummy variable (ICTs)
D_2=1, if the farmer was employing ICTs
D_2=0, if otherwise
βo is the intercept, βs are the elasticities, and μ is the random error
ln = Natural log

RESULTS AND DISCUSSIONS

Fresh Milk Demand Function

The dependent variable is fresh milk consumption while the independent variables for this research article includes price paid for fresh milk, the number of family members, income of participant family, education, ICTs, age and monthly food expenses of participants, were evaluated with the help of double log regression analysis.
The descriptive statistics of maximum, mean, minimum, and standard deviation were used to understand the reliant on variables such as milk consumption and independent variables such as several family members, the price paid for fresh milk, participants' family income, education, ICTs, age and monthly nutritional needs of participant families. As per the concept of collinearity or multicollinearity, the relationship between independent variables is more powerful. With the help of sample resistance, the multicollinearity between the independent variables is estimated. The summary of stats and graphical representation is provided in Table 1 and Figure 1, respectively.

Table 1. Summary Statistics of data used for model estimation

Variables	VIF	Tolerance	Minimum	Std. Dev	Mean	Maximum
Income of respondent (Rs. /month)	3.728	0.268	8,000	29,082.44	37,717.2	200,000
Monthly food expenditure (Rs.)	4.041	0.247	3,500	8,320.377	15,470	45,000
Purchase price of milk (Rs. /month)	1.072	0.933	30	4.39	41.73	50
Age of the family head (Years)	1.144	0.874	22	11.82	41.66	67
Education of the family head (Years)	1.116	0.896	5	2.69	13.5	18
Family size (No.)	1.323	0.756	2	1.88	5.46	11
Milk consumption (Kg/month)	0	0	1	1.56	2.94	10

Source: Author's own calculations.

The graphical representation of the stats as mentioned above is presented in Figure 1.
Variable mutually led to a 61% change in the dependent variable, which is milk utilization, while maintaining other variables at a constant state.
This assessment also means that the rest of the 39% variation in the variable resulted from

multiple factors, which cannot be determined based on the current model (Table 2).

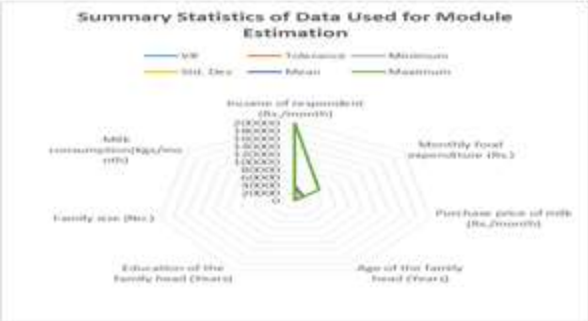

Fig. 1. Summary Statistics of Data used for model
Source: Author's own illustration.

The measurement of F is used to understand if explanatory variables are significant or not to assess the response variable. F measurement in the current study was 14.10 with p less than 0.05, which was significant and thus verified the general fitting of the model in Table 2. A substantial amount of milk interest is controlled by family members. The study found that families with large sizes consumed higher milk.

Table 2. Estimated Demand Function for Fresh Milk

Variables	Significance (P-value)	T-Value	Coefficient
Constant	0.041	2.112	3.29
Family Size (No.)	0.027	2.296	0.268
Purchase price of milk (Rs./Kg)	0.064	-1.899	-0.17
Income of respondent (Rs. /month)	0.102	1.672	0.213
Education of the Family Head (Years of Schooling)	0.908	0.18	0.021
Age of the Family Head (Years)	0.789	0.269	0.036
Employing ICTs by consumer	0.005	0.301	0.245
Monthly Food Expenditure (Rs.)	0.007	2.812	0.104

Source: Author's own calculations

Results in Table 2 show that a 1% expansion in family size would result into a 0.268% rise in milk consumption. It was revealed statistically significant. The price tag of new milk is a conspicuous variable that affects the milk utilization quantity of families.

A decline in milk costs is related to the expansion in dairy items utilization. Evaluated coefficient estimation shows a negative relationship between milk cost and its utilization. A 1 % rise in milk cost would imply a decline of 0.17% in milk utilization. The coefficient of milk cost was high with a 10% value.

The fresh milk quantity consumed is closely related to the family wages. The milk utilization, as well as consumption of dairy items, is closely related to salary levels. Milk spending in month is high in family of higher incomes with a 10% significance level. As per monetary hypothesis, salary is indicative of the obtaining capacity of the family, and hence salary increment is likely to have a positive influence on milk consumption and training lead to better eating habits and nutritional consumption. Milk is an important food products. Education is closely associated to the buying and milk consumption. The coefficients of education, monthly food expenditures and ICTs are positively related to milk utilization, having p-value lower than 1 (Figure 2).

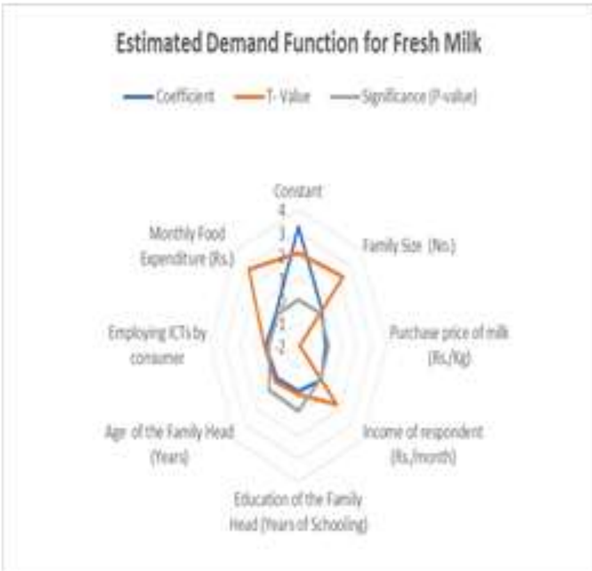

Fig. 2. Estimated demand function of fresh milk
Source: Author's own illustration

Milk is rich in fat and calcium and hence a popular dietary product. Education level, in general, does not have much impact on milk consumption. The age of the household family head has a positive impact on milk consumption but is statistically insignificant. This implies age does not have a major impact on milk utilization. Milk and dairy items form an important dietary component in various parts of the world, and milk is critical for the growth and maintenance of body. This study shows that a 1% change in family food expenses would lead to a 0.104% change in milk utilization. The regression coefficient for food expenses is a highly significant variable for milk consumption.

Fresh Milk Supply Function

The relation between milk quantity, i.e., the dependent variable and sales price of milk, the value of fodder, concentrates value used in farms, monthly labour expenses, the strength of milking animals, experience of farmers involved in cattle rearing and ICTs, i.e., the independent variables were estimated with the help of double log type regression model. The base was that scattered plot in the middle of response and explanatory variables indicated such a relationship.

The statistical summary was utilized to explain the response variable, milk quantity produced, and quantitative explanatory variables such as milk sales price, fodder value consumed, concentrate value, monthly labour expenses, the strength of milking animals, and experience of farmers involved and ICTs. Variance Inflation Factor (VIF) is directly related to resistance. As VIF expands, the regression coefficient changes, thus making it an unsteady factory. Extensive VIF values mean multicollinearity. Estimations are show

n in Table 3.

Table 3. Summary Statistics of data used for model estimation

Variables	VIF	Tolerance	Std. Deviation	Minimum	Mean	Maximum
Monthly Quantity of milk produced (Kgs)	0	0	2,292.95	240	1,370	11,880
Number of mulching animals (No.)	1.333	0.75	8.386	1	5.57	44
Dairy farming experience (Years)	1.1776	0.85	10.35	1	23.7	45
Value of fodder (Rs.)	3.378	0.296	20,701.04	6,000	17,133.34	120,000
Value of concentrate (Rs.)	1.086	0.921	25,185.17	1,500	12,538.34	140,000
Labour expenditures (Rs. /month)	3.476	0.288	3,643.44	4,000	5,633.34	20,000
Sale price (Rs. /Kg)	1.394	0.717	3.66	30	37.24	47.5

Source: Author's own calculations

The graphical representation of the stats as mentioned above is presented in Figure 3.

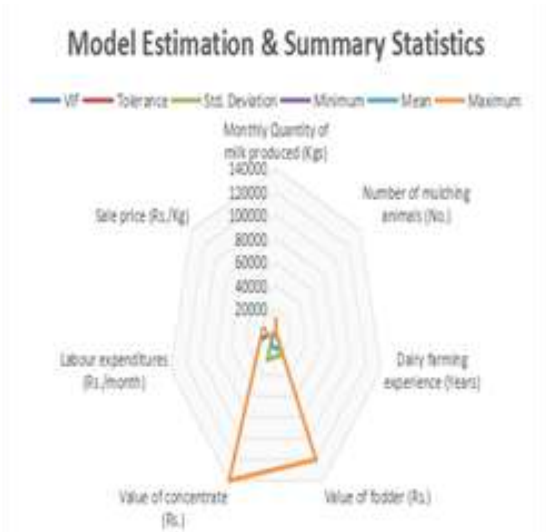

Fig. 3. Model estimation & summary statistics
Source: Author's own illustration

Figure 3 shows the spread of estimated coefficients on a radar graph. Adjacent R^2 in our research was 0.67, which means that every change in the independent variable meant 67% mutual change in the response variable, i.e., the quantity of milk sold while keeping other factors constant.

That explains the remaining 33% change in response variable resulted from multiple variables whose impact cannot be clarified by the current model in Table 4.

F statistic means each independent variable is significant or non-significant for changing response variable.

The F statistic value in the current study was 17.89 with p less than 0.05 and thus accounts for the model's utility (Table 4).

Table 4. Estimated Production Function for Fresh Milk

Variables	Significance (P-value)	T-Value	Coefficient
Constant	0.003	3.335	11.301
Number of mulching animals (No.)	0.079	1.842	0.298
Dairy farming experience (Years)	0.778	0.285	0.028
Value of fodder (Rs.)	0.108	1.677	0.086
Value of concentrate (Rs.)	0	4.331	0.115
Labour expenditures (Rs.)	0.894	-0.135	-0.14
Sale price (Rs. /Kg)	0.02	2.507	0.525
Availing credit facility (dummy variable)	0.561	1.85	0.123
Employing ICTs (dummy variable)	0.004	0.301	0.234

Source: Author's own calculations

Table 4 shows that mulching animals have a direct impact on milk production. Milking animals are a significant factor in milk production. As per estimated regression coefficients, a 1 % rise in milking animals' population will lead to a 0.298% rise in milk production.

The experience of farmers is a critical factor since experienced farmers are likely to be aware of business practices and factors affecting the business. Experience of farmers has a positive impact on dairy business. Results show that a 1 % rise in farmer experience would mean a rise of 0.298% in production of milk. However, statistically insignificance with a p-value less than 0.1 is found in variable. In Pakistan, farmers in majority, follow old-fashioned dairy procedures and own minor farms. In livestock feeding, Fodder is a critical factor in production of milk owing to its usage. Green fodder, as well as dry fodder, are utilized in animal feedstuff. Milk production can increase with the help of balanced feeding to animals. Between fodder consumption and milk production a positive relationship exists. In the current model, a 1 % rise in fodder value means a rise of 0.086% in milk production.

The graphical representation of the stats as mentioned above is presented in Figure 4.

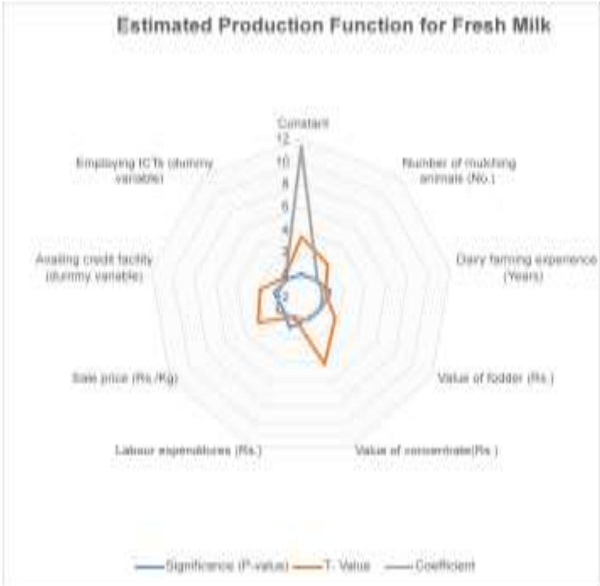

Fig. 4. Estimated production function for fresh milk
Source: Author's own illustration

The concentrate is used for various purposes, such as feeding animals to enhance milk production. It is highly effective in enhancing milk production. A positive relationship has been found between milk production and concentrates value by the estimated model. As per this research, a 1 percent rise in concentrate value is expected to raise milk production by 0.115 percent. Price and input quality have a substantial impact on milk production. Also, fodder and concentrates are considered critical input factors for milk production, and both have a positive impact. This positive relationship indicates that dairy milk production in Pakistan is still below economies of scale. Both fodder and concentrate are statistically significant, thus confirming their criticality for milk production. As per the estimated elasticity coefficient for monthly labor expenses, a 0.014 percent fall in milk production will be the consequence of 1% rise in labor expenses. This variable was statistically insignificant, with a p-value greater than 0.1. Another key factor for milk production is the sales price. Results shown in Table 4 show that a 1 percent rise in price means a rise in milk production by 0.0525 percent. It was established to be a statistically significant value with a p-value greater than 0.05. The sales price has a short-term impact on milk production.

Credit plays a critical part in any business. A dummy variable was included in the model to analyze the possible impact of credit on milk production. It was found that the credit coefficient was positively linked to milk production, but it was insignificant, i.e., the p-value was greater than 0.1. In Pakistan, the majority of the farmers hesitate to take credit due to cumbersome documentation procedures and credit terms set by banks and other financial institutions.

The use of information and communication technologies has been the key to successful expansion. Communication and access to information are directly linked to the development of dairy cooperatives. A dummy variable was included in the model to analyze the possible impact of ICTs on milk production. It was found that the ICT coefficient was positively linked to milk production, and it was significant, i.e., the p-value was lower than 0.1. Dairy cooperatives are one of the most potential areas where ICT can work effectively, primarily for social and economic development, and is directly linked to dairy farms. However, it is still difficult for the rural people of our country to convey important information and communicate in the form they understand. ICT offers the potential to address these issues for different categories of end-users. For this, it is necessary to build information and communication infrastructure in the dairy cooperative.

The results were noticed using various statistical tests such as multicollinearity, F-test, and Variance Inflation Factor (VIF). The scholars found these statistical tests as valid in the context of estimating the level of significance. For instance, [22] observed that with the concept of 'collinearity' or 'multicollinearity,' the relationship between variables could be more powerful. Moreover, [25] observed that measurement of F can be used to understand if explanatory variables are significant or not to assess the response variable. Furthermore, [28; 24] observed that VIF is directly related to the resistance between variables.

Several Scholars were found to be having their views in line with the results of this study. For instance, [42] noticed that family size significantly affects milk consumption. The other in-line views include:

-Worker's training leads to better eating habits and nutritional consumption of animals [33; 27].

-The per capita milk utilization is next to cereal consumption in Pakistan, considering aggregate family unit consumption [3; 9; 7; 21].

-The consumption of domesticated livestock is higher than other items in Pakistan [10; 6; 34].

-One of the most important factors in milk production is concentration [32].

-The concentrate is highly effective in enhancing milk production. Both the production and consumption has been affected by ICTs gradually [10].

-Price and input quality have a substantial impact on milk production [5; 4; 12].

-The sales price is a key motivator for milk producers to enhance milk production [43].

Altogether, Pakistan's livestock industry is dealing with issues of low milk production, poor distribution framework, lower storage quality and competition from international milk producers. Hence, there is a need to reorganize this industry. The government authorities in Pakistan need to work on multiple milk products such as milk augmentation through manual sperm injection, veterinary administration and rearing administration to enhance milk yield. More resources need to be added towards milk advertising and distribution strategy. The dairy sector in Pakistan has been largely ignored, with no critical studies of the sector being conducted.

Based on the knowledge of dairy stakeholders, it was noted that at the farm level, the usage of ICT is low, that puts dairy farmers at their fingertips. He revealed that major dairy countries such as the United States, Europe, New Zealand and Australia use agricultural ICT tools to manage animals from birth to death. The usage of ICT on the farm in relationship of several animals, the genetic make-up of animals, feed, mobility, milk production and milk quality has enabled farmers to manage their farms superior than in

Pakistan. Is. In Pakistan, except for the control of milk fat content and SNF (which is a decisive aspect in determining the value of milk farm gate), the usage of ICT is nowhere to be discovered and becomes an obstacle. The main problems for livestock farms are reducing the number of farmers per farmer (average per farmer 1 or 2 animals) along with lack of information and benefits of ICT in dairy farms. It is difficult for small dairy farmers to get the latest and reliable agricultural information, limiting their maximum agricultural yield. The proper usage of information and communication technologies (ICTs) by smallholders as a tool for agricultural expansion can change the landscape and improve farmers' productivity and incomes through increased prosperity [24].

CONCLUSIONS

Results obtained from the current research show that fresh milk demand is affected by multiple factors such as family size, milk price, monthly income, ICTs and food expenses. On the other hand, the fresh milk supply is affected by the strength of milking animals, fodder value, concentrate value, sales price, and ICTs. The price structure needs to be modified to give advantage to the end consumers by making milk available at a lower price. In the current scenario, consumers are helpless to pay a higher price for inferior quality milk. Additionally, milk producers cannot get high price benefits due to the interference of intermediaries and the absence of financial incentives and schemes. As a result, milk production in rural areas is on a lower side than in urban areas. Here comes the need to reform livestock producer’s cooperative societies. Such societies should buy milk from producers and market it to consumers. Other steps such as pushing higher milk production by providing interest-free loans to landless and small farm owners are also needed. Modern dairy farms with indigenous, high-yielding breeds should be raised. We believe that ICTs and digitization will become an effective means of increasing milk production and processing, increasing the competitiveness of dairy products and understanding export potential. ICT depicts an imperative part in the processing and marketing of milk. ICT allows users to save time on ordering and delivery as well as receiving feedback. The management of Dairy Cooperative understands that in the current competitive environment, there is an urgent need to attract new customers and retain existing customers. There is an urgent need to provide ICT services keeping the real state of milk production and marketing [8].

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THE IMPACT OF TECHNOLOGY TRANSFER ON SESAME EXPORT COMPETITIVENESS: INSIGHTS FROM TURKEY AND UZBEKISTAN

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Abstract

This study examines the trade relationship between Turkey and Uzbekistan, particularly in sesame exports, with the aim of strengthening Uzbekistan's competitiveness. Based on the theory of comparative advantage and using key indicators such as the Revealed Comparative Advantage (RCA) Index, the Revealed Symmetric Comparative Advantage (RSCA) Index, and the Normal Revealed Comparative Advantage (NRCA) Index, this study highlights the robust competitiveness of Turkey in exporting agricultural machinery designed specifically for sesame production. Through a comprehensive analysis of these indices, the study highlights Turkey's particular strength in this sector, sheds light on its comparative advantage and emphasises the country's strategic position in the global market for sesame-related agricultural machinery. However, Uzbekistan currently lacks competitiveness in sesame exports. The study underlines the key role of effective technology transfer, especially in machinery exports from Turkey, in improving Uzbekistan's position. Econometric models show the significant impact of exchange rates and domestic demand on Uzbekistan's sesame exports. The study's findings highlight ways to improve the efficiency of agricultural machinery exports between the two countries. This provides policymakers with valuable insights to strengthen sustainable trade relations and increase the volume of agricultural exports.

Key words: *agricultural machinery technology transfer, sesame export, comparative advantage, export competitiveness*

INTRODUCTION

In global trade, the pursuit of comparative advantage serves as a driver of growth and competitiveness [11]. Nations specialise in areas in which they excel, as proposed by the basic concept of international trade theory [21].

This study examines the relationship between trade between Turkey and Uzbekistan and how it can enhance the competitiveness of Uzbekistan's sesame exports. Sesame, a valuable export for Uzbekistan, has an untapped potential due to its limited competitiveness [23].

Our analysis examines the dynamics of sesame trade between Turkey and Uzbekistan, taking into account technology transfer and machinery exports. Effective transfer could catalyse improvements in Uzbekistan's sesame exports.

To measure the competitive advantage of machinery exports and to compare sesame exports, we use the RCA, RSCA and NRCA indices [2, 7, 36]. Using a model, we establish a link between Uzbekistan's sesame exports and Turkey's machinery. By extending the scope of the comparative advantage literature, our study sheds new light on the intricacies of the Turkey-Uzbekistan sesame trade. Agricultural machinery exports from Turkey emerge as a catalyst for improving Uzbekistan's sesame competitiveness. The cornerstone of sustainable growth is effective technology transfer. The paper's structure includes a literature review in Section 2, a description of the methodology in Section 3, presentation of the data in Section 4, and a brief summary of the findings and their implications in Section 5. The paucity of relevant articles stems from the specific focus of the study - the application of comparative advantage theory to the niche context of the sesame market between Turkey and Uzbekistan. This specificity limits the pool of relevant literature in the WOS database, and the collected articles are categorised according to their country of origin. For example, [18] scrutinised the agricultural potential of Ukraine and its contribution to the economy through foreign exchange inflows. The study revealed the benefits of foreign trade and identified potential opportunities for exports.

[33] dissected the European and Ukrainian agri-food sectors, identifying the comparative advantages of each country and suggesting strategies to enhance competitiveness.

[5] explored the impact of climate change on comparative advantage, highlighting the importance of groundwater and the trade elasticity of water in vulnerable countries.

[6] assessed China's grape industry, highlighting the modest global competitiveness of Chinese grape products. [17] challenged the belief in Japan's import restrictions on primary agricultural products, pointing instead to an active facilitation of imports.

[1] looked at Latin American renewable energy initiatives, emphasising the shaping of biofuel policies by comparative advantage. [14] evaluated Canada's interprovincial milk quotas through the lens of comparative advantage theory.

[26] navigated trade prospects between Indonesia and Chile, revealing untapped potential despite aligned comparative advantages. [29] examined the determinants of trade between Australia and China, highlighting the central role of comparative advantage. [12] Fen and Latif (2014) analysed trade between Canada and China, revealing untapped potential despite growing trade.

[4] assessed the revealed comparative advantages of Bosnia and Herzegovina. [3] traversed the trade relationship between New Zealand and India, highlighting indicators of trade intensity and comparative advantage.

[19] formulated strategies to boost trade between India and Pakistan, including the removal of barriers and facilitation measures. [35] examined trade trends between China and India, highlighting policy implications. Reference [22] analysed the dynamics of the United States' services trade with China and India, identifying sector-specific factors that determine comparative advantage. The study cited as [10] examined the dynamics of agricultural trade between China and Ghana and highlighted Ghana's comparative advantage in this context, while this literature review highlights a notable gap in understanding the nuanced dynamics of comparative advantage within the sesame trade between Turkey and Uzbekistan. This observation highlights the need for further scholarly exploration and empirical research in this specific area. In this context, our study emerges as a novel and essential contribution to this area of research as it aims to examine the trade relationship between Turkey and Uzbekistan, particularly in sesame exports, to strengthen Uzbekistan's competitiveness based on technology transfer incorporated in agricultural machinery and using the comparative advantage indices.

MATERIALS AND METHODS

RCA Analysis

In this study, we discussed the role of trade with Turkey in the competitiveness of Uzbekistan's sesame exports. We are looking at the trade situation in sesame and related fields from Turkey to Uzbekistan, we see that there have been no exports of sesame seeds and derivatives from Turkey to Uzbekistan so far. In addition, Uzbekistan’s sesame production technology includes agricultural machinery exported from Turkey. In this respect, Turkey's role can be important for Uzbekistan's sesame exports to become competitive. In this framework, an effective technology transfer from Turkey to Uzbekistan can make Uzbekistan's sesame exports competitive.

In the preliminary analysis, the identification of Turkey's export competitiveness in machinery related to sesame agriculture and industry serves as a crucial step in delineating its comparative advantage. Furthermore, an examination of the competitive structure encompassing Turkey's and Uzbekistan's exports of sesame products is imperative. In order to rigorously assess and measure their comparative advantage at the product level, this study uses three different indices: the RCA index [2], the RSCA index [7] and the NRCA index [36].

The Relative Comparative Advantage (RCA), also known as the Balassa index, is emerging as a key indicator for understanding the export competitiveness of an industry, as illustrated by examining export market shares. The RCA is derived by comparing a country's world market share in a specific good with its total share in all traded goods. According to the RCA index, a country achieves specialisation in the export of a particular product if its market share in that product exceeds the average, or if the weight of the product in the country's export portfolio exceeds the total weight of exports [28].

The RCA index identifies the region's most important export destinations and product categories [15]. The size of a country's economy or industry is neutralized in the RCA index, allowing meaningful comparisons between economies and allowing different industries to perform on a global scale [31]. RCA indices are calculated using Balassa's (1965) methodology as follows:

$$RCA_j^i = \frac{E_j^i / E^i}{E_j / E} \qquad (1)$$

In Equation 1, is the export of good j by country i; is the export of all goods by country i; is the export of good j by all countries in the world; and is the export of all goods by all countries. If the Relative Comparative Advantage (RCA) is greater than one, it indicates the existence of a comparative advantage for country i, suggesting an endogenous strength in the production and export of the specific good, denoted good j. Conversely, an RCA below one indicates a comparative disadvantage for country i in the production and export of good j. The advantage of using the RCA is its ability to take into account the endogenous advantages associated with the specific good, denoted good j. Conversely, an RCA of less than one indicates a comparative disadvantage for country i in the production and export of good j. The advantage of using the RCA index lies in its ability to take into account the endogenous advantages associated with a particular export good, thus contributing to a more nuanced understanding of a country's trade dynamics. However, Balassa's RCA index has been criticized for ignoring some of its effects and showing asymmetric values [32]. To solve the problem of asymmetric values, [7] introduced the RSCA by modifying the RCA index as follows:

$$RSCA_j^i = \frac{(RCA_j^i - 1)}{(RCA_j^i + 1)} \qquad (2)$$

The Revealed Symmetric Comparative Advantage (RSCA) index takes values in the range from -1 to +1, where the RCA index values in the intervals [0, 1] and [1, +∞] are replaced by [-1, 0] and [0, +1] respectively, while retaining comparable economic implications. Consequently, RCA values between 0 and 1 indicate a country's comparative export advantage, while RSCA values between -1 and 0 indicate a country's comparative disadvantage. The inherent symmetry and zero-centred distribution of the RSCA mitigates potential bias and ensures a balanced representation of a country's comparative advantage or disadvantage across different export commodities [7]. [36] developed an alternative measure of RCA to overcome various weaknesses of Balassa's RCA index such as asymmetry, non-normality and unstable mean [8].

The (NRCA) index measures the extent to which a country's realised exports deviate from its comparative advantage neutral threshold, taking into account the relative size of the global export market dynamics [36]. NRCA is symmetric and its value ranges from -0.25 to 0.25, with 0 serving as the point of comparative-neutral disadvantage. Moreover, NRCA reflects the relative nature of comparative advantage because the sum and average of NRCA scores of a country or a good are constant and equal to zero. Moreover, NRCA values can be compared across countries, goods and time [34]

In particular, the consistency of NRCA over time is also valuable for using time series analysis to assess competitiveness [27]. NRCA is defined as follows:

$$NRCA_j^i = \left(\frac{E_j^i}{E} - \frac{E_j \times E^i}{E^2} \right) \qquad (3)$$

NRCA greater than 0 indicates that actual exports of good j by country i are higher than expected exports. An NRCA value less than 0 means that the actual exports of good j by country i are lower than the expected exports [36].

Econometric Methodology: Product Level Export Model

After determining the export competitiveness situation for Turkey and Uzbekistan in the relevant products, we assumed that the link between Uzbekistan's exports of sesame products and the machinery used in sesame farming/industry exported from Turkey is determined by the following equation-4. The export function in equation 4 is constructed using a theoretical framework similar to [13] and [37].

$$EX_{1207,t}^{UZ} = \beta^{'} x_t + \varepsilon_t \quad (4)$$

where: $EX_{1207,t}^{UZ}$ is the variable representing Uzbekistan's exports of sesame products with code HS-12.07(40) (sesame exports as a percentage of total exports.). x_t is the set of other relevant theoretical variables observed. β is the parameter vector and ε_t is the error term, which is assumed to be normally distributed. The main variables in the set *x* on which $EX_{1207,t}^{UZ}$ depends are the effective exchange rate ($/som), world demand (average of the world industrial production index) and the industrial production index (Uzbekistan), which is considered to represent domestic demand pressure as in [37].

The resulting model is called the "Benchmark Model. The other variables in cluster x are control variables. Respectively, these variables are the export values of machinery used in sesame cultivation and industry exported by Turkey to Uzbekistan (the ratio of agricultural machinery exports to total exports in the relevant HS code). These products are classified under HS codes 84.32, 84.33, 84.38 and 84.79 respectively ($EX_{8432,t}^{TR}, EX_{8433,t}^{TR}, EX_{8438,t}^{TR}$, and $EX_{8479,t}^{TR}$). The model in which the control variables are included is called the "Control Model."

The main purpose of doing this is to determine the impact of exported agricultural machinery with these HS-codes on sesame exports in Uzbekistan (Table 1).

Table 1. HS Codes for Machinery Used in Uzbekistan

	Machinery	HS code
1	Plows	84.32
2	Pre-planting tillage cultivators	
3	Sesame seed drill	
4	Intermediate hoe cultivators	
5	Fertilizer machine	
6	Sesame harvester	84.33
7	Sesame stone sorting sieve	84.38
8	Sesame light grain sieve	
9	Sacking packaging unit	
10	Sesame peeling line	
11	Tahini Line	
12	Tahini halva line	
13	Croquant line	
14	Oil extraction line	84.79
15	Sesame Field sieve (coarse sieve)	
16	Sesame calibration sieve	

Sesame Agriculture and Industry

Dynamic Least Squares (DOLS) Approach

It encompasses the temporal sequence of variables specified in equation 4, which poses potential estimation challenges arising from the underlying data structure. As a result, academic discourse in recent years has often focused on conventional cointegration methods for the contemporary analysis of the interrelationships between macroeconomic variables. However, due to the endogeneity problem that arises in the estimation process and the inability to interpret the long-run coefficients obtained, the traditional co-integration methods used to reveal the long-run relationships between variables have been replaced by FMOLS developed by [16], CCR developed by [24] and DOLS developed by [30].

These cointegration methods, like the traditional cointegration methods, are based on the condition that the series used are stationary at difference. However, the possibility of interpreting the coefficients obtained is an important advantage. In addition, it is able to produce reliable results in small samples.

FMOLS tries to eliminate this problem by using kernel estimators of the parameter that causes endogeneity problem. In addition, FMOLS uses the co-variance matrix of error terms to eliminate problems arising from long-run correlations between cointegration equations and stochastic processes.

The DOLS method takes into account the first difference of the explanatory variables, allowing lags to be included in the estimation. In addition, it provides an asymptotically efficient estimator that eliminates feedback effects in the cointegration equation. The DOLS method can be expressed by equation (5) below:

$$EX^{UZ}_{1207,t} = \beta x_t' + d_{1t}\phi_1 \sum_{j=q}^{r} \Delta x_{t+j}' \delta + \hat{\varepsilon}_{1t} \qquad (5)$$

where: q and r allow for differencing the explanatory variables, which allows to eliminate the long-run correlation between the error terms.

The estimation process yields parameter estimates with an asymptotic distribution.

Data and Analysis

We used annual frequency data to calculate the RCA index values for Turkey and Uzbekistan's exports of related products. Turkey data covers 2002-2021, while Uzbekistan data covers 2017-2021. We obtained these data from "trademap.org". The frequency of the series included in the export function in Equation 4 is monthly. We also obtained these data from "comtrade.un.org".

The three different RCA index values calculated to measure and evaluate the competitive structure of exports of agricultural machinery used in Turkish sesame agriculture and industry are shown in Figure 1.

According to Figure 1, we can say that Turkey has become competitive especially after the second half of the 2010s in products coded HS-84.32 and HS-84.38 among the agricultural machinery used in sesame agriculture and industry. In products coded HS-84.33 and HS-84.79, Turkey did not have a comparative advantage between 2002 and 2021.

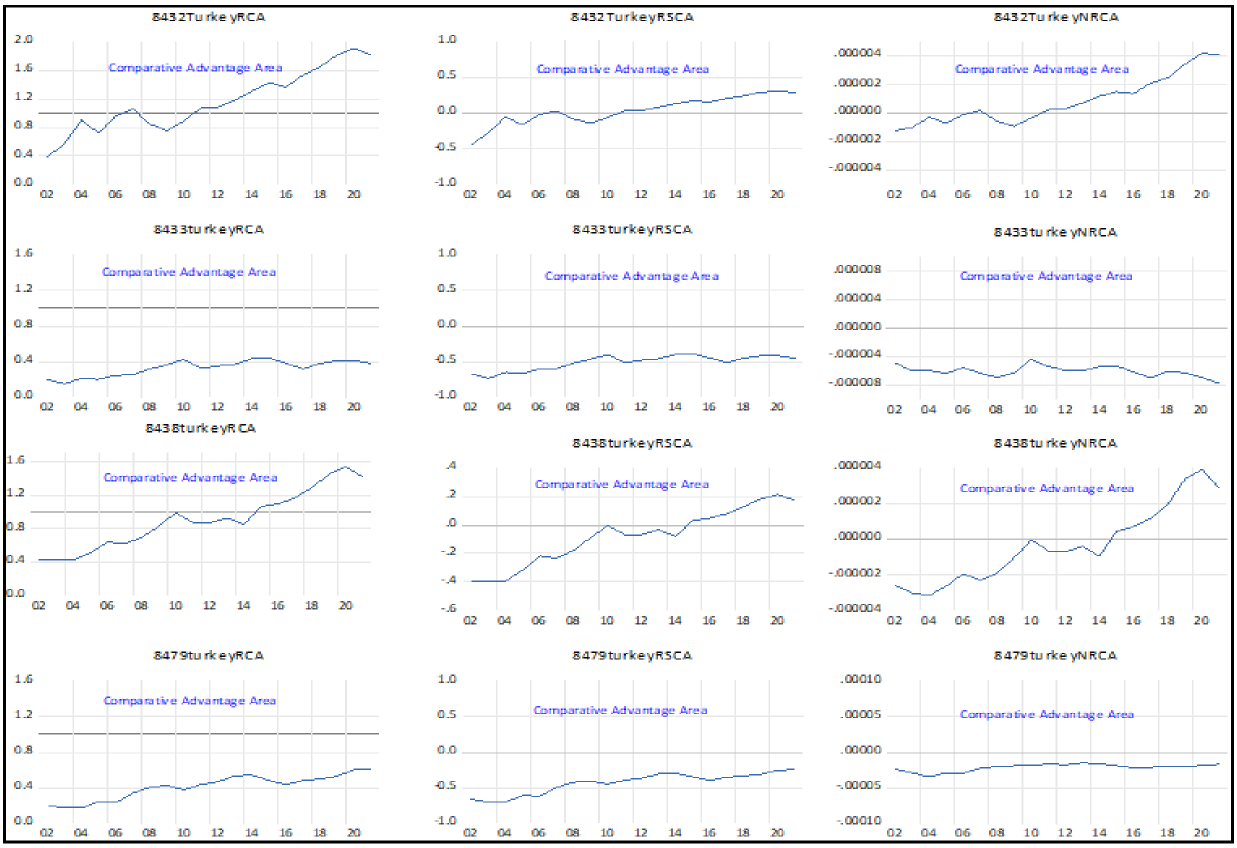

Fig. 1. RCA Analysis of Machinery Used in Sesame Agriculture and Industry for Turkey
Note: For all three indices, above the gray line represents periods of comparative advantage.
Source: Own results.

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The similar structure of all calculated RCA indices makes the analysis robust. In addition, we also measured the competitive structure of Turkey and Uzbekistan in sesame exports (HS-code 12.07(40)) with three different RCA index values. These values are shown in Figure 2 and Figure 3.

According to Figures 2 and 3, Turkey is in a competitive position in sesame exports between 2002-2021. However, Uzbekistan is not in a competitive position in sesame exports between 2017-2021.

All three calculated index values show similar results.

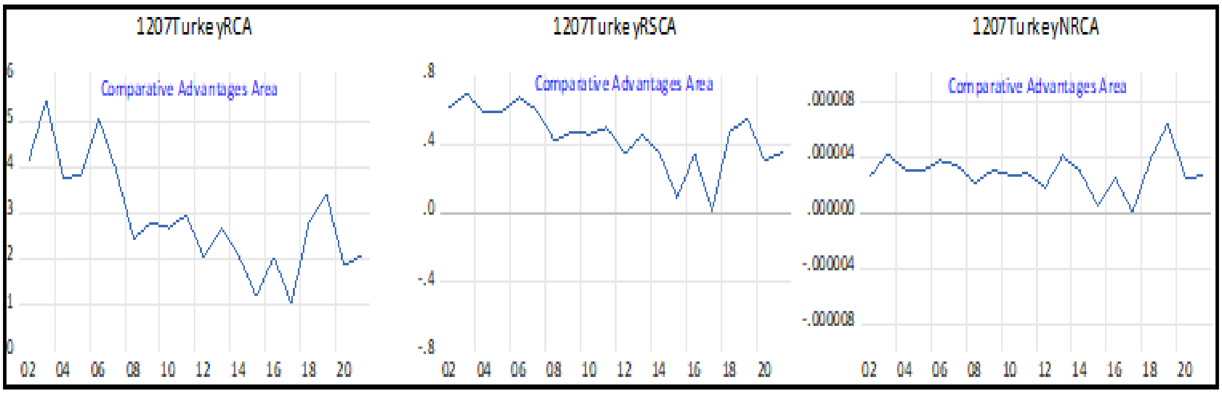

Fig. 2. Turkey Sesame Product RCA Analysis
Note: For all three indices, above the gray line represents periods of comparative advantage.
Source: Own results.

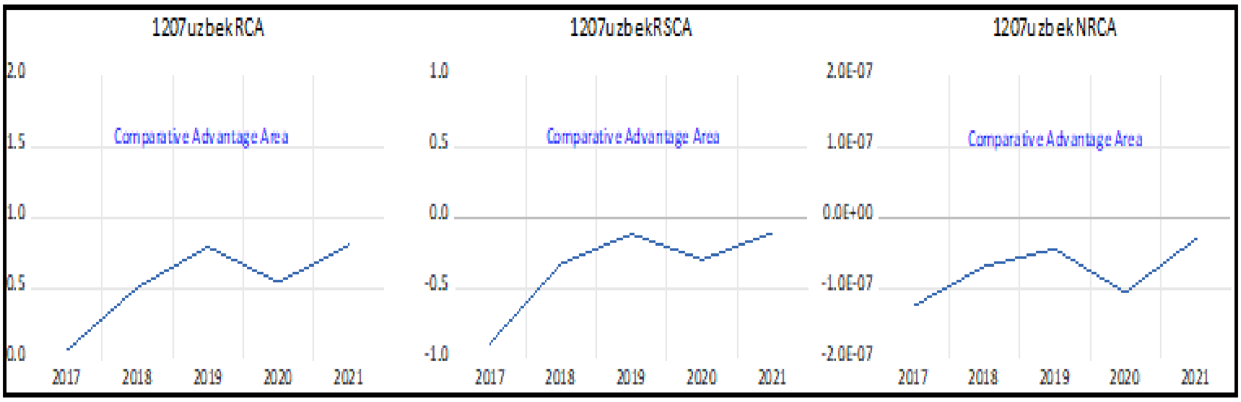

Fig. 3. Uzbekistan Sesame product RCA Analysis
Note: For all three indices, above the gray line represents periods of comparative advantage.
Source: Own results.

After determining the competitive levels in the exports of sesame products and sesame agricultural/industrial goods, we proceeded to the estimation of the link between Uzbekistan's exports of sesame products and sesame agricultural machinery exported from Turkey.

Before estimating the relevant model, we investigated the stationarity properties of the series in the model. We conducted standard unit root tests: ADF [9], PP [24], and KPSS [20] to examine the stochastic properties of these variables. The unit root tests results are presented in Table 2.

Test results in Table 2 show that, $EX^{UZ}_{1207,t}$ WD_t $EX^{TR}_{8432,t}, EX^{TR}_{8433,t}, EX^{TR}_{8438,t}, ve\ EX^{TR}_{8479,t}$ variables are stationary at level according to ADF, PP and KPPS tests. $Exch_t$ ve IP^{UZ}_t variables are not stationary at level in all tests.

After examining the unit root processes of the variables, the export function estimated by OLS and DOLS methods. The estimation results are as shown in Table 3.

Table 2. Linear Unit Root Tests

		ADF Test		PP Test		KPSS Test	
		Constant	*Constant and Trend*	*Constant*	*Constant and Trend*	*Constant*	*Constant and Trend*
Uzbekistan Sesame Exports	$EX^{UZ}_{1207,t}$	-3.610***	-3.600***	-3.353**	-4.271**	0.610	0.097
Uzbekistan Effective Exchange Rate	$Exch_t$	-1.019	-1.005	-1.811	-1.777	0.042***	0.032***
Uzbekistan Industrial Production Index	IP^{UZ}_t	-2.010	-2.055	-2.408	-1.238	0.451***	0.295**
World Demand	WD_t	-3.899**	-3.564***	-3.093***	-3.555***	0.411	0.484
Turkey Export Values by HS Codes	$EX^{TR}_{8432,t}$	-3.569***	-3.571***	-3.979***	-3.968***	0.323	0.302
	$EX^{TR}_{8433,t}$	-5.625***	-5.564***	-5.478***	-4.782***	0.540	0.218
	$EX^{TR}_{8438,t}$	-3.348**	-3.564**	-2.093***	-2.555***	0.214	0.484
	$EX^{TR}_{8479,t}$	-5.956***	-5.661**	-4.513***	-5.927***	0.245	0.342

Notes: The lag length for the ADF test is chosen according to the AIC criterion. The PP and KPSS tests are computed using the Bartlett kernel with the Newey-West bandwidth. The null hypothesis tested in the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests is non-stationarity within the series, while the null hypothesis tested in the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test is stationarity against the alternative hypothesis of a unit root. Significance levels denoted by ***, ** and * respectively indicate statistical significance at the 1%, 5% and 10% levels.
Source: Own results.

Table 3. Product Level Export Model Estimation Results

Depended Variable: $EX^{UZ}_{1207,t}$	Benchmark Model		Control Model	
	OLS	**DOLS**	**OLS**	**DOLS**
C	0.640*** (0.177)	1.053*** (0.252)	0.702*** (0.157)	1.116*** (0.254)
Exch	-0.097*** (0.025)	-0.137*** (0.024)	-0.098*** (0.022)	-0.159*** (0.015)
IP^{UZ}_t	0.020* (0.010)	0.045 (0.029)	0.015 (0.011)	0.053 (0.038)
WD_t	0.033 (0.029)	-0.001 (0.252)	0.026 (0.030)	0.053 (0.078)
$EX^{TR}_{8432,t}$			0.219 (0.389)	0.817 (0.046)
$EX^{TR}_{8433,t}$			-0.579 (0.565)	-3.080** (1.371)
$EX^{TR}_{8438,t}$			-0.066 (0.198)	-0.892 (0.838)
$EX^{TR}_{8479,t}$			0.471*** (0.223)	0.701 (0.527)
R^2	0.42	0.63	0.49	0.92
Prob(F)	0.000		0.000	
Breusch-Godfrey Test	14.128		13.292	
White Test	20.810***		41.410	

Note 1: The values in parentheses are the standard errors of the parameters.
Note 2: Diagnostic tests of the OLS models revealed that there is no autocorrelation problem in both models, but there is a problem of variance in the base model. In order to correct this problem, the standard errors of the base model were estimated with the HAC (Newey-West) covariance method.
Note 3: ***, ** and * indicate statistical significance at 1%, 5% and 10% levels, respectively.
Source: Own results.

The (OLS) results from the benchmark model, as detailed in Table 2, show that both the exchange rate and domestic demand pressure have a statistically significant impact on Uzbekistan's sesame exports. However, the Dynamic Ordinary Least Squares (DOLS) results indicate that only the exchange rate has statistical significance, implying a discernible impact on Uzbekistan's sesame exports.

The sign of the coefficients is consistent with the theoretical expectation. In addition, world demand has no significant effect on

Uzbekistan's sesame exports. We believe that this finding is consistent with our RCA analysis findings on Uzbekistan's sesame exports. The fact that Uzbekistan does not have a competitive structure in sesame product exports shows us that it has an inefficient structure in its foreign trade.

OLS results of the control model in Table 2 show that the exchange rate has a significant effect on Uzbekistan's sesame exports. This finding is similar to the DOLS results. The sign of this coefficient is also consistent with the theoretical expectation. In the control model, we do not find a significant effect of domestic demand pressure and world demand on Uzbekistan's sesame exports. When the effect of the control variables is analyzed, the OLS results show that among the machines used in sesame cultivation/industry exported from Turkey, only the machines coded HS-8479 have a significant and positive effect on Uzbekistan's sesame exports. Other control variables did not have a significant effect. According to the DOLS results, only HS-8433 coded machines have a significant and negative effect on Uzbekistan's sesame exports. Clearly, these findings may be an indication that agricultural machinery exports between Turkey and Uzbekistan are not efficiently secured. In particular, we think that giving weight to products coded HS-84.32 and HS-84.38, in which Turkey is competitive in exports, may help Uzbekistan to achieve competitiveness in sesame product exports. [10], focusing on the bilateral agricultural product trade between China and Ghana, highlighted the importance of exploring untapped opportunities and implementing measures to enhance agricultural trade cooperation. We think that this finding is in line with your study's emphasis on the potential for technology transfer from Turkey to Uzbekistan to improve the competitiveness of Uzbekistan's sesame exports.

Comparing the relevant literature with the study findings, despite the different research objectives, both the literature and our findings show the importance of comparative advantage in shaping trade relationships. Moreover, it also recognizes the potential for trade relationships to boost exports based on relevant strengths. The literature review emphasizes the importance of factors such as climate change, water resources, and renewable energy initiatives in shaping comparative advantage and trade patterns. Our study identifies the exchange rate as the most influential factor affecting Uzbekistan's sesame exports, while domestic demand pressure also plays a role. The findings of our study are consistent with the literature's emphasis on the importance of considering specific factors and control variables in the analysis of comparative advantage.

Overall, while the literature review highlights limited studies directly addressing the specific topic of your research, several studies provide relevant insights that overlap with our findings. These studies emphasize the importance of exploring untapped potential, increasing competitiveness in specific products, and implementing measures to enhance trade cooperation. Building on and in line with these empirical findings, our study serves to enrich the scholarly understanding of comparative advantage and trade dynamics in the sesame market, and in particular to shed light on the intricate dynamics that characterize the trade relationship between Turkey and Uzbekistan.

CONCLUSIONS

This study systematically examines the impact of trade dynamics between Turkey and Uzbekistan on strengthening the competitive position of Uzbekistan's sesame exports. By incorporating insights from the relevant literature on comparative advantage in agricultural trade and applying a comprehensive methodological approach, our research provides nuanced insights into the unique dynamics characterising sesame exports between these two countries. The literature review underscores the central role of comparative advantage in shaping bilateral trade relations and fostering economic growth, thereby contributing to the scholarly discourse on international trade dynamics. Several studies have investigated the determinants and outcomes of comparative advantage across countries in different agricultural sectors, emphasizing the importance of comprehensive competitiveness assessment, export structure analysis, and technology transfer. Consistent with the literature, our findings provide valuable insights into the factors affecting Uzbekistan's sesame exports and the potential role of trade with Turkey in improving competitiveness. Our analysis highlights the key role played by Turkish agricultural machinery exports in influencing Uzbek sesame production technology, and highlights the latent potential for technology transfer to enhance competitiveness in this sector. Using three different Revealed Comparative Advantage (RCA) indices, our assessment examines Turkey's export competitiveness specifically in agricultural machinery tailored for sesame farming and industry, thereby identifying strategic areas of comparative advantage.

This methodological approach contributes to a nuanced understanding of the complex dynamics governing the technological landscape and export competitiveness in the context of sesame production between Turkey and Uzbekistan. Our findings reveal that Turkey's competitiveness in exports of agricultural machinery related to sesame agriculture and industry increased in the second half of the 2010s, especially in products coded HS-84.32 and HS-84.38. However, Turkey does not have a comparative advantage in HS-84.33 and HS-84.79 coded products between 2002 and 2021. These results, which are consistently supported by all calculated indices, provide a robust assessment of Turkey's competitive position. We also examined the competitive structure of Turkey and Uzbekistan in sesame exports by considering the three RCA indices. The analysis revealed that Turkey maintained its competitive position in sesame exports between 2002 and 2021, while Uzbekistan lacked competitiveness in the same period. These findings, supported by all calculated indices, underline the need for Uzbekistan to improve its competitive position in sesame exports. The econometric analysis investigates the determinants of Uzbekistan's sesame exports and Turkey's potential role in this regard. Our models showed that exchange rate and domestic demand pressure significantly affect Uzbekistan's sesame exports. We also found that only agricultural machinery coded HS-8479 has a significant and positive impact on Uzbekistan's sesame exports, while agricultural machinery coded HS-8433 has a significant and negative impact.

These results suggest that there may be room for improvement in the efficiency of agricultural machinery exports between Turkey and Uzbekistan. The findings emphasize the importance of considering comparative advantage and agricultural machinery technology transfer in improving Uzbekistan's competitiveness in sesame exports. Policy-makers and stakeholders can use these findings to formulate strategies aimed at promoting sustainable trade relations and increasing agricultural exports.

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GLOBAL EVALUATION OF THE TURKISH PASTA INDUSTRY IN TERMS OF COMPETITIVENESS

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Abstract

Pasta is one of the most stable and popular foods in the daily diet for many consumers due to its good nutritional quality, low price, long shelf life, and versatility. Along with its beneficial effects on health with its low fat and available carbohydrates, pasta can also be enriched with various functional additives. According to the data for the last ten years, pasta production worldwide has increased by approximately 22%. Türkiye ranks third in world pasta production after Italy and the United States. In this study, the pasta sector was evaluated globally, and the competitiveness of major exporting countries was analyzed. Vollrath's Relative Export Advantage Index (RXA) was used to determine competitiveness. For this purpose, indices of major pasta exporting countries Türkiye, Italy, China, the Republic of Korea, Thailand, Iran, the United States, Indonesia, Belgium, and Germany were calculated. The results showed that these countries, except the USA, China, and Germany, have a comparative advantage in pasta trade. Increasing the production of high-quality durum wheat and searching for new markets are important in maintaining a comparative advantage.

Key words: *macaroni, durum wheat, competitiveness, export, Türkiye*

INTRODUCTION

Agriculture has played a significant role in the economic development of many countries, just like in Türkiye, and continues to do so. However, factors such as global climate change, natural disasters, and the depletion of water resources threaten the agriculture sector. Therefore, innovative solutions are needed to ensure sustainability in the agriculture sector. These solutions include more efficient and sustainable agricultural techniques, better water and soil management, renewable energy sources, and agricultural technologies. In order to reduce the nutritional concerns of the increasing world population, efforts to increase the yield per unit area and reduce waste are significant.

Since ancient times, cereals and their products have been important in human nutrition. Wheat has a strategic role among cereals with its wide cultivation area and high production quantity. According to the latest data, the world's total wheat production is 770,877 million tons (FAOSTAT, 2023) [15]. Globally, durum wheat constitutes 5% of the total wheat production, with 16 million hectares of planting area. Bread wheat (*T. aestivum ssp. Vulgare*) is the first and durum wheat (*Triticum durum L.*), with an average annual production of 40 million tons, the second most cultivated wheat species in the world (Beres et al., 2020) [9].

Pasta is one of the most widely consumed foods in the world and has been known since ancient times. Pasta comes after bread among the industrial products made from wheat in terms of production quantity and nutritional importance (Köten et al., 2014) [26].

Varlık (2021) [41] reported that the information on the history of pasta is uncertain, and the general belief is that Marco Polo, who returned to Italy from his trip to China at the end of the 1200s, introduced pasta to Europe. However, there are also opinions that pasta was first produced by Arabs and spread from the Middle East to Europe.

There is a growing trend for pasta in Türkiye following a global trend due to its high nutritional content, affordable price, easy storage and preparation, the use of modern technology in its production, and widespread availability. Pasta is perfect for a healthy, tasty, and filling meal. It can be served as a main dish or after mixing with vegetables, legumes, red or white meats, with or without sauce, or other dishes if desired. In this way, it facilitates the consumption of other nutrients by making them more delicious and satisfying (Anonymous, 2023) [2].

Currently, with the increase in consumers' awareness of healthy nutrition, there is a great interest in enriching pasta with functional ingredients such as asparagus flour from non-commercial plants (Vital et al., 2020) [42], wheatgrass powder (Bawa et al., 2022) [4], green leek powder (Biernacka et al., 2022) [10], spirulina (Raczyk et al., 2022) [28], various animal and plant protein sources (Teterycz et al., 2022; Khodaei et al., 2023) [36, 24], pseudocereals and legumes (Hoehnel et al., 2022) [16]. In contrast, Altamore et al. (2020) [1] reported that, in line with new consumption trends, Italian consumers were not very interested in time-saving or functional products; they were more like to use wholemeal pasta.

The adventure of the pasta industry in Türkiye started with the first pasta factory in İzmir-Bayraklı in 1922. Thanks to this factory, a product already existing in Turkish culture known as “erişte (Turkish noodle)” was industrially produced for the first time. The capacity, which was 33,000 tons/year in 1962, reached 100,000 tons/year in the 1970s with the establishment of large factories, and as of the end of 2005, it reached 1 million tons/year. Currently, 24 producer companies operate in the pasta industry in Türkiye (Anonymous, 2023) [2]. The Turkish pasta industry can meet domestic and international demand and has reached a level that can compete with developed countries with its ever-developing technology (Karlı et al., 2015) [22].

While 2,500 people were employed in the industry in 1995, the increase in production and exports led to increased capacity, and the number of employees increased to 3,200 in 1997. However, due to the economic crisis in 1999 and 2000, this number decreased to 2,000, and as of 2019, employment was provided for 35,000 people. The pasta industry was one of the sectors with the highest capacity utilization rate, with a production capacity of 2,314,000 tons in 2019 (Taşcı et al., 2020a) [31]. The sector employs 10 thousand people directly and 100 thousand indirectly (Taşcı et al., 2022a) [34].

The concept of comparative advantage was first introduced by the classical economist Ricardo and the neo-classical economists Heckscher and Ohlin (Ilyas et al., 2009; Sachithra et al., 2012) [17, 30]. Balassa (1965) [3] advanced the concept of revealed comparative advantage, while Vollrath (1991) [43] laid out the difference between competitive and comparative advantage. Competitiveness is regarded as an essential criterion for assessing the success of countries, industries, and businesses. Furthermore, competitiveness can be defined as increasing market share, profitability, and long-term stability and growth of these indicators, thereby improving people's welfare and living standards. In today's competitive and dynamic environment, if a company wants to succeed in the competition arena, it must have a competitive advantage, which means creating and maintaining superior performance (Mehralian&Shabaninejad, 2014) [27]. Competitiveness is, therefore, one of the essential instruments of a market economy. In order to have an advantage in both local and global markets, it is crucial to have superior competitiveness.

Competitiveness analysis has been addressed in many studies (Benalywa et al., 2019; Durmuş &Dokuzlu, 2019; Bayav&Çetinbaş, 2021; Demir & Aksoy 2021; Khalid et al., 2021; Kadakoğlu&Karlı, 2022; Kadakoğlu et al., 2022a, 2022b: Bayav& Şahin, 2023) [8, 12, 6, 11, 23, 19, 20, 21, 7]. Although studies on the pasta sector and durum wheat (Uzunlu&Bayaner, 1993; Ertaş, 2002; Eser, 2009; Bayaner et al., 2010; Taşcı et al., 2020b; Taşcı et al., 2021; Taşcı et al., 2022a; Taşcı et al., 2022b) [40, 13, 14, 5, 32, 33, 34, 35] are prominent in Türkiye, four papers evaluating the competitiveness of the pasta sector in Türkiye are noteworthy. The first is a study by Koo &Bayaner (1998) [25]. In this study, after a general evaluation of pasta and durum wheat production and trade in Türkiye and the world, future durum wheat production was forecasted, and competitiveness was analyzed by calculating Volrath's Revealed Comparative Advantage index. The second is a study by Saraçoğlu & Köse (2000) [29]. The study determined the competitiveness of 16 countries, including Türkiye, by the Comparative Export Performance Index and Principal Component Analysis. Turhan (2008) [37] conducted the third study. To determine competitiveness, the study calculated the import penetration rate, specialization coefficient, openness to foreign competition, export market share, and export/import ratio. It was concluded that Türkiye's pasta sector recovered after 1999, and its competitiveness increased. The fourth research was carried out by Taşcı et al. (2020a) [31]. This study conducted face-to-face interviews with 18 pasta factories operating in Türkiye. The competitiveness of pasta factories was determined by considering their internal dynamics using the data obtained.

In this study, Türkiye's position in the global pasta sector was evaluated based on world pasta production and trade, and the competitiveness of the leading countries in the world pasta trade was analyzed.

MATERIALS AND METHODS

In this study, pasta production, export, and import values were used to determine Türkiye's position in the pasta sector and its competitiveness. The data were obtained from the Turkish Statistical Institute (TURKSTAT), the International Trade Centre (ITC-TRADE MAP), and the Food and Agriculture Organization of the United Nations (FAO) websites.

In competitiveness analysis, different indices are calculated to determine the position of countries in the international arena in terms of the product under consideration. In this study, the competitiveness of countries was analyzed using the Relative Export Advantage Index (RXA) developed by Vollrath (1991) [43]. The reason for selecting the RXA index in this study was that the index with the highest level of importance according to the Analytic Hierarchy Process Method in the study carried out by Bayav and Şahin (2023) [7] was the RXA index. Italy, China, the Republic of Korea, Thailand, Iran, the United States, Indonesia, Belgium, and Germany, major pasta exporters, were considered Türkiye's competitors in this field. In the competitiveness analysis of the leading countries in pasta exports, 10-year export data covering 2012-2021 were used.

The Relative Export Advantage Index (RXA) was developed by Vollrath (1991) [43] based on Balassa's (1965) [3] Revealed Comparative Advantage Index (RCA). The RXA equation is as follows:

$$RXA_j^i = \frac{x_j^i / \sum x^i}{\sum x_j^w / \sum x^w} \quad ......(1)$$

In Equation 1, RXA_j^i is the Relative Export Advantage Index of country i for product j, x_j^i is the export value of country i for product j, $\sum x^i$ is the total export value of country i, $\sum x_j^w$ is the total export value of world product j, and $\sum x^w$ is the total export value of the world. Interpretation is based on whether the RXA value is greater than 1. An RXA value greater than 1 indicates the country's comparative advantage and specialization in the product. The interpretation is that the country has a strong export sector and high competitiveness in the product in question. An RXA value less than 1 means that the country's export performance is lower than the world export performance in the product in question.

RESULTS AND DISCUSSIONS

Pasta consumption is increasing day by day due to its easy preparation, nutritional ingredients, affordable price, and appeal to the mouth-pleasing of every segment of society. In order to correctly interpretation of the future of the pasta industry, it is necessary to know how the production and trade of durum wheat, which is the raw material of pasta, is progressing. Unfortunately, it was impossible to reach the durum wheat statistics of the major pasta trading countries except for Türkiye. Because the production quantity of the countries is given as total wheat, and no distinction is made between bread and durum wheat. This situation makes it difficult to follow the world durum wheat production quantity.

Unlike bread wheat, durum wheat has more special climate and soil requirements. For this reason, its cultivation in the world remains limited. Durum wheat, which does not have wide adaptability, can be grown in certain areas in Türkiye (Yazar&Karadoğan, 2008) [44]. Table 1 shows the durum wheat cultivation areas, production, and yields of Türkiye, one of the significant durum wheat producers. When Table 1 is examined, it is seen that according to the average of 2020-2022, 3,633,333 tons of durum wheat were produced in a 12,221,462 ha area in Türkiye. Although there was an increase of approximately 29% in yield compared to the average of 2002-2004, the 35% decrease in production area caused a 16% decrease in production.

Table 1. Durum wheat production areas, yield, and production in Türkiye

Item	2002-2004[a]	2008-2010[a]	2012-2014[a]	2016-2018[a]	2020-2022[a]	Change (%)[b]
Production areas (ha)	1,870,000	1,336,333	1,250,366	1,225,895	1,221,462	-34.68
Yield (kg ha^{-1})	2,323	2,630	2,853	3,013	3,000	29.12
Production (tons)	4,333,333	3,324,000	3,558,333	3,673,333	3,633,333	-16.15

[a]Average of 3 years.
[b]This refers to the change in the 2020–2022 period compared to the 2002–2004 period.
Source: Created by authors based on the data from TURKSTAT (2023)[38].

Durum wheat export and import quantities and prices of Türkiye by year are given in Figure 1. Although durum wheat exports reached the highest level in 2005-2007, they were very low compared to import quantities. Durum wheat export prices ranged from $0.18 to $0.50 per kg, while import prices averaged between $0.22 and $0.46 per kg. While the import price was higher than the export price until 2008-2010, it had a reverse situation after these years. Although import quantities showed a continuous upward trend until 2017-2019, they started to decline after these years. Imported durum wheat is processed and exported as pasta. It is important to export an imported product with added value.

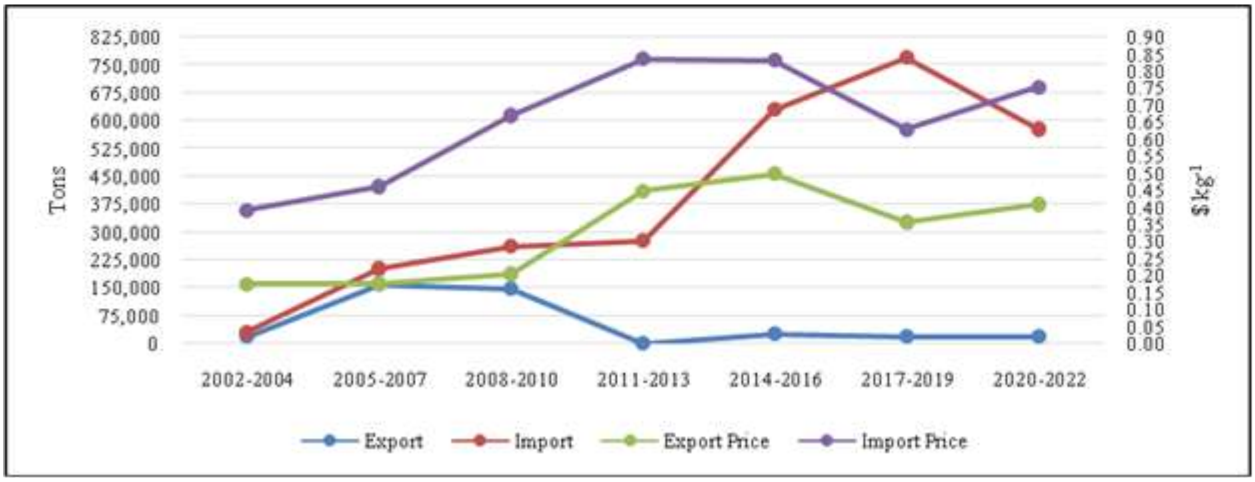

Fig. 1. Türkiye's durum wheat export and import quantities and prices by years
Source: Created by authors based on the data from TURKSTAT (2023) [38].

World pasta production reached 16.95 million tons as of 2021. Italy was the world's largest pasta producer, with a production of 3.89 million tons and a production share of 22.95%. Italy was followed by the USA at 11.80%, Türkiye at 11.22%, Egypt at 7.08%, Brazil at 6.97%, and Russia at 6.47% (Table 2). Compared to 2011, world pasta production increased by 22.16%. While Egypt increased its production the most in terms of quantity and percentage, Italy and Türkiye increased their production the most in terms of quantity.

The first 15 leading countries in pasta production accounted for approximately 87% of the world's pasta production.

Table 2. Pasta production and changes by country

Countries	2011	2021	Share (%)	Change (%)
Italy	3,246,488	3,890,467	22.95	19.84
USA	2,000,000	2,000,000	11.80	0.00
Türkiye	1,315,690	1,902,423	11.22	44.60
Egypt	400,000	1,200,000	7.08	200.00
Brazil	1,204,900	1,182,000	6.97	-1.90
Russia	1,083,000	1,096,912	6.47	1.28
Nigeria	--	700,000	4.13	--
Iran	560,000	560,000	3.30	0.00
Argentina	381,908	407,336	2.40	6.66
Peru	286,089	358,519	2.12	25.32
Tunisia	335,500	345,000	2.04	2.83
Germany	332,214	334,390	1.97	0.65
Mexico	330,000	302,456	1.78	-8.35
France	237,157	258,101	1.52	8.83
Chile	128,480	216,481	1.28	68.49
Top 15 Country Total	11,841,426	14,756,106	87.05	24.61
Other Countries	2,034,441	2,194,356	12.95	7.86
World	13,875,867	16,950,462	100.00	22.16

Source: UN.A.F.P.A., 2023 [39].

The limited cultivation area of durum wheat, which is the raw material of pasta, causes a large part of the pasta produced to be subject to trade. Although it varies from year to year, approximately 35% to 50% of the pasta produced is traded. Türkiye is the world's third-largest pasta producer and second-largest pasta exporter. The ten countries in Table 3 accounted for 71% of world pasta exports.

Table 3. Export quantity, value, and price of major pasta exporting countries

Countries	2009-2011[a] Quantity (tons)	2009-2011[a] Value (1000 $)	2014-2016[a] Quantity (tons)	2014-2016[a] Value (1000 $)	2019-2021[a] Quantity (tons)	2019-2021[a] Value (1000 $)	Price ($ kg^{-1})	Share (%) in 2019-2021	Change in Quantity (%)[b]
Italy	1,817,384	2,568,027	2,005,615	2,738,286	2,391,043	3,410,131	1.43	29.91	31.57
Türkiye	304,963	206,877	746,233	449,232	1,369,225	715,730	0.52	17.13	348.98
China	461,034	641,369	511,671	831,492	578,219	987,125	1.71	7.23	25.42
Republic of Korea	75,002	245,903	111,957	353,580	243,992	765,198	3.14	3.05	225.31
Thailand	119,446	281,502	163,707	404,577	219,800	591,608	2.69	2.75	84.02
Iran	27,717	23,703	62,097	55,294	160,538	64,891	0.40	2.01	479.21
USA	183,941	326,440	200,987	368,057	194,504	378,187	1.94	2.43	5.74
Indonesia	108,792	145,907	128,720	203,509	185,051	300,529	1.62	2.32	70.10
Belgium	132,188	298,749	148,981	285,370	180,661	334,579	1.85	2.26	36.67
Germany	84,949	202,870	112,180	228,460	150,021	332,194	2.21	1.88	76.60
Top 10 Country Total	3,315,416	4,941,347	4,192,148	5,917,857	5,673,054	7,880,172	1,39	70.98	71.11
World	4,863,312	7,335,690	6,064,157	8,949,034	7,992,935	11,827,554	1.48	100.00	64.35

[a]Average of 3 years.
[b]This refers to the change in the 2019–2021 period compared to the 2009–2011 period.
Source: Created by authors based on the data from ITC-TRADE MAP (2023) [18].

Regarding export prices, Thailand and the Republic of Korea had the highest at $2.69/kg and $3.14/kg, respectively, while Iran and Türkiye had the lowest at $0.40/kg and $0.52/kg, respectively. Italy, the leading country in world pasta production and exports, traded at an average price of $1.43/kg, close to the world average. The world average pasta export price was 1.48 $/kg. Türkiye has increased its exports approximately 4.5 fold in the last ten years and has the highest export increase in quantity. Saraçoğlu and Köse (2000) [29] emphasized that Türkiye's export unit price was 0.44 $/kg in 1993 and 0.55 $/kg in 1997.

Figure 2 shows the growth rates of pasta export value in Türkiye and the world. The pasta export value of Türkiye and the world increased until 2015. In 2015, there was a significant decrease, but after 2015, it started to increase again.

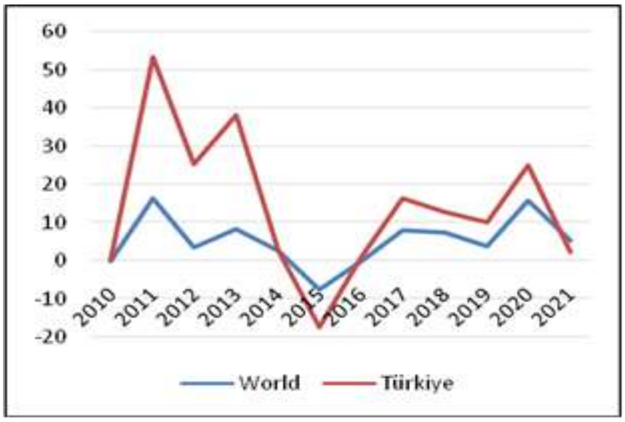

Fig. 2. The growth rate of pasta exports in Türkiye and the world
Source: Created by authors based on the data from ITC-TRADE MAP (2023)[18].

Although Türkiye exported pasta to 154 countries in 2021, more than half of its exports (52.71%) were to Venezuela, Somalia, Benin, Ghana, and Togo. Türkiye's pasta market was South America and African countries, while Italy, the world's largest exporter, exported to European Union countries such as Germany, France, and the United Kingdom. Koo & Bayaner (1998) [25] reported that the countries Türkiye exported the most were the USA, the Commonwealth of Independent States, Germany, Belgium-Luxembourg, and Romania. Saraçoğlu & Köse (2000) [29] stated that Russia and the USA were the most important markets of Türkiye in the 90s. It was emphasized that while the share of the Russian Federation in Türkiye's total pasta exports was approximately 10% in 1992, this share increased to 82.5% in 1997 and 79.7% in 1998. It was stated that the position of the USA showed a different change and that its share in Türkiye's total pasta exports decreased from 53.5% in 1992 to 1% in 1998.

As can be seen, Türkiye's export destinations have changed over time. The leading importer countries in the world pasta market are Germany, the USA, France, and the United Kingdom (Table 4). These countries mostly imported pasta from Italy. Although Türkiye has a say in the world pasta trade, its very low share in these markets is considered as a disadvantage.

Table 4. Import quantity, value, and price of major pasta-importing countries

Countries	2009-2011[a] Quantity (tons)	2009-2011[a] Value (1000 $)	2014-2016[a] Quantity (tons)	2014-2016[a] Value (1000 $)	2019-2021[a] Quantity (tons)	2019-2021[a] Value (1000 $)	Price ($ kg^{-1})	Share (%) in 2019-2021	Change in Quantity (%)[b]
Germany	502,729	723,314	519,587	761,675	572,157	899,836	1.57	7.83	13.81
USA	367,664	708,478	451,215	905,574	569,379	1,211,157	2.13	7.79	54.86
France	390,469	593,101	426,002	626,989	501,160	796,534	1.59	6.86	28.35
United Kingdom	375,928	523,032	373,043	572,206	459,889	763,513	1.66	6.30	22.33
Somalia	52,555	42,660	114,820	76,392	251,189	120,042	0.48	3.44	377.96
Venezuela	9,792	14,523	31,100	31,506	217,837	122,503	0.56	2.98	2,124.72
Canada	189,738	357,367	205,816	401,006	225,609	474,951	2.11	3.09	18.91
Netherlands	102,981	186,624	156,962	284,263	198,021	398,015	2.01	2.71	92.29
Japan	176,300	340,647	183,247	313,713	223,152	381,839	1.71	3.05	26.57
Belgium	100,755	201,116	146,608	200,007	179,752	268,056	1.49	2.46	78.41
Top 10 Country Total	2,268,910	3,690,863	2,608,398	4,173,330	3,398,145	5,436,446	1.60	46.52	49.77
World	5,827,355	8,141,047	5,799,174	8,418,238	7,305,208	11,230,805	1.54	100.00	25.36

[a]Average of 3 years.
[b]This refers to the change in the 2019–2021 period compared to the 2009–2011 period.
Source: Created by authors based on the data from ITC-TRADE MAP (2023) [18].

While the USA and Canada were the countries that imported pasta at the highest prices, Somalia, and Venezuela, which are important markets for Türkiye, had the lowest import prices.

The countries among the top ten in world pasta exports were evaluated as competitors of Türkiye in this sector, and the Relative Export Advantage Index (RXA) developed by Vollrath was calculated based on the export values covering 2012-2021. The RXA values of the world's top ten exporters in the pasta sector from 2012 to 2021 are presented in Table 5. The RXA values calculated for the selected countries showed different trends across countries in this period. The results indicated that seven countries, including Italy, Türkiye, the Republic of Korea, Thailand, Iran, Indonesia, and Belgium, have a comparative advantage in pasta exports because their RXA values are greater than 1.

In contrast, China, the USA, and Germany have a comparative disadvantage in pasta exports because their calculated RXA values are less than 1.

Koo & Bayaner (1998) [25] concluded that Türkiye could not compete against Italy in certain markets in international pasta trade, but in general, it was a country with high competitiveness. Saraçoğlu & Köse (2000) [29] reported that Türkiye has a disadvantage only against Italy in the pasta sector.

Table 5. RXA indexes of the world's major pasta exporters

Year	Türkiye	Italy	China	Republic of Korea	Thailand	Iran	USA	Indonesia	Belgium	Germany
2012	5.28	16.62	0.80	1.26	3.60	0.82	0.50	2.24	1.52	0.32
2013	6.60	16.21	0.73	1.18	3.79	1.61	0.45	2.33	1.33	0.29
2014	6.39	15.94	0.69	1.12	3.66	1.36	0.44	2.59	1.30	0.29
2015	5.71	15.26	0.64	1.19	3.65	1.60	0.46	2.43	1.29	0.30
2016	5.64	14.21	0.69	1.54	3.68	1.25	0.40	2.49	1.31	0.30
2017	6.10	13.24	0.68	1.71	3.62	1.15	0.40	2.58	1.38	0.31
2018	6.59	13.81	0.68	1.80	3.99	1.36	0.37	2.79	1.40	0.34
2019	6.31	13.67	0.63	2.08	4.14	1.64	0.36	2.91	1.26	0.33
2020	6.82	14.25	0.50	2.31	3.88	2.33	0.36	2.92	1.09	0.33
2021	6.29	13.77	0.50	2.49	4.24	1.93	0.38	2.32	1.18	0.37
Mean	6.17	14.70	0.66	1.67	3.82	1.51	0.41	2.56	1.30	0.32
CV	7.92	7.79	13.60	28.29	5.70	26.59	11.06	9.09	8.59	7.55

CV- Coefficient of variation.
Source: Calculated using Equation 1.

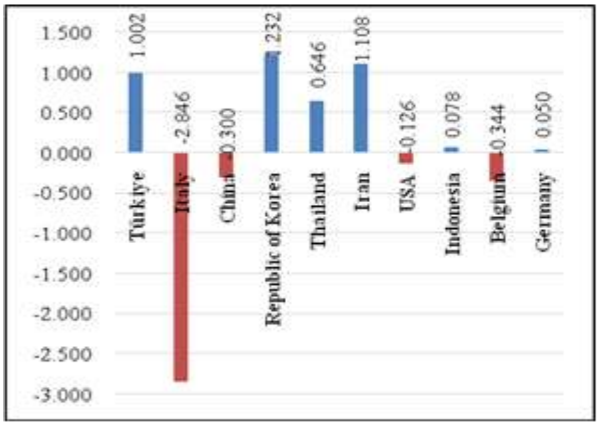

Fig. 3. Change in RXA of the world's major pasta exporters
Source: Created by authors.

Globally, Türkiye ranked second in pasta exports, fourth in export value, and second in RXA values after Italy. These results indicate that Türkiye has a comparative advantage in the pasta sector.

Figure 3 describes the changes in RXA values among selected countries from 2012 to 2021. The results showed that all countries have become more specialized in pasta exports except Italy, China, the USA, and Belgium.

The biggest improvement can be seen in the Republic of Korea, Iran, and Türkiye. Türkiye's specialization in this period is considered promising.

CONCLUSIONS

Türkiye is the largest pasta-producing country in the world, after Italy and the USA. The increased production quantity of pasta in recent years has led to an increase in pasta trade.

The pasta sector is an important sector with high export potential for Türkiye.

In this study, the world pasta sector was discussed, and the competitiveness of the exporting countries, including Türkiye, was analyzed in light of the last 10 years of data.

The most important problem in Türkiye's pasta sector is the good quality raw materials supply.

Especially in recent years, factories have increased their capacity to export more, which has caused this problem to grow even more (Taşcı et al., 2020a) [31].

Although the use of high-quality seeds and varieties suitable for the region partially solves the raw material problem, the decrease in durum wheat production day by day makes it necessary for the state to provide subsidies in this field.

A competitiveness analysis of the sector showed that Türkiye's competitiveness was high. Although the quotas and other barriers imposed by the European Union and the USA have caused Türkiye's target markets to change from the West to the East, they could not prevent Türkiye from having a say in the pasta sector. Italy is the undisputed leader in the pasta sector.

The differences in raw material supply and export prices reduce Türkiye's chances of competing with Italy. It was determined that China, the USA, and Germany, considered Türkiye's competitors in this sector, had a relative disadvantage, while the other competitors had a relative advantage.

The results showed that Türkiye was in a better position than its other competitors, except for Italy.

Finally, it should be said that if the problem of high-quality raw material supply is solved, there is no need to worry about Türkiye's competitiveness in the pasta sector.

In addition, accelerating the search for new markets and increasing the market share in actual markets are also important for the industry to move forward.

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ELASTICITY DYNAMICS AND TRADE BALANCE PERFORMANCE AS METRICS FOR FOOD SECURITY – AN ASSESSMENT OF ROMANIA'S SWINE MEAT MARKET

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Abstract

In addressing the critical interplay between market dynamics and food security within Romania's swine meat market, amidst evolving economic and social challenges, the research aimed to elucidate the roles of elasticity dynamics and trade balance performance in ensuring a high food security level. Utilizing data from 2011 to 2022, the analysis employed key elasticity metrics—price elasticity of demand (PED), income elasticity of demand (IED), factor elasticity of demand (FED), and income elasticity of the swine meat trade balance's deficit (IET)—to dissect the complex interactions configuring demand, supply, and international trade dependencies. The methodology was grounded on quantitative analyses, contrasting year-over-year and base-year elasticities to capture both immediate and longitudinal market responses to socio-economic stimuli. This detailed approach uncovered pertinent findings: despite general price inelasticity in swine meat demand, significant fluctuations in response to income changes and production factors were observed, with 2015 marking a year of heightened sensitivity due to external factors like the African swine fever outbreak. This study underscores the imperative of leveraging elasticity analyses to inform the development of agricultural policies aimed at enhancing domestic production, managing trade deficits, and ultimately reinforcing Romania's food security socio-economic infrastructure against the backdrop of global market volatilities and domestic supply constraints.

Key words: *swine meat market, elasticity analysis, trade balance performance, food security, market dynamics*

INTRODUCTION

In the aim of assuring food security, nations must traverse a complicated maze of economic, social, and environmental issues. Of these, the elasticity dynamics and trade balance performance are crucial variables that provide valuable insights into the resilience and stability of agricultural markets [4]. The deep consequences for Romania's food security are particularly visible in the country's swine meat business, where the complex interplay of supply, demand, and trade linkages is highly influential. Before delving into an evaluation of Romania's swine meat market, it is crucial to situate our investigation within the current corpus of academic research [25]. Extensive study has emphasized the significance of elasticity dynamics in comprehending market behaviour and adapting to changes in supply and demand. Economists, including Smith (2017) and Jones (2019), have clarified the idea of price elasticity of demand and its effects on consumer behaviour [19, 28, 29]. These studies emphasize the importance of using flexible strategies in agricultural production and marketing. Moreover, the correlation between the performance of trade balance and food security has received significant attention in scholarly circles [24, 26]. Scholars like Brown (2018) and Martinez (2020) have investigated the deep links between trade dynamics, domestic production capacity, and nutritional adequacy, emphasizing the significance of trade policies in affecting food security outcomes [10, 22]. Utilizing the extensive body of research available, this study seeks to enhance and expand current understanding by explicitly examining the market for swine meat in Romania [6]. Given the importance of the agricultural sector in the Romanian environment, it is necessary to conduct a focused evaluation, notwithstanding the rich insights provided by earlier research on broader agricultural trends [17]. The rapid and widespread transmission of African swine fever (ASF) in Eastern European Union countries, such as Romania, has had a significant influence on the swine meat market [27]. This has affected the evaluation of the changes in demand and supply and the trade balance performance, which are crucial for ensuring food security [9, 15]. Outbreaks of ASF have caused major interruptions in the production of swine meat, resulting in a fall in supply and subsequent changes in market dynamics [12]. The decrease in the availability of swine meat has probably caused an increase in its pricing, which in turn has affected the responsiveness of consumers to price changes, as they adapt their buying habits in response to the higher prices [14, 16]. Moreover, the implementation of trade limitations and prohibitions on the export of pork from impacted areas has upset the trade balance, worsening trade imbalances and potentially impacting Romania's overall food security by restricting the availability of alternative protein sources [20]. It is crucial to comprehend the influence of ASF on the Romanian swine meat market in order to evaluate the market's ability to withstand challenges and develop methods to minimize the consequences of ASF outbreaks on food security [23, 13]. The significance of trade balance performance as a criterion for guaranteeing food security within Romania's swine meat industry cannot be exaggerated. Like numerous other countries, Romania relies significantly on trade to supplement its domestic supply and satisfy consumer demand for pork [18]. Nevertheless, unexpected occurrences like the development of ASF can disturb the output at a local level, resulting in a decrease in supply and the possibility of increased prices [7]. During such situations, it is crucial to prioritize the maintenance of a positive trade balance in order to guarantee continuous access to swine meat and minimize the negative consequences of supply disruptions. Assessing the trade balance performance of Romania's swine meat sector provides important information about its ability to withstand challenges and maintain long-term viability [21]. The importance of elasticity dynamics in Romania's swine meat business resides in its potential to offer useful insights on market behaviour, flexibility to fluctuations in supply and demand, and overall resilience [1]. Examining the changes in elasticity in Romania's swine meat business allows policymakers and industry players to predict consumer behaviour and optimize the allocation of resources [5]. This sector is of significant economic and food security significance in Romania, which can improve market efficiency, promote stability, and strengthen its global position in the swine meat industry by utilizing elasticity dynamics [8]. An in-depth analysis of the elasticity dynamics and trade balance performance, incorporating the challenges related to ASF, offers a comprehensive understanding of the various factors influencing Romania's swine meat market. This highlights the significance of taking proactive measures to ensure food security in the event of ASF outbreaks [11].

Taking these aspects into consideration, as well as the necessity and opportunity to boost the Romanian swine industry on domestic and global markets, the objective of this research paper was to study the elasticity dynamics and trade balance performance as metrics for food security.

MATERIALS AND METHODS

The study utilized a comprehensive dataset spanning from 2011 to 2022, focusing on the Romanian swine meat market. Primary data sources included national statistical data series from Romania's National Institute of Statistics accessed via the TEMPO platform. Trade data were collected online from the United Nations Commodity Trade Statistics Database (UN Comtrade). Thus, specific datasets comprised annual figures on swine meat demand in Romania (measured in monthly kg per capita), the swine livestock numbers, average national income, and the trade balance deficit of swine meat (in thousand USD).

In this paper, the research framework was structured around the analysis of four key elasticities: price elasticity of demand (PED), income elasticity of demand (IED), factor elasticity of demand (FED), and the income elasticity of the trade balance's deficit (IET) in swine meat. Thus, each elasticity metric was calculated with the aim of assessing its impact on the dynamics of the swine meat market and implications for food security in Romania.

PED's aim was to assess the responsiveness of swine meat demand to changes in its price. In addition, IED was include in the analysis to ascertain how variations in national income levels affect the demand for swine meat. FED had the purpose of studying the impact of changes in the number of swine livestock on the domestic meat demand. Lastly, IET's objective was that of studying the relationship between the average national income growth and the trade balance deficit in swine meat.

The study adopted a quantitative research methodology, employing statistical methods to calculate each elasticity. The year-over-year elasticity was determined by comparing annual changes, while the base-year elasticity used the year 2011 as the base year for all subsequent calculations. Elasticity formulas were applied as follows: PED and IED were determined by using the standard elasticity formulas: the percentage change in quantity demanded divided by the percentage change in price or income, respectively. Following, FED was calculated by the percentage change in demand relative to the percentage change in the number of swine livestock. Lastly, IET was calculated based on the percentage change in the trade balance deficit of swine meat relative to the percentage change in the average income. The chosen elasticity metrics are pivotal for dissecting the complex nature of the Romanian swine meat market. Each metric offers unique insights into the market's responsiveness to different economic stimuli, providing a detailed perspective of the factors driving demand and supply.

RESULTS AND DISCUSSIONS

Consistent with methodologies documented in economic literature [2, 3, 9], the price elasticity of demand (PED) for swine meat was calculated by examining the ratio between changes in the demand and the corresponding price changes. The results were presented in Table 1, which included findings derived from two different methodologies: (a) the year-over-year analysis and (b) the base-year approach, with the year 2011 being considered as the reference year.

Table 1. Price elasticity of demand (PED)

Year	Demand (monthly kg per capita)	Price (monthly RON per capita)	Year-over-year PED	Base-year PED
2011	0.939	9.410	—	—
2012	0.986	10.610	0.393	0.393
2013	0.989	11.740	0.029	0.215
2014	1.043	12.200	1.394	0.374
2015	1.176	12.690	3.175	0.724
2016	1.194	13.100	0.474	0.693
2017	1.257	14.870	0.391	0.584
2018	1.283	16.690	0.169	0.474
2019	1.317	18.350	0.266	0.424
2020	1.352	22.390	0.121	0.319
2021	1.444	24.480	0.729	0.336
2022	1.514	28.220	0.317	0.306

Source: Authors' own calculations on the basis of TEMPO data [30].

The average monthly consumption of swine meat per capita (TEMPO code: BUF110J) was proxy for demand and the average monthly expenditure for swine meat per capita (TEMPO code: BUF114J) was considered proxy for the price.

Through these methodologies, insights into both the immediate and long-term effects of price variations on demand were provided, thereby enhancing the understanding of the Romanian swine meat consumer behavior.

The year-over-year PED values lower than one, such as 0.393 in 2012, 0.029 in 2013, and similarly low values in subsequent years, led to the finding that the swine meat demand can be considered inelastic. In these instances, a 1% increase in price resulted in less than a 1% decrease in demand, hence indicating that consumers were relatively insensitive to price changes. In addition, these PED patterns are typically noticed for goods that are considered as necessities, rather than luxury goods, as their consumption does not significantly differ with price increases or decreases.

The year 2015 was an outlier with the highest year-over-year PED: 3.175 that indicated a highly elastic swine meat demand specific to this period. This means that a 1% increase in the price of swine meat led to a 3.175% decrease in demand in 2015, showing a significant sensitivity to price changes.

From a food security perspective, the initial (2014 and 2015) higher PED elasticity values indicated that Romanians could have been vulnerable to swine meat price increases, potentially impacting their access to essential protein sources. When demand was elastic, it meant that consumers were likely to reduce swine meat consumption in response to price increases, which could have led to concerns about nutritional adequacy and food security, especially for the lower-income segment. The subsequent decrease in elasticity (indicating demand became more inelastic after 2015) could imply an improvement in economic resilience, market adjustments, or changes in food consumption patterns.

Transitioning to the base-year PED analysis, where 2011 served as the reference point, the empirical research findings ensured a broader perspective on the demand elasticity evolution in relation with a fixed point in time. Thus, this second elasticity quantification method complements the year-over-year findings by highlighting that apart from the outlier year of 2015, the demand for swine meat generally exhibited inelastic characteristics, considering that the Romanian consumers showed limited responsiveness to price changes. However, the base-year analysis added depth by showing a gradual shift in the degree of elasticity when viewed against the backdrop of a fixed year.

To gain a more comprehensive understanding of consumer behavior and the dynamics of swine meat demand, it is essential to consider the income elasticity of demand (IED) as well. This specific type of elasticity studied the responsiveness of the quantity demanded to a change in consumers' income in Table 2, providing different lens through which the Romanian swine meat demand was analyzed. While PED focused on price sensitivity, IED was specific to the analysis on how changes in income levels influenced demand for swine meat. A full comprehensive understanding of multiple elasticities is fundamental to ensure a comprehensive analysis of domestic demand.

Table 2. Income elasticity of demand (IED)

Year	Demand (monthly kg per capita)	Income (RON)	Year-over-Year IED	Base-year IED
2011	0.939	1,444	—	—
2012	0.986	1,507	1.147	1.147
2013	0.989	1,579	0.064	0.570
2014	1.043	1,697	0.731	0.632
2015	1.176	1,859	1.336	0.878
2016	1.194	2,046	0.152	0.651
2017	1.257	2,338	0.370	0.547
2018	1.283	2,642	0.159	0.442
2019	1.317	2,986	0.204	0.377
2020	1.352	3,217	0.344	0.358
2021	1.444	3,416	1.100	0.394
2022	1.514	3,801	0.430	0.375

Source: Authors' own calculations on the basis of TEMPO data [30].

The average monthly consumption of swine meat per capita (TEMPO code: BUF110J) was proxy for demand and the average monthly nominal net earnings (TEMPO code: FOM106E) were considered proxy for the income.

In 2012, an year-over-year IED of 1.147 was observed, indicating that a 1% increase in income led to a 1.147% increase in the swine meat demand. Thus, research findings showed that, initially, swine meat was considered a normal good, with demand increasing more than proportionally to income increases. The subsequent year, 2013, showed a significant drop in IED to 0.064, reflecting a much less sensitive response to income changes. Notably, in 2015, the IED reached 1.336, the highest in the observed period, underscoring a strong positive response in swine meat demand to income growth. This confirmed the characterization of swine meat as a normal good during periods of economic growth, with consumption being substantially increased in response to rising incomes. After 2015, while the trend in IED values generally indicates a stabilization or moderation of demand growth relative to income, the year 2021 stood out as an outlier, since this year was marked by a significant sensitivity increase of swine meat demand to income, proving the complexity of Romanian consumer behavior.

The IED fluctuations, particularly the high elasticity observed in 2012, 2015, and 2021 were found to carry implications for food security. In periods of economic growth, the rising incomes were seen to lead to increased demand in swine meat, which need to be met with adequate supply to ensure price stability and accessibility to all population segments.

The base-year IED value corresponding to the year 2015 (0.878) highlighted a peak in the sensitivity of demand to income compared to the base year. This peak was reflective of a particularly strong consumer response to increased income levels, possibly fueled by economic optimism or shifts in consumer preferences in Romania.

The PED analysis indicated that demand for swine meat was generally inelastic, except for a notable exception in 2015, suggesting that consumers were relatively insensitive to price changes most of the time. On the other hand, the IED findings showed periods of higher elasticity (2012, 2015, and 2021), therefore indicating that demand for swine meat was responsive to changes in income during these years. This correlation suggests that while consumers might not significantly reduce their swine meat consumption in response to price increases, consumption patterns are notably influenced by changes in income levels. The year 2015 was a highlight for both PED and IED analyses, with high elasticity observed in both dimensions, which might indicate a specific economic condition or consumer sentiment prevailing in that year, which made consumers both highly sensitive to price changes and highly responsive to income changes. It could reflect a period of economic optimism where consumers were willing to increase their spending on swine meat with rising incomes but were also cautious and responsive to price increases, possibly due to inflationary pressures or to other influencing economic factors. Policies aimed at stabilizing swine meat prices could be refined, knowing that Romanian consumers might continue to purchase swine meat despite price increases.

Following the insights gained from the PED and IED analyses, attention was shifted to the factor elasticity of demand (FED). Hence, this transition facilitated the exploration of another vital aspect of the Romanian swine industry dynamics: the impact that changes in meat production factors, specifically the number of swine livestock, had on the demand for swine meat. More specifically, the FED analysis from Table 3 examined how changes in the availability of a crucial production factor—livestock—affected consumption patterns.

Table 3. Factor elasticity of demand (FED)

Year	Demand (monthly kg per capita)	Livestock (number)	Year-over-year FED	Base-year FED
2011	0.939	5,363,797	—	—
2012	0.986	5,234,313	−2.073	−2.073
2013	0.989	5,180,173	−0.294	−1.555
2014	1.043	5,041,788	−2.044	−1.845
2015	1.176	4,926,928	−5.597	−3.099
2016	1.194	4,707,719	−0.344	−2.220
2017	1.257	4,406,014	−0.823	−1.897
2018	1.283	3,925,283	−0.190	−1.366
2019	1.317	3,834,136	−1.141	−1.412
2020	1.352	3,784,507	−2.053	−1.494
2021	1.444	3,619,581	−1.561	−1.654
2022	1.514	3,328,734	−0.603	−1.614

Source: Authors' own calculations on the basis of TEMPO data [30].

The average monthly consumption of swine meat per capita (TEMPO code: BUF110J) was proxy for demand and the swine livestock (TEMPO code: AGR201A) were considered proxy for the factor.

Thus, this transition from examining the role of consumer incomes to the analysis of the influence of production capabilities offered a more rounded and holistic understanding of the complexities within the swine meat market, while also highlighting the interplay between economic forces affecting consumer behavior and practical constraints on supply. This approach ensured a balanced approach in managing both demand and production factors to ensure market stability and food security.

Year-over-year FED values were calculated to assess the immediate impact of changes in livestock numbers on swine meat demand, and these values were consistently negative throughout the observed period. For instance, a significant negative FED value of −5.597 was recorded in 2015, signifying a substantial increase in demand, in spite of a decrease in swine livestock numbers, marking the highest responsiveness of demand to changes in the production factor within the dataset. This FED aspect highlights the importance of a resilient supply chain capable of adapting to changes in production factors. For food security, a resilient supply chain is critical to ensure that fluctuations in domestic production do not adversely affect the swine meat availability and affordability. Thus, the ability to maintain supply through imports or other means is vital in preventing food shortages or price spikes, but not sustainable. The combined PED, IED, and FED insights from the analyses in 2015 highlighted the challenges of the domestic Romanian market stability in the face of fluctuating domestic production and changing economic conditions. The reliance on imports to satisfy demand in the context of reduced livestock numbers can potentially lead to increased vulnerability to fluctuations in the global market and trade dynamics. For food security, this underscored the need for policies and strategies that actively support domestic swine meat production capabilities, diversify supply sources, and manage the dependency on imports to safeguard against crisis periods.

Following the detailed the exploration of the domestic market dynamics through the FED and its implications on domestic production and demand, the concept of income elasticity of the trade balance's deficit (IET) with swine meat was added into the research framework. This innovative approach had the purpose to assess the impact of changes in consumer income on the trade deficit for swine meat, thereby extending the analysis beyond the domestic market dynamics and included the dimension of Romania's international trade flows. The introduction of IET was a pivotal research development direction in the study of food security and economic interplays, while considering Romania's dependency on the imports of swine meat. By incorporating IET, the research framework was further enriched and provided insight into how income growth influenced the balance between domestic consumption and the reliance on imports to meet demand. This broader perspective was fundamental for the exploration of the interconnectedness of global trade outcomes with domestic economic conditions, providing overall depth and breadth of the research.

The negative year-over-year IET values from Table 4: −3.514 (2012), −1.196 (2015), and −0.367 (2020), indicated income increases associated with reductions in the trade deficit for pork, despite the fact that the end-to-start ratio of the deficit was 2.50.

Table 4. Income elasticity of the trade balance's deficit (IET)

Year	Swine meat deficit (thousand USD)	Income (RON)	Year-over-year IET	Base-year IET
2011	346,252	1,444		
2012	293,169	1,507	−3.514	−3.514
2013	315,465	1,579	1.592	−0.951
2014	326,576	1,697	0.471	−0.324
2015	289,302	1,859	−1.196	−0.572
2016	325,991	2,046	1.261	−0.140
2017	479,684	2,338	3.303	0.622
2018	577,110	2,642	1.562	0.804
2019	694,027	2,986	1.556	0.941
2020	674,307	3,217	−0.367	0.772
2021	714,592	3,416	0.966	0.779
2022	866,937	3,801	1.892	0.921

Source: Authors' own calculations on the basis of INTRACEN, UN Comtrade [31] and TEMPO data [30]. The average monthly nominal net earnings (TEMPO code: FOM106E) were considered proxy for the income.

This is alarming for the food security level, especially if taking the pork import price vulnerability into account, considering price volatility aspects.

Positive IET values in other years, and peaks like 3.303 in 2017 and 1.892 in 2022, implied that as national income rose, so did the trade deficit for swine meat, indicating an increased dependency on imports as incomes grew. The growing trade deficit in swine meat, as incomes rise, poses important questions for Romania's food security. It highlights the need for comprehensive policies to significantly enhance domestic production capacity, to improve efficiency in the Romanian swine industry, and to sustainably manage the trade deficit. In addition, ensuring that economic growth translates into improved domestic production capabilities could help mitigate the risk of over-reliance on imports for essential food items like swine meat.

Calculating the IET against a base year (2011) provided a longitudinal perspective on the elasticity of the deficit to changes in income over a longer period. Thus, previous findings based on the year-over-year IET were confirmed by the trend towards increasingly positive base-year IET values over time that culminated in the year 2022 (0.921). This suggested a growing sensitivity of the trade balance deficit to domestic income increases. Hence, a structural dependency on imported swine meat was reflected. It became more pronounced as the economy grew.

The insights derived from the IET analysis complement the findings from the PED and IED analyses by adding a new dimension, that of international trade, to the understanding of complex market dynamics. While PED and IED focused on domestic demand sensitivity to price and income changes, respectively, IET explored how these domestic economic conditions translated into international trade outcomes, particularly in terms of the trade balance deficit. Together, these elasticity analyses offer a comprehensive view of the Romanian swine meat market's response to economic growth, both within the domestic market and in the context of global trade.

CONCLUSIONS

The multidimensional exploration of various elasticities, including the price elasticity of demand (PED), income elasticity of demand (IED), factor elasticity of demand (FED), and income elasticity of Romania's trade balance's deficit (IET), spanning from 2012 to 2022, unveiled an insightful perspective on the forces shaping Romania's swine meat market. Through the analysis of both year-over-year and fixed-base elasticities, with 2011 serving as the benchmark year, nuanced findings were garnered regarding the dynamics between price, income, production factors, and trade balance deficits, as well as their collective influence on the demand and supply patterns within the Romanian swine sector.

This series of elasticity analyses shed light on the intricate nature of the Romanian swine meat market, revealing its susceptibility to influencing socio-economic factors such as consumer preferences, production capabilities, domestic and international economic trends. Particularly notable was the year 2015, which stood out across all metrics for its heightened price sensitivity, robust demand fueled by income growth, production factor shifts, and incoherent trade outcomes. The ASF's impact of the outbreak within the EU around this year added novel layers of complexity to the situation for the Romanian swine market. Consequently, these observed dynamics underscored the importance of a holistic approach to elasticity analysis in decoding market behaviors, guiding policy formulation, strategic market planning, and enhancing food security frameworks.

This elasticities research paper has significant implications for Romania's food security. The fluctuations in demand and supply underscore the country's vulnerabilities to the changes in market conditions. The observed elasticity trends, especially the constantly-increasing import dependency and the challenges posed by constantly- decreasing swine livestock numbers, highlight critical areas of concern for maintaining stable supplies and prices for swine meat in Romania. The analysis provides a framework for understanding how shifts in these variables can affect the availability and affordability of swine meat.

On one hand, Romania's reliance on imports to satisfy domestic demand for swine meat ensures that consumer needs are met, since current domestic production capabilities do no keep up with the demand, as highlighted by the FED and IET analyses. On the other hand, this dependency exposes the country to risks associated with global market fluctuations, trade policies, and international supply chain disruptions, which can lead to price volatility and potential shortages. By examining the income elasticity of the trade balance's deficit (IET), this study offers insights into how economic growth strategies could be aligned with efforts to mitigate the risks associated with swine meat import dependency.

Furthermore, the analysis of factor elasticity of demand (FED) emphasized the challange posed by the decreasing swine livestock. Results encourage policymakers and industry stakeholders to develop targeted interventions aimed at enhancing domestic production capabilities. This could involve investments in disease prevention and control, improvements in swine breeding and feeding efficiencies, and adoption of sustainable farming practices that can help reverse the trend of decreasing livestock numbers. Strengthening domestic production will contribute to the amelioration of the trade deficit in swine meat and it will also enhance the resilience of the food supply chain, thereby improving food security.

This research paper, while it does provide valuable insights into the dynamics of the Romanian swine meat market through the analysis of a variety of elasticities, it also carries inherent limitations that pave the way for future research directions. While the framework incorporates socio-economic and production factors, alongside international trade dynamics, it does not extensively delve into the nuances of external influences such as disease outbreaks, geopolitical shifts, and alterations in EU regulations and international trade agreements. These key-elements can significantly impact market conditions and food security. The methodological focus on elasticity, while it did provide a wellstructured approach to market responsiveness, it may not fully capture the complex interdependencies and the multifaceted nature of these external factors. This limitation underscores the need for a broader analytical lens in future research endeavors. An in-depth analysis of the impact of specific policies, regulatory changes, and trade agreements on the swine meat market would be valuable.

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THE ECONOMIC PROFITABILITY OF PEPPER CULTIVATED IN SOLAR SYSTEM IN CONVENTIONAL AND ORGANIC AGRICULTURE – CASE STUDY IN ROMANIA

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Abstract

The paper presents the analysis of the profitability threshold of bell pepper cultivation in the solar system in conventional farming and organic farming with proposed for the crop year 2022/2023. Thus, by using a system of indicators (specific indicators, result indicators and profitability indicators, production costs, capitalization prices and the degree of profitability per product unit can be estimated. Economic profitability is evaluated in terms of the use of production framework technologies in the production process and the rational use of raw materials, human and financial resources with the aim of obtaining low-cost and high-quality products. Agribusiness actions will always be based on crop profitability.The findings of the undertaken study can favourably influence farmers, giving them the opportunity to adjust their existing farm resources and capacities to achieve higher yields.

Key words: *profitability threshold, bell pepper culture in solar, conventional system, ecological system*

INTRODUCTION

Belonging to the Solanaceae family, pepper (*Capsicum annuum* L.) is considered a popular vegetable being one of the most widespread crops grown in greenhouses around the world [5]. Originally from Central and South America, the pepper is considered to be one of the oldest cultivated plants. Brought to Europe in 1943, it spread very quickly in Italy, France (16th century) and the Balkan Peninsula (17th century). In our country, first appeared the hot pepper from the western area, then the bell pepper and the donut from the southern part (18th-19th centuries) [8].

In our country, pepper is among the main cultivated vegetable crops, being an annual plant with a long production cycle. According to the Official Catalog of Cultivated Plant Varieties in Romania for the year 2023, more than 80 varieties of pepper (*Capsicum annuum* L, - Pepper) are registered, the most recommended and appreciated being those varieties or hybrids that ensure constant production over the entire period of vegetation, have an increased resistance to diseases and the fruits have a thick and uniform pulp [10].

Pepper fruits have multiple uses: fresh or cooked food, raw material in the canning industry, the food industry (food dyes) or the pharmaceutical industry (due to the capsaicin content) [6]. Peppers have a vitamin C content between 150-300 mg/100 g, this being influenced by the degree of maturity, the size or color of the fruits, but also by the cultivation conditions used (field, protected spaces) [3, 12].

Soil properties and nutrients have a high impact on bell pepper growth and yield quality [1].

Also, some authors comparatively studied sweet pepper cropping in plastic tunnels and open field, emphasizing the beneficial effect of crop protection in protected areas [11].

Under a proper fertilization and irrigation management, organic production of peppers is equivalent to that produced in conventional system [13, 4].

Investments in protected areas are largely used and their feasibility and advantages are justified by the fast income return [14].

The specialization and development of agricultural activities while lowering production costs characterize traditional agricultural systems. Ecological agricultural system can be represented by the min-max function, this means maximizing production while minimizing the negative side effects of agricultural activities [2].

According to the Eurostat database, in protected areas, peppers were grown on an area of 170 hectares in 2010, with a maximum of 550 hectares in the years 2018–2019. After having an upward trend from 2010 to 2019, the evolution of the pepper-cultivated area in protected spaces saw a little reduction by 1.85%, registering by the end of 2020 at just 540 hectares. For the next 3 years (2020-2022) the cultivated area remained constant, at 540 hectares, this being an increase of 217.6% compared to the cultivated area in 2010 (Fig.1).

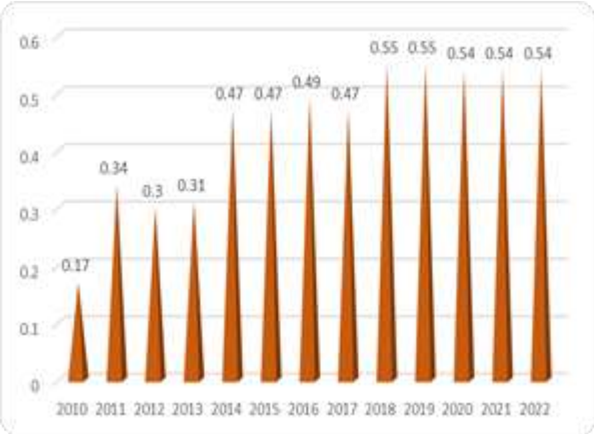

Fig. 1. The evolution of the area cultivated with peppers in protected areas in Romania in the period 2010-2022 (1,000 ha)
Source: Own design based on the data from [7].

Regarding the total production of peppers grown in protected areas (Fig. 2), for the analyzed period, it had an oscillating trend, varying from 3,540 tons in 2010 and a maximum of 19,030 tons in 2018, the productions being influenced by the cultivated areas but and the varieties used. Thus, compared to 2018, when a production maximum was recorded, in 2022 the production level decreased by 28.37%, reaching 13,630 tons.

The main reasons that led to the decrease in pepper production in protected areas are the rather high technological costs (energy and water for irrigation).

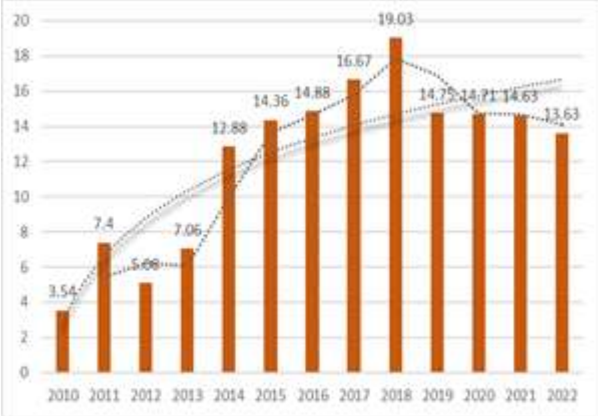

Fig. 2. The evolution of pepper production in protected areas in Romania in the period 2010-2022 (1,000 tons)
Source: Own design based on the data from [7].

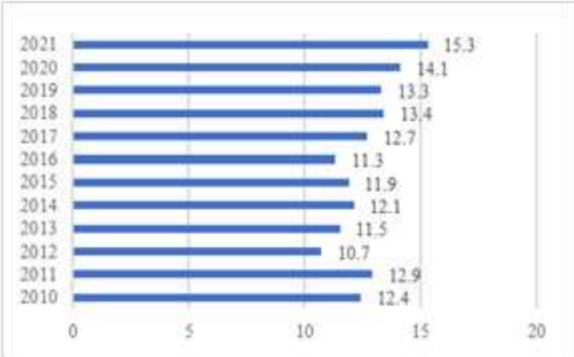

Fig. 3. Average annual consumption of peppers in Romania during 2010-2021 (kg/inhabitant)
Source: Own design based on the data from [9].

According to data from the National Institute of Statistics, between 2010 and 2021, Romania's average annual pepper consumption varied (Fig. 3). Thus, in 2010 the average annual consumption of peppers was 12.4 kg/inhabitant, reaching in 2021 a consumption of 15.3 kg/inhabitant, representing an increase of approximately 23.3%. In 2012, the lowest pepper consumption of 10.7 kg/inhabitant was recorded.

The objective of this study is to determine the economic profitability of solar peppers grown by conventional and organic methods in 2022/2023.

MATERIALS AND METHODS

Using the techno-economic analysis method, the profitability of pepper cultivation in conventional and organic farming systems was analyzed.

From a methodological point of view, the aim is to develop income and expenditure budgets at the level of the culture under study, differentiated according to the applied technologies, the level of allocation of the production factors, but also the yields per surface unit corresponding to the economic conditions for the two systems of culture, conventional and ecological.

The income and expenditure budget for pepper cultivation in solar includes elements of economic evaluation with final techno-economic indicators: costs, benefits, profitability and capitalization price estimates.

In this research, the production framework technologies for pepper culture in conventional and organic farming systems were adapted to the existing resources and conditions in Romania in the vegetable basin in the area of Buzău county and proposals were made for the year 2022/2023.

RESULTS AND DISCUSSIONS

Analysis of the income and expenditure budget for the bell pepper culture in solar grown in conventional farming system

The estimated average production of 35,000 kg/ha of bell pepper on land cultivated with traditional farming methods corresponds to a production value of 323,250.5 lei/ha. Adding 18,992.1 lei/ha of subsidies, the total production value is 342,242.6 lei/ha (Table 1). Variable costs account for 74% of total agricultural technology expenditure, which is 82% of total raw material and input consumption. Fixed costs account for 26% of total costs and 82% of consumption by permanent workers. If the total expenses are deducted from the production value, this results in taxable income of 53,875.1 lei/ha, final net income of 48,487.6 lei/ha and an income rate of 20%. The cost of production is calculated by dividing the total agricultural technology costs by the estimated average production and provides a general indication of the level of economic efficiency that can be achieved by growing bell pepper in solar using conventional farming methods.

Table 1. The income and expenditure budget for bell pepper culture in greenhouses, conventional system – estimated average production 35,000 kg/ha, calculations per hectare, proposed for 2022/2023

Indicator	UM	Value	
		lei	Euro*
A. Production value, of which:	lei	323,250.5	65,505
B (+). grants	lei	18,992.1	3,849
C (=) Gross product	lei	342,242.6	69,353
D (-) Total expenses	lei	269,375.4	54,587
I. Variable expenses	lei	198,749.0	40,275
II. Fixed expenses	lei	70,626.4	14,312
E (=) Taxable income	lei	53,875.1	10,917
E.1(-) Taxes and fees	lei	5,387.5	1,092
F (=) Net income + subsidies	lei	67,479.7	13,674
F.1 (=) Net income	lei	48,487.6	9,826
G. Rate of taxable income	%	20.0	20.0
H. Net income rate + subsidies	%	25.1	25.1
H.1 Net income rate	%	18.0	18.0
Production cost	lei/to	7,696.4	1,560
Predictable domestic market price	lei/to	9,235.7	1,872

*euro = 4.93477 lei
Source: processing own calculations.

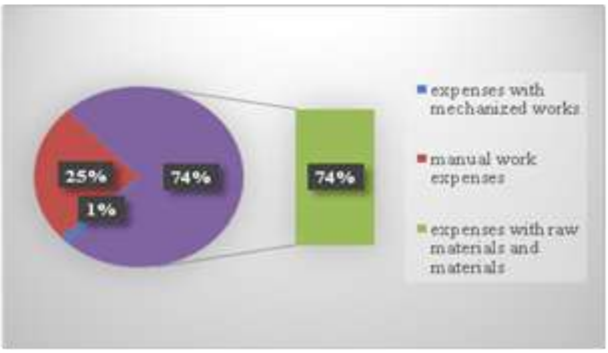

Fig. 4. The distribution of total agrotechnical expenses for bell pepper culture in solar in conventional farming system
Source: design based on own calculations.

Most of the production costs are concentrated on the work with raw materials and materials, so that, for the proposed for the bell pepper harvest in solar in the conventional farming system for the year 2022/2023, they represent 74% of the total production costs, followed by the costs of manual works with 25% and mechanized works with only 1% of the total costs (Fig. 4).

Analysis of the income and expenditure budget for bell pepper cultivation in solar grown in organic farming system

The estimated average production of 28,000 kg/ha of bell pepper cultivation in organically grown plantations is equivalent to a production value of 337,873.1 lei/ha, which when added to the subsidy of 18,992.1 lei/ha results a total realized production of 356,865.2 lei/ha (Table 2).

Table 2. Income and expenditure budget for bell pepper culture in greenhouses, ecological system – estimated average production 28,000 kg/ha, calculations per hectare, proposed for 2022/2023

indicator	UM	Value	
		lei	Euro*
A. Production value, of which:	lei	337,873.1	68,468
B (+). grants	lei	18,992.1	3,849
C (=) Gross product	lei	356,865.2	72,316
D (-) Total expenses	lei	259,902.4	52,668
I. Variable expenses	lei	194,860.5	39,487
II. Fixed expenses	lei	65,041.8	13,180
E (=) Taxable income	lei	77,970.7	15,800
E.1(-) Taxes and fees	lei	7,797.1	1,580
F (=) Net income + subsidies	lei	89,165.7	18,069
F.1 (=) Net income	lei	70,173.6	14,220
G. Rate of taxable income	%	30.0	30.0
H. Net income rate + subsidies	%	34.3	34.3
H.1 Net income rate	%	27.0	27.0
Production cost	lei/to	9,282.2	1,881
Predictable domestic market price	lei/to	12,066.9	2,445

*euro = 4.93477 lei
Source: processing own calculations.

Variable costs account for 75% of the total agricultural technology costs and 83% of the consumption of raw materials and inputs. Fixed costs account for 25% of total costs and 81% of permanent labor consumption. When total expenses are deducted from the production value, the taxable income is 77,970.7 lei/ha, resulting in a final net income of 70,173.6 lei/ha and an income rate of 30%. Production costs were calculated by dividing total agricultural technology costs by estimated average production as a general indicator of the level of economic efficiency that can be achieved by organic bell pepper cultivation in solar.

Most of the production costs are concentrated on the work with raw materials and materials, so that, for the proposed for the bell pepper harvest in solar in the organic farming system for the year 2022/2023, they represent 76% of the total production costs, followed by the costs of manual works with 23% and mechanized works with only 1% of the total costs (Fig. 5).

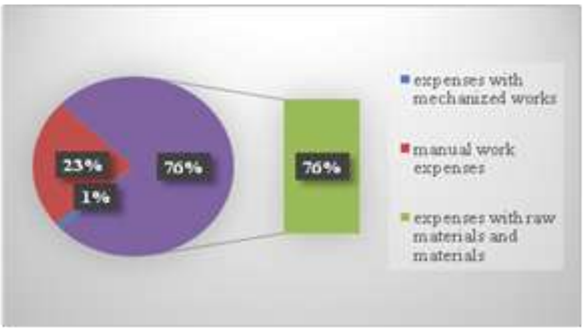

Fig. 5. The distribution of total agrotechnical expenses for the cultivation of bell peppers in solar in the organic farming system
Source: design based on own calculations.

Analysis of the total economic indicators for bell pepper cultivation under conventional and organic farming methods reveals the following:

- bell pepper is produced 20% less in the organic system than in the conventional system, but its production value is 5% higher than in the conventional system.
- the production value from the two systems exceeds the costs incurred by 20% in the conventional system and 30% in the conventional system.
- variable costs account for 74% of total technology costs in conventional systems and 75% in ecological systems, with the difference represented by fixed costs. Raw materials and supplies are 1.3% higher in the conventional system compared to the ecological system.
- the indicator referred to in the assessment of the economic efficiency of costs per unit of product is the unit production obtained, which is 7.7 lei/kg in conventional systems and 9.3 lei/kg in organic systems.
- the average collection price is 9.2 lei/kg for conventional systems and 30.6% higher for eco systems.
- the rate of return obtained was 20% in the conventional system and 30% in the organic system. Thus, solar bell pepper cultivation can be considered profitable in the conventional system with an average production of 19,900 kg/ha and a value of 183,371.5 lei, while in the ecological system this threshold is 12,700

kg/ha in physical units and 153,664 lei in value.

Table 3. Summary economic indicators for the culture of bell pepper in solariums, conventional and ecological system – proposed for 2022/2023

Economic indicators of synthesis	Conventional	Ecological	Deviations	
			UM	%
Average production per ha (to/ha)	35	28	-7.0	80
Production value per ha (lei/ha)	323,251	337,873	14,622	105
Production expenses per ha (lei/ha)	269,475	259,902	-9,573	96
Variable expenses (lei)	198,749	194,861	-3,888	98
Raw materials and materials (lei)	163,304	161,198	-2.106	99
Permanent labor costs (lei)	58,005	52,807	-5,198	91
Fixed expenses (lei)	70,626	65,042	-5,584	92
Unit production cost (lei/kg)	7.7	9.3	1.6	121
Capitalization price (lei/ton)	9,236	12,067	2,831	131
Labor productivity in physical expression (man-hours/ton)	80.4	91.4	11.0	114
Profit or loss per production unit (lei/ha)	53,875	77,971	24,096	145
Profit or loss per product unit (lei/ton)	1,539	2,785	1,246	181
Rate of return (%)	20	30	10	150
The profitability threshold in value units (lei)	183,372	153,664	-29,708	84
The profitability threshold in physical units (to)	19.9	12.7	-7.2	64
Exploitation risk rate (%)	56.7	45.5	-11.2	80
Security Index (Is)	0.4	0.5	0.1	125

Source: processing own calculations.

- The exploitation risk ratio is an indicator that estimates the risk of not realizing the expected production. In the case of bell pepper cultivation in solar, this indicator is 56.7% for conventional systems and 45.5% for ecological systems.
- the safety index represents the margin of security available to achieve the expected production and increases in the same direction as the value of the safety index. This indicator is 0.4 for conventional systems and 0.5 for ecosystem systems.

CONCLUSIONS

Bell peppers have a valuable position among vegetables due to their high nutritional value and medicinal properties. In Romania, the cultivation of bell pepper in solariums is a traditional occupation with agronomic and commercial advantages for the production obtained, due to the period in which it can appear on the market, the first decade of June, when it can be capitalized at a higher price.

Given that the unit production cost of producing 1 kg of bell peppers in solar in conventional farming system is 7.7 lei and 9.3 lei for bell peppers in solar in the organic system, then the profitability of this cultivation is noted for a profit prism of 1.5 lei/kg profit for cultivation in the conventional system and 2.7 lei for cultivation in the ecological system.

In addition, the break-even point represents the level of production, expressed physically or in terms of value, from which the value of the production achieved completely covers the costs incurred, that is, the level from which the culture starts to make a profit. Thus, profitability for bell pepper in solar in the conventional system corresponds to an average production of 19.9 to/ha or 183,371.5 lei, while in the ecological system this threshold is 36.1% lower in physical units and 16.2% lower in monetary units.

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SUSTAINABLE DEVELOPMENT OF THE YIELD AND QUALITY OF GRAIN CROPS DEPENDING ON ORGANIC AND MINERAL FERTILIZER SYSTEMS IN THE CONDITIONS OF UNSTABLE MOISTENING IN UKRAINE

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Abstract

The purpose of the article is to establish long-term dynamics and ways to increase the yield and quality of grain products in the conditions of unstable moistening in Ukraine based on the use of modern cost-effective and ecologically safe technologies, which include: scientifically based crop rotations with the effective use of highly productive and competitive varieties and hybrids of grain and leguminous crops, optimal combination of mineral and organic fertilizers with the use of by-products of the predecessors – straw of winter wheat, spring barley and peas, as well as stalks of corn. It was found that during 2016–2022, when applying the organo-mineral fertilization system, there was a rapid increase in yield compared to the control option without fertilizer application: winter wheat and corn for grain – by 17%, peas – by 30%, spring barley – by 32%; increase of all productivity indicators of short crop rotation – by 20–24%. When using an organic fertilization system, an increase in quality indicators is noted: in the grain of winter wheat and peas – protein, in the grain of corn and spring barley –digestible protein and starch. It was determined that the cultivation of highly productive and competitive corn for grain and winter wheat in a short crop rotation, as well as the reduction of costs when applying an organic fertilization system with the introduction of by-products of the predecessors, ensured the highest conditionally net profit – 12.8 thousand UAH/ha, as well as a high level of profitability – 121%.

Key words: *sustainable development, grain crops, short crop rotation, yield, grain quality, organic and mineral fertilization, unstable moistening, Ukraine*

INTRODUCTION

The dynamic growth of the global population, which increased more than 3 times during 1950–2022, and in 2050, according to UN forecasts, will increase to 9.7 billion people, is one of the global trends that causes a constant increase in food consumption [15; 19]. At the same time, along with the increase in soil degradation, during 1950–2022, the area of arable land for person decreased by 3 times, and in 2050 it will decrease by another 15% [3; 20]. This will lead to a significant increase in demand for food products, including grain products. Thus, the growth of world grain consumption depends on the increase in the number of the planet's population, and is one of the factors in increasing the volume of its production and export [3; 15]. In particular, during 2008–2022, there is a tendency to increase world grain production by 32% and world grain exports by 76% [15; 20]. In this context, it is important to use the biological potential of varieties and hybrids of grain crops, which is maximally realized thanks to the use of the organic component in innovative technologies [16; 17; 18]. Thus, to increase the yield and quality of grain products, as well as to improve soil processes, grain crops are grown in scientifically based crop rotations with the introduction of organic matter and nutrients in the form of organic and mineral fertilizers [1; 22; 26; 27]. For extended reproduction and stabilization of the soil fertility level, it is of great importance to use directly in the field the by-products of the predecessors – straw of grain crops and chopped stalks of row crops [10]. The necessity and relevance of the mentioned measures is determined by several circumstances. First of all, the integration of Ukraine into the European space requires the activation of domestic experience in the effective use of the organic component in innovative technologies for growing grain crops. Secondly, the practical significance of the results of scientific research is aimed at revitalizing the domestic market, ensuring a stable export potential, confirming economically profitable and ecologically safe production of high-quality grain products, as well as preserving the environment.

The use of straw of grain crops and chopped stalks of row crops as organic fertilizer in crop rotations is a publicly available, comprehensive and low-costless expensive measure, which is justified by the following factors: it provides the soil with organic matter and reduces the production costs associated with their collection, transportation and storage [10; 29]. When applied to the soil, by-products not only improve its physical and chemical properties [4; 12], and is also an effective means of combating water and wind erosion, improves the structure of the arable layer and reduces moisture evaporation [6; 11; 13; 28]. When by-products are wrapping before growing leguminous crops, nitrogen is additionally accumulated, which can be used by the following crop rotations [5; 7; 8]. With the use of such technologies, the natural fertility of soils and the environment is reproduced [14], the demand of consumers of the world market for high-quality grain products is satisfied [23; 24; 25].

The purpose of the article is to establish long-term dynamics and ways to increase the yield and quality of grain products in the conditions of unstable moistening in Ukraine based on the use of modern cost-effective and ecologically safe technologies, which include: scientifically based crop rotations with the effective use of highly productive and competitive varieties and hybrids of grain and leguminous crops, optimal combination of mineral and organic fertilizers with the use of by-products of the predecessors –straw of winter wheat, spring barley and peas, as well as stalks of corn.

MATERIALS AND METHODS

The research was carried out in a long-term field stationary experiment in the conditions of unstable moistening of the Left-Bank Forest-Steppe of Ukraine on the typical low-humus chernozem of the Panfil Research Station of the National Scientific Center «Institute of Agriculture of the National Academy of Agrarian Sciences of Ukraine». During 2016–2022, the effect of various organic and mineral fertilization systems on the yield and quality of production of grain crops grown in a four-field crop rotation was determined: peas – winter wheat – corn for grain – spring barley. In particular, the effectiveness of fertilization systems was determined: 1 – without fertilizers (control), 2 – mineral fertilization system (introduction of $N_{45}P_{55}K_{55}$), 3 – organo-mineral fertilization system (introduction of $N_{45}P_{55}K_{55}$ + by-products of the predecessors), 4 – organic fertilization system (introduction of by-products of the predecessors). The effectiveness of the elements of organic technologies was established: the use as of by-products of the predecessors – straw of winter wheat, spring barley, peas and corn stalks as organic fertilizer; the cultivation of peas in short crop rotation, which improved the soil structure and contributed to the effective accumulation of biological nitrogen.

The experiment was repeated three times. The size of the sowing area is 90 m^2, the accounting area is 40 m^2. Placement of plots is randomized. The technology of growing agricultural crops in the experiment is generally accepted and recommended for conditions of unstable moistening in the Left-Bank Forest-Steppe of Ukraine.

The object of the study is varieties of winter wheat – Kraevyd, spring barley – Image, peas

– Hajduk; corn hybrid – KWS KAVALIER F1. Grain samples were taken according to DSTU 3355-96, DSTU ISO 13690:2003; grain quality was determined according to DSTU 4117:2007, DSTU 3768:2019. Productivity and economic efficiency of various fertilization systems in short crop rotation were determined using an improved methodology developed on the basis of modern methods of calculating productivity and economic efficiency indicators using technological maps [8; 10; 29]. To confirm the reliability of the obtained experimental data, with the help of dispersive analysis the smallest significant difference was determined–SD_{05}.

The climate of the research area is moderately continental. The soils are characterized by a high content of humus – 3.18%, phosphorus – 146 mg/kg of soil and exchangeable potassium – 102 mg/kg of soil, low nitrogen content – 123 mg/kg of soil. The reaction of the soil solution pH-salt is weakly acidic – 5.7, the degree of saturation with bases is high – 85–99%.

The indicators of air temperature and amount of precipitation in the years of the study differed slightly from the average multi-year norm, as well as between years, as a result of which the yield and quality of grain crops changed. According to the observations of the Yagotyn Meteorological Station, the average long-term norms are: air temperature – 7.3°C, precipitation amount – 442 mm. Compared with the average long-term norms, during 2016–2022, the air temperature was higher by 2.4°C, the amount of precipitation was lower by 5 mm. It was found that 2016, 2018 and 2021 were marked by the higher amount of precipitation, where 594, 449 and 555 mm fell, respectively. Precipitation was almost within normal limits in 2020 and 2022 – 439 and 441 mm, respectively. 2017 and 2019 were characterized by a significant moisture deficit, where precipitation was 265 and 319 mm, respectively. In general, during the years of research, weather conditions were favorable for obtaining high yield and quality of grain crops, but with some contrasting periods, that is, rainless and excessively dry periods in the summer months, especially in 2017, 2019 and 2022.

RESULTS AND DISCUSSIONS

Analysis of the structure of world grain production in 2022 shows that the largest share belongs to four leading grain crops: corn – 42%, wheat – 28%, rice – 18%, barley – 6% and other grains – 6% (Fig. 1) [20]. In Ukraine, the largest share of grain production is somewhat consolidated and belongs to three leading grain crops: corn – 49%, wheat – 38%, barley – 10% and other grains – 3% [21].

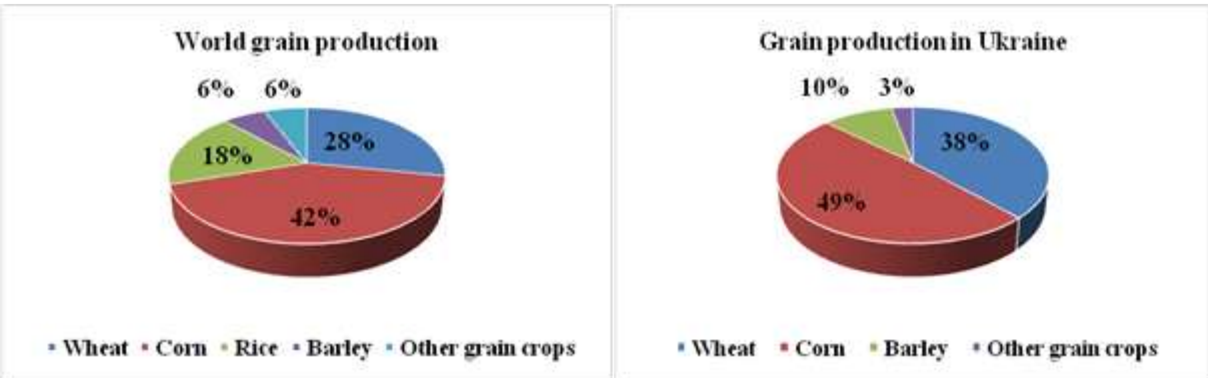

Fig. 1. The structure of world and national grain production, 2022
Source: Own design based on the data from [20; 21].

We will analyze the effectiveness of technologies for growing leading grain crops in a scientifically based short crop rotation depending on different levels of intensification. In particular, on average for 2016–2022, the yield level of winter wheat after peas with the introduction of organic and mineral fertilizers was within 4.81–5.51 t/ha

(Table 1). When using the organo-mineral fertilization system, the highest yield of winter wheat was obtained – 5.51 t/ha, which is higher than the control variant without fertilizer application by 0.85 t/ha. When applying the mineral fertilization system, the yield of winter wheat exceeded the control option by 0.75 t/ha. When introduction only by-products of the predecessor in the form straw of peas, the yield increases of winter wheat amounted to 0.15 t/ha.

Table 1. Yield and grain quality of winter wheat depending on fertilization systems in short crop rotation, 2016–2022

№	Fertilization system of winter wheat	Yield, t/ha	Glassiness, %	Protein, %	Gluten, %
1	No fertilizers (control)	4.66	44	11.1	21.6
2	Mineral ($N_{60}P_{60}K_{60}$)	5.41	46	11.2	21.9
3	Organo-mineral ($N_{60}P_{60}K_{60}$ + by-product of the predecessor – straw of peas)	5.51	56	11.5	26.3
4	Organic (by-product of the predecessor – straw of peas)	4.81	51	11.6	24.8
	SD_{05}	1.23	17	0.7	1.8

Source: authors' own results.

It is of great importance to determine the quality indicators of winter wheat grain, which are conventionally divided into three groups: physical (glassiness), biochemical (protein) and technological (gluten) [9]. When the glassiness of the grain increases, its mechanical strength is ensured [8; 29]; protein-starch processes improve; the content of protein and gluten increases, thanks to which the baking properties and nutritional value of bread improve [2]. On average, in winter wheat grain, the indicated indicators are: glassiness – 40–60%, protein – 11–14%, gluten – 18–28% [29].

During 2016–2022 the effectiveness of the application of fertilization systems with the introduction of by-products of the predecessor in the form straw of peas was established, which contributed to the growth of all winter wheat grain quality indicators. In particular, the application of the organo-mineral fertilization system provided the highest glassiness of winter wheat grain – 56%, which exceeded the control option without fertilizer application by 12%. A high degree of glassiness was obtained when applying an organic fertilizer system – 51%, which exceeded the control option by 7%. At the same time, the glassiness of winter wheat grain decreased to 46% when only mineral fertilizers were applied. This indicator exceeded the control variant by only 2%.

The highest protein content in winter wheat grains was obtained with the application of organic fertilizer in the form straw of peas– 11.6%, which exceeded the control option without fertilizer application by 0.5%. When using the organo-mineral fertilization system, the protein content in winter wheat grains was high and amounted to 11.5%. When only mineral fertilizers were applied, the protein content decreased to 11.2%, which exceeded the control variant by only 0.1%. The high content of gluten in winter wheat grains was provided by the organo-mineral fertilization system – 26.3%, the organic fertilization system – 24.8%. The specified indicators of gluten content exceeded the control option without fertilizers by 3.2–4.7%. When using the mineral fertilizer system, compared to the control option, the gluten content increased by only 0.3%.

In the unfavorable 2017, 2019, and 2022, the yield level of winter wheat decreased somewhat. At the same time, cultivation after the leguminous predecessor, as well as mineral fertilization and application straw of peas as an organic fertilizer, reduced the negative impact of weather conditions and did not affect the quality indicators of winter wheat grain. Therefore, when growing winter wheat in a short crop rotation, the use of organo-mineral and organic fertilization systems using by-products of the predecessor – straw of peas, where the highest yield and

quality indicators of winter wheat grain – glassiness, protein and gluten – were obtained.
The efficiency of growing corn for grain in a short crop rotation after winter wheat depended on different levels of intensification. In particular, on average for 2016–2022, when applying organic and mineral fertilizers, the level yield of corn for grain was within 7.19–7.72 t/ha, which is 0.63–1.16 t/ha more than the control variant without fertilizers application (Table 2). The highest yield of corn for grain was obtained when using the organo-mineral fertilization system – 7.72 t/ha, which exceeds the control variant by 18%. A high yield of corn for grain was obtained when applying: mineral fertilizer system – 7.58 t/ha, which ensured a 16% increase; organic fertilizer system – 7.19 t/ha, which contributed to a 10% increase.

Table 2. Yield and grain quality of corn depending on fertilization systems in short crop rotation, 2016–2022

№	Fertilization system of corn for grain	Yield, t/ha	Digestible protein, %	Fat, %	Starch, %
1	No fertilizers (control)	6.56	8.4	4.1	71.9
2	Mineral ($N_{60}P_{60}K_{60}$)	7.58	8.1	4.4	72.2
3	Organo-mineral ($N_{60}P_{60}K_{60}$ +by-product of the predecessor – winter wheat straw)	7.72	8.9	4.3	72.5
4	Organic (by-product of the predecessor – winter wheat straw)	7.19	9.0	4.5	72.6
SD_{05}		1.62	1.3	0.3	1.2

Source: authors' own results.

The analysis of corn grain quality indicators proved the effectiveness of the application of fertilization systems with introduction of by-products of the predecessor as winter wheat straw. In particular, the use of an organic fertilization system provided the highest quality indicators of corn grain: digestible protein – 9.0%, fat – 4.5%, starch – 72.6%. When using the organo-mineral fertilization system, these indicators were high and amounted to: digestible protein – 8.9%, fat – 4.3%, starch – 72.5%. When using the mineral fertilizer system, digestible protein in corn grain decreased to 8.1%, starch to 72.2%, although with some increase in fat to 4.4%.
In the humid 2016, 2018 and 2021, the level yield of corn for grain increased significantly. However, in the unfavorable 2017, 2019 and 2022, a slight decrease in the digestible protein content of corn grain was noted. At the same time, mineral fertilization and the introduction of winter wheat straw as an organic fertilizer reduced the negative impact of weather conditions and did not affect other grain quality indicators. Thus, when growing corn for grain in a short crop rotation, the use of organo-mineral and organic fertilization systems using by-products of the predecessor – winter wheat straw, where the highest yield and quality indicators of corn grain – digestible protein, fat and starch – were obtained.
Different levels of intensification influenced the production efficiency of spring barley, which was grown in a short crop rotation after corn for grain (Table 3).
In particular, on average for 2016–2022, the yield level of spring barley with the application of organic and mineral fertilizers was in the range of 4.02–4.91 t/ha, which is higher than the control variant without the application of fertilizers by 0.34–1.23 t/ha. It should be noted that the highest yield of spring barley was obtained when using the organo-mineral fertilization system – 4.91 t/ha, which exceeds the control variant by 32%. A high yield of spring barley was obtained when the mineral fertilizer system was applied – 4.74 t/ha, which provided a 29% increase.
When applying the organic fertilization system, which involved the introduction of by-products of the predecessor as corn stalks, compared to the control variant, an increase in spring barley yield was ensured by 9%.

Table 3. Yield and grain quality of spring barley depending on fertilization systems in short crop rotation, 2016–2022

№	Fertilization system of spring barley	Yield, t/ha	Protein, %	Cellulose, %	Starch, %
1	No fertilizers (control)	3.68	11.3	4.7	61.1
2	Mineral ($N_{60}P_{60}K_{60}$)	4.74	12.0	4.4	62.2
3	Organo-mineral ($N_{60}P_{60}K_{60}$ + by-product of the predecessor – corn stalks)	4.91	12.1	4.9	62.3
4	Organic (by-product of the predecessor – corn stalks)	4.02	11.9	5.1	62.5
SD_{05}		1.01	0.7	0.5	1.4

Source: authors' own results.

The analysis of spring barley grain quality indicators proved the effectiveness of applying fertilization systems with introduction of by-products of the predecessor as corn stalks. In particular, the introduction of an organo-mineral system of fertilization provided the highest protein content – 12.1%, which exceeds the control variant without fertilization by 0.8%. High levels of cellulose content – 4.9%, starch – 62.3% were also noted. When applying the organic fertilizer system, the highest indicators were obtained: cellulose content – 5.1%, which exceeds the control variant by 0.4%; starch – 62.5%, which exceeds the control variant by 1.4%. A high rate of protein content was noted – 11.9%. When applying the mineral fertilization system, the cellulose content in spring barley grain decreased to 4.4%, starch content to 62.2%, although with some increase in protein content to 12.0%.

A slight decrease in yield and protein content of spring barley grain was established in the unfavorable 2017, 2019 and 2022. However, the application of corn stalks as organic fertilizer along with mineral fertilizer reduced the negative impact of weather conditions and did not affect other grain quality indicators. In humid 2016, 2018 and 2021, the cellulose level in spring barley grain increased. Therefore, when growing spring barley in a short crop rotation, it is of great importance to use organo-mineral and organic fertilization systems using the by-products of the predecessor – corn stalks, where the highest yield and quality indicators of spring barley grain – protein, cellulose and starch – were obtained.

The efficiency of growing peas in a short crop rotation after spring barley depended on different levels of intensification. In particular, on average for 2016–2022, the yield level of peas with the application of organic and mineral fertilizers was in the range of 4.05–4.65 t/ha, which provided an increase compared to the control variant without the application of fertilizers by 0.51–1.11 t/ha (Table 4). It should be noted that the highest yield of peas was obtained when using the organo-mineral fertilization system – 4.65 t/ha, which exceeds the control variant by 31%. A high yield of peas was obtained with the introduction of a mineral fertilizer system – 4.40 t/ha, which provided a 24% increase.

Table 4. Yield and grain quality of peas depending on fertilization systems in short crop rotation, 2016–2022

№	Fertilization system of peas	Yield, t/ha	Protein, %	Digestible protein, %
1	No fertilizers (control)	3.54	19.9	18.6
2	Mineral ($P_{40}K_{40}$)	4.40	20.4	19.3
3	Organo-mineral ($P_{40}K_{40}$ + by-product of the predecessor – spring barley straw)	4.65	20.9	19.5
4	Organic (by-product of the predecessor – spring barley straw)	4.05	20.8	19.4
SD_{05}		1.05	0.5	0.6

Source: authors' own results.

When applying the organic fertilization system, which involved the introduction of by-products of the predecessor as spring barley straw, compared to the control variant, the increase yield of peas was ensured by 14%.

The analysis of peas grain quality indicators proved the effectiveness of the application of fertilization systems with introduction of by-products of the predecessor. In particular, the use of the organo-mineral fertilization system ensured the highest quality indicators of peas grain: protein – 20.9%, digestible protein – 19.5%. The organic fertilization system contributed to obtaining high protein values – 20.8%, digestible protein – 19.4%. When using a mineral fertilizer system, protein in peas grains decreased by 20.4% and digestible protein by 19.3%.

In the humid 2016, 2018 and 2021, the level of peas grain yield increased significantly. Mineral fertilization and introduction of spring barley straw as an organic fertilizer ensured the highest quality indicators. Thus, obtaining the highest yield and quality indicators of peas grain – protein and digestible protein was facilitated by the growing peas in a short crop rotation with the use of by-products of the predecessor – spring barley straw as part of organo-mineral and organic fertilization systems.

It was established that, on average, for 2016–2022, high performance indicators of short crop rotation were ensured thanks to the use of mineral, organo-mineral and organic fertilization systems. In particular, the yield of grain crops was 5.05–5.72 t/ha, including food grain – 1.21–1.43 t/ha, fodder grain – 3.84–4.29 t/ha. Production of grain units was 6.48–7.13 t/ha, fodder units – 8.87–9.77 t/ha, digestible protein – 0.72–0.79 t/ha (Fig. 2).

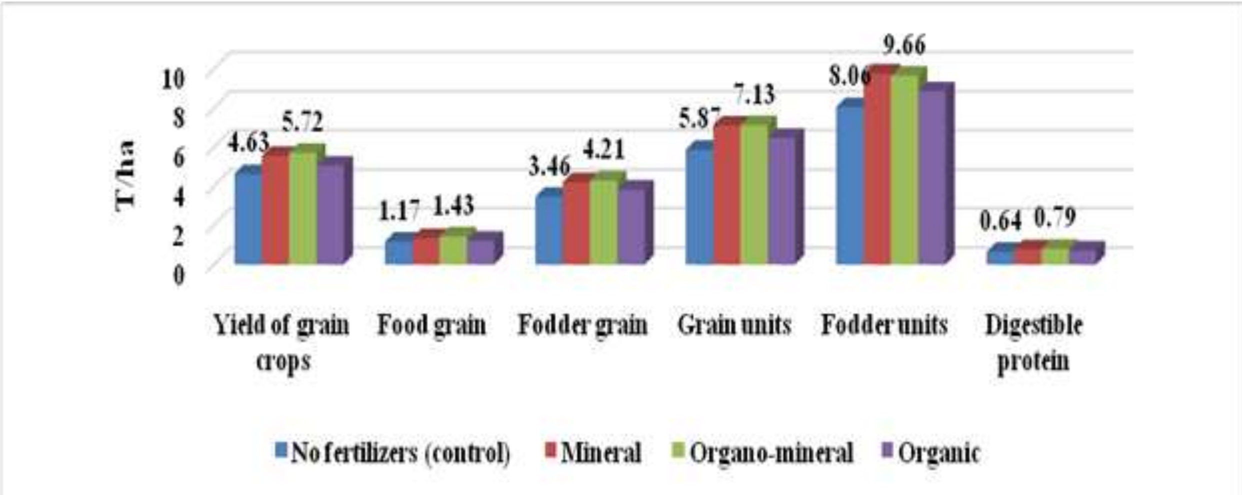

Fig. 2. Productivity of short crop rotation depending on fertilization systems, 2016–2022
Source: authors' own results.

The highest indicators of short crop rotation productivity were obtained with the introduction of the organo-mineral fertilization system: the yield of grain crops was 5.72 t/ha, including food grain – 1.43 t/ha, fodder grain – 4.29 t/ha. The collection of grain units was 7.13 t/ha, fodder units – 9.66 t/ha, digestible protein – 0.79 t/ha. When applying the mineral fertilization system, productivity indicators decreased slightly: the yield of grain crops – up to 5.56 t/ha, including food grain –up to 1.35 t/ha, fodder grain –up to 4.21 t/ha. The collection of grain units was 7.11 t/ha, fodder units – 9.77 t/ha, digestible protein – 0.78 t/ha. When applying the organic fertilization system in short crop rotation with introduction of by-products of the predecessors, high productivity indicators were noted: the yield of grain crops – 5.05 t/ha, including food grain – 1.21 t/ha, fodder grain – 3.84 t/ha. Harvest of grain units was 6.48 t/ha, fodder units – 8.87 t/ha, digestible protein – 0.72 t/ha.

In the unfavorable 2017, 2019 and 2022, a slight decrease in all productivity indicators of short crop rotation was noted, while mineral fertilization and introduction of by-products of the predecessors as organic fertilizer reduced the negative impact of weather conditions. In the humid 2016, 2018 and 2021, productivity indicators of short crop rotation increased significantly.

On average, for 2016–2022, the economic indicators of short crop rotation depended significantly on the cultivation of highly productive and competitive winter wheat and corn for grain, the fertilization systems, and weather conditions. Thus, the highest conditionally net profit, which amounted to 12.8 thousand UAH/ha, was obtained when applying the organic fertilization system with the introduction of by-products of the predecessors (Fig. 3).

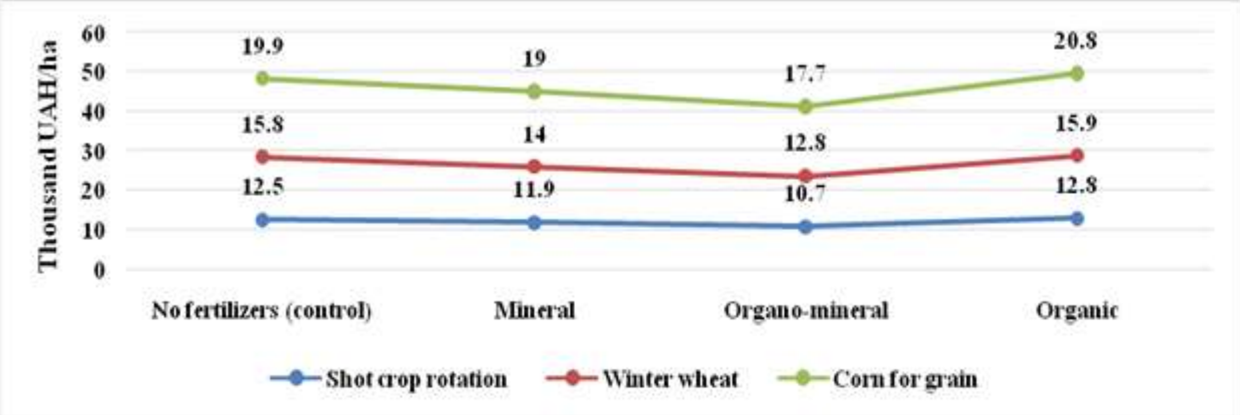

Fig. 3. Conditionally net profit of growing corn for grain, winter wheat and in general in short crop rotation depending on fertilization systems, 2016–2022
Source: authors' own results.

Thanks to a significant reduction in total costs to 10.6 thousand UAH and the cost of grain to 2.09 thousand UAH/t, even with a decrease in yield to 5.05 t/ha and the total cost of gross production to 23.4 thousand UAH, received a high the level of profitability – 121% (Figs. 4 and 5). When using the mineral component in organo-mineral and mineral fertilizer systems, the total costs increased by 3.2–5.2 thousand UAH and the cost of grain by 0.39–0.67 thousand UAH/t, which led to a conditional decrease net profit by 0.9–2.1 thousand UAH/ha and the level of profitability – by 35–53%, although even at the highest level of yield of grain crops – 5.56–5.72 t/ha and the total cost of gross production – 25.7–26.5 thousand UAH.

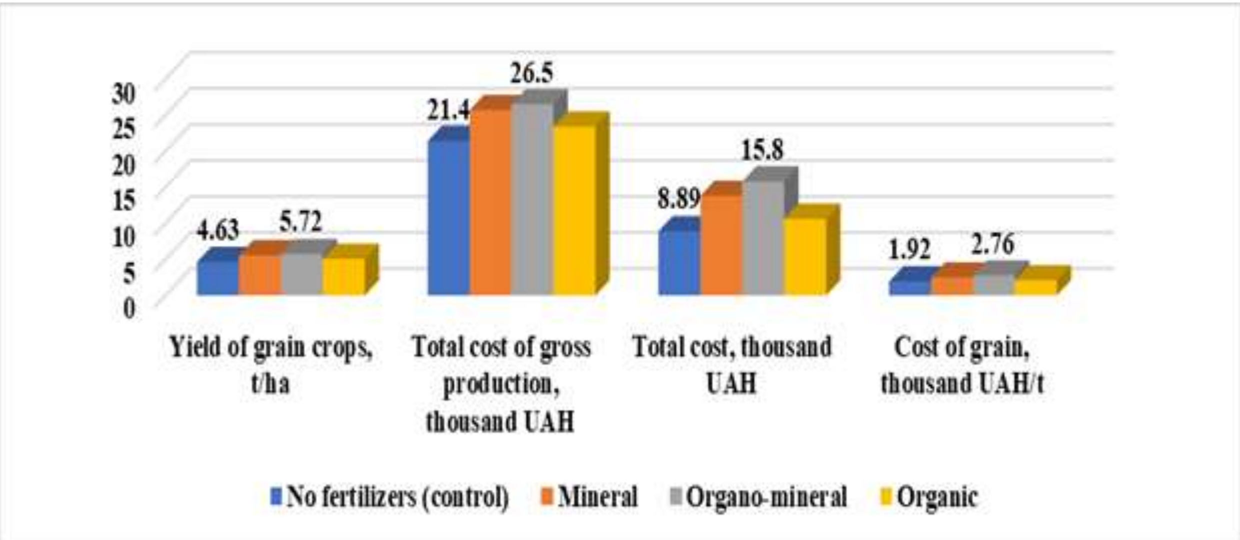

Fig. 4. Economic efficiency of fertilization systems in short crop rotation, 2016–2022
Source: authors' own results

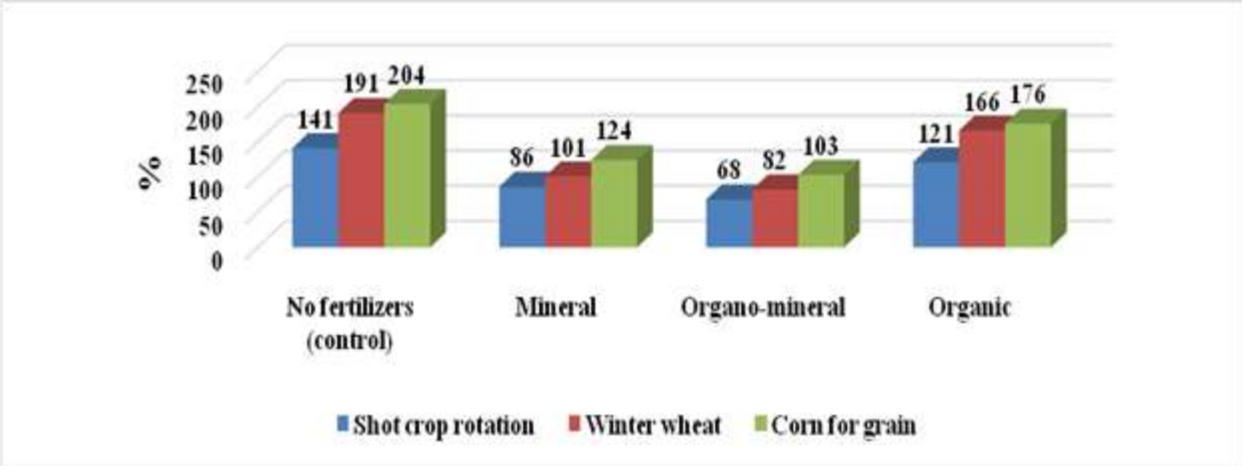

Fig. 5. The level of profitability of growing corn for grain, winter wheat and in general in short crop rotation depending on fertilization systems, 2016–2022
Source: authors' own results.

The most profitable was the cultivation of highly productive and competitive winter wheat after peas and corn for grain after winter wheat in a short crop rotation, where an organic fertilization system was used with the introduction of predecessor straw.

In particular, received the highest conditional net profit of 15.9–20.8 thousand UAH/ha and a high level of profitability – 166–176% due to a significant reduction in total costs and cost of grain.

When using the mineral component in organo-mineral and mineral fertilization systems, the total costs and cost of grain increased significantly, which led to a decrease in conditional net profit by 1.8–3.1 thousand UAH/ha and the level of profitability – by 52–84%.In the unfavorable 2017, 2019 and 2022, a slight decrease in all indicators of economic efficiency in short crop rotation was noted, at the same time, mineral fertilization and introduction of by-products of predecessors as organic fertilizer reduced the negative impact of weather conditions. In the humid 2016, 2018 and 2021, indicators of economic efficiency in short crop rotation increased significantly.

CONCLUSIONS

It was established that, on average, for 2016–2022, the growing highly productive and competitive varieties and hybrids of grain crops in short crop rotation, the use of by-products of predecessors as part of organo-mineral and organic fertilization systems, contributed to obtaining the highest yield and quality indicators of grain of winter wheat, spring barley, peas and corn, especially in conditions of unstable moistening in Ukraine. In particular, when using the organo-mineral fertilization system, there is a rapid increase in yield compared to the control variant without fertilizer application: winter wheat and corn for grain – by 17%, peas – by 30%, spring barley – by 32%, in short crop rotation – by 24%. With the application of organo-mineral and organic fertilization systems, winter wheat grain increased: glassiness by 7–12%, protein – by 0.4–0.5%, gluten – by 3.2–4.7%. In corn grain, digestible protein increased by 0.5–0.6%, fat by 0.2–0.4%, starch by 0.6–0.7%. In spring barley grains, the following increased: protein by 0.6–0.8%, cellulose– by 0.2–0.4%, starch – by 1.2–1.4%. In peas for grain, protein increased by 0.9–1.0%, digestible protein by 0.8–0.9%.

The highest productivity indicators were obtained when using the organo-mineral fertilization system, which increased by 20–24% compared to the control variant without fertilizer application. Cultivation in a short crop rotation of highly productive and competitive corn for grain and winter wheat, as well as reducing costs when applying an organic fertilization system with the introduction of by-products of the predecessors, ensured the highest conditional net profit – 12.8 thousand UAH/ha, as well as a high level of profitability – 121%. At the same time, a significant increase in the cost of applying mineral fertilizers led to a decrease in these indicators by 7–16% and 35–53%, respectively. In years with unfavorable weather conditions, the scientifically based rotation of crops in short crop rotation, the optimal combination of mineral fertilizers and by-products of the predecessors as organic fertilizers, reduced the negative impact of unstable moistening.

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ADAPTATION OF ENTREPRENEURIAL EDUCATION AND TRAINING IN ECONOMICS FOR THE STUDENTS OF "ION IONESCU DE LA BRAD" UNIVERSITY OF LIFE SCIENCES (IULS) IAȘI, ROMANIA, IN THE CONTEXT OF CHANGING LABOUR MARKET NEEDS

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Abstract

The role of university education in providing access to the labour market (employment) is reflected in increased employment opportunities for the educated population. The relationship between the unemployment rate and educational attainment is evident: the unemployment rate decreases as one moves from lower to higher levels of education. It can be seen that the unemployment rate, in terms of its size and dynamics, is inversely proportional to the level of education: it falls as the level of education rises, and vice versa. The aim of the research in this paper is to respond to the need to teach students with practical solutions for getting the skills needed to be easily employable in the labour market after graduation. The paper used a quantitative (questionnaire) and a qualitative (bibliometric) analysis. The data studied through the research shows the need for final-year students to receive additional practical skills training for employability. Entrepreneurship education, in addition to the university curriculum, can provide them with a viable alternative to increase their chances of integrating into the 21st century labour market. The innovative character of the work derives from the concrete practical activities that supported the optional entrepreneurial training of IULS students from Iasi. We can affirm, following the study undertaken, that the development of such additional and adapted educational activities increases young graduates' practical skills needed on the labour market. The access to non-reimbursable European funds, which offer additional educational opportunities to students, must be continued in order to produce the major economic effects expected by the whole Romanian society, with the aim of reducing youth unemployment.

Key words: *entrepreneurship, education, students, labour market*

INTRODUCTION

The future of the labour market in the 21st century is still a topic of constant debate, but despite the fact that experts have different views on what it will be, there is a consensus that *education systems must prepare young people for a changing and uncertain economic environment* [4, 12, 13].
Employers typically point to a significant difference in the skills and abilities they expect from young people and the skills they have when they graduate. The fact that youth unemployment is high, there is little on-the-job training, and many young people enter adulthood without having had enough work experience all serve to exacerbate this situation [5, 6, 8].
An educated person is more likely to be integrated into the labour market, to find a job in line with his or her level of competence, to be more mobile, more open to lifelong learning, to professional reorientation or diversification, etc.
In economic and social terms, they perform better. Education also plays a particularly important role in reducing long-term unemployment, both through initial training

and by equipping the workforce with the skills to cope with change [2, 3, 9, 10].

These new forms of education involved both new educational resources and pedagogical methods adapted to the new conditions [1].

The paper refers to studies on the adaptation of entrepreneurial education and training to changes in the labour market, the role of the University for Life Sciences of Iasi in the vocational training of young people, entrepreneurship among students, and the expectations of students at IULS for increasing employability through qualifications and occupations with entrepreneurial potential.

Promoting the integration of young people in the labour market, either as employees or entrepreneurs, is an essential component for increasing youth employment in the labour market, reducing youth unemployment, promoting youth autonomy, increasing the likelihood of adequate allocation of human resources at a geographical, occupational, and professional level, as well as developing their potential to contribute to the sustainable development of society in the NE Region of Romania.

The objectives pursued for this analysis are as follows:

O1: To investigate the training needs of students at the Faculty of Agriculture, specialisation in Economic Engineering in Agriculture (IEA), of the University for Life Sciences of Iasi by analysing the correlation of professional training (competences) in order to develop skills needed in the labour market.

O2: Identification of good practices for increasing the adaptability of young people to labour market requirements and supporting youth entrepreneurship through youth work.

The aspects analysed can be used to take a snapshot of the real situation of the level of skills that young economics graduates have after graduation and how this preparation for labour market integration can be supplemented by additional entrepreneurial education during the degree period [5, 7]. The research instruments used were the mechanisms through which the data in the present research were collected and the perceptions that were intended to be relevant to the proposed topic, the results of which were intended to provide insight into how young economists should be prepared for integration into the ever-changing labour market.

MATERIALS AND METHODS

The research carried out through this paper aims to analyze the level of university education offered to economics students at IULS in Iaşi and whether it provides them with the necessary skills for employment after graduation on the labour market in order to reduce unemployment among young graduates in the NE Region of Romania.

The methodology used was selected appropriately to provide answers to the proposed research theme and is in line with it. A study was carried out beforehand on these and on the extent to which the data collected are relevant to the research objectives.

In order to study the relationship between education and the labour market, the investigation was carried out using both quantitative methods (questionnaires) and qualitative methods (bibliometric) analysis.

Questionnaire research is a very good technique or investigative tool for explaining human behaviour and identifying the factors that determine it. With the questionnaire as an investigative tool, questions and issues are asked that elicit various responses from the respondents.

The data obtained by conducting quantitative research allows the collection of important information through representative samples of students in their final year of study.

The questionnaire was administered to a sample of 38 students of Agricultural Business Engineering and Management 4th year, day courses, year 2019, of the 44 enrolled students, i.e. a degree of representativeness of 88.63%, so that the precision of the results leads to pertinent conclusions to be extrapolated to the total number of students from the economic profile.

The evaluative items on which the study was based were the following:

Item 1: How do you rate the curriculum and course offerings during your undergraduate studies?
Item 2: How do you rate the programme during your undergraduate studies?
Item 3: How do you rate the teaching process during undergraduate studies?
Item 4: How do you rate your assessment and grading during your undergraduate studies?
Item 5: How do you rate career counselling and guidance during undergraduate studies?
Item 6: Why did you choose to do your undergraduate studies?
Item 7: Does an advanced level of education help you find a job?
Item 8: Does the vocational training system correspond to the requirements of the labour market (in terms of quality of studies, supply-demand ratio)?
Item 9 : What are your chances of employment, according to your profession, after graduation?,
Item 10: What is the correspondence between the work of employed students and the field of study?
Item 11: Have you worked during your years of study, did the experience you gained later help you in your employment?
Item 12: What actions should universities take to increase graduate employability?
Item 13: What do you think are the reasons why you or your colleagues have had difficulties in finding a job?
Item 14: Which of the following criteria do you think are given priority consideration when hiring someone?
Item 15: What ways/resources do/will you use in your job search?
Item 16: Have you volunteered during your years of study?
Item 17: Why did you decide to volunteer?
Item 18. Did the volunteering activity correspond to your field of study?
Item 19: Did volunteering during your years of study help you to gain experience later on in your employment?
Item 20: Does USV Iasi provide me with the necessary tools to achieve my personal and professional goals?

Data processing was done using statistical methods, the results being then presented through the interpretations, graphs in the paper.

In order to ground the study theoretically, we used a qualitative research method, namely a bibliometric analysis of the literature on the topic. The literature on the adaptation of entrepreneurial education and training of economics students at IULS in Iaşi in the context of the changing needs of the labour market was analyzed using the VOSviewer programme using the Web of Science collections database. This method represents a preliminary stage of the individual study's validation.

RESULTS AND DISCUSSIONS

The paper aimed to investigate the training needs of economics students at IULS in Iasi and what practical solutions regarding the training of skills needed to easily engage in the labour market after graduation can be offered to them [1, 3, 5].

For this purpose, a literature review on sustainable rural development using support measures analysed through the VOSviewer programme was carried out for the whole topic addressed in the paper.

In order to validate the individual literature study on the relationship between entrepreneurship and education among students, a bibliometric keyword correlation analysis was conducted to validate the increased interest in the topic.

To perform this analysis, Vosviewer academic software was used by accessing the Web of Science database. The limitations of the search were those related to the keywords correlated with the subject analysed, namely: entrepreneurship, labour market, entrepreneurship education, employment rate, and business.

Subsequently, following the selection of a sample of bibliographically suitable papers, a total of 2,990 articles were generated for the keyword co-occurrence map. It can be said that their number is relatively small, which can be considered a limitation of this analysis.

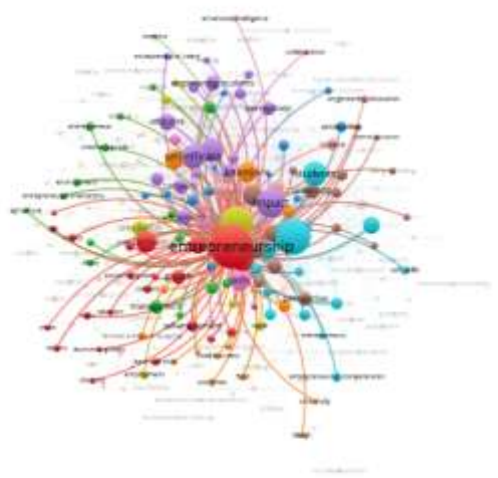

Fig. 1. Keyword co-occurrence map
Source: Generated by the authors using Vosviewer by Web of Science.

We can see that for the period under review, the interest of researchers in analysing the link between entrepreneurship, young students, and their skills was very high. Entrepreneurship is correlated with students, their performance, their intentions, the university environment, and education in different fields, especially engineering. The appropriateness of the large nodes representing the primary linking areas that have been associated can explain these facts.

The limitations of the analysis were that each scientific article should include the terms introduced but also have a minimum of four keywords relevant to the current study. Thus, out of a total of 2,990 papers, only 2,850 were considered to be relevant.

In the following, we will present how the two objectives pursued for this analysis have been addressed.

Objective O1: Education and the labour market are in an interdependent relationship in which sometimes education is dominant and sometimes the labour market is not. Many economists are of the opinion that there are three types of relationships between education and the labour market that also have the quality of giving specificity to a country: at the level of the education system (training system, qualification, and mobility), at the organisational level (workplace, hierarchy, and organisational management), and at the industrial level (industrial relations, ways of resolving conflicts within companies).

In any relationship, including that between education and the labour market, there are social constructions resulting from negotiations and compromises between different actors.

Insertion into the labour market is not only dependent on the adaptation of university education but also on independent factors: the specificity of the job (complexity of tasks, personnel policy, etc., e.g., economic engineering), the level of experience associated with the job, and the type of tasks associated with the job.

Social partners, in particular employers, play a crucial role in this process, helping to maintain the adaptability of the workforce and contributing to improving the quality of education and training. In this context, the university education system in Iasi has to face important challenges: to anticipate labour market requirements in terms of qualifications, skills, and competences; to attract companies to collaborate in training students by providing them with the experience required in their first job; and to create ideas for new businesses and appropriate qualifications for them.

In an age where information is the most important asset, entrepreneurship is certainly a model for the economic development of an individual or a team and is even sustainable at the national level, especially among young people.

Specific courses at an entrepreneurial university include: Introduction to Entrepreneurship, Developing a Business Plan, Financing a Small Business, Legal Aspects of a Small Business, and Small Business Case Studies.

In order to see if the IULS in Iasi offers economics students the level of training they expect in order to be able to integrate into the labour market, quantitative analysis was used as a method of investigation by applying a questionnaire. This questionnaire aimed to monitor the indicators of quality of studies at the Agronomic University, Iasi, Faculty of Agriculture, to identify the general level of student satisfaction, to determine the strengths and weaknesses of the services and resources provided by the university, the quality of the teaching process, and the level of opportunities for personal and professional development, and to collect suggestions and formulate measures to improve the quality of the level of education offered to students of the EMAB specialisation of the Faculty of Agriculture in relation to the conditions of professional development provided by the IULS in Iasi.

Students were asked to answer the following questions by selecting the appropriate answer for the situation they found appropriate. As far as personal data is concerned, students were only required to fill in their study programme and year of study (the questionnaire was anonymous). They were informed that the information requested was useful to us in the framework of the project "Active measures to increase participation in tertiary entrepreneurial education of students from disadvantaged backgrounds", POCU/379/6/21/124388, in order to get a better picture of students' expectations.

After the application of the questionnaire, through which we aimed to investigate the students' satisfaction with education, their training needs, their information needs, and their expectations from the IULS-EMAB specialisation, we interpreted it as follows:

Statistical interpretation

The questionnaire was applied to a sample of 38 students of the Agricultural Business Engineering and Management specialisation, 4th year, day courses, year 2019, chosen in order to gather as wide a range as possible of students' expectations regarding the areas of agri-food activity in the areas of interest.

Qualitative interpretation of questionnaire data of the 4th year - EMAB.

The questionnaire applied to the students of the Faculty of Agriculture, specialisation EMAB 4th year, is composed of 20 items distributed in such a way as to provide information both on their opinions and on the concrete actions they undertake regarding the proposed theme.

In this regard, 20 closed questions were formulated with pre-defined answer options, giving respondents the opportunity to freely express their opinion or to present their knowledge, especially in relation to the conditions of professional development provided by the IULS Iasi.

***Item 1*: How do you rate the curriculum and course offerings during your undergraduate studies?** Students had to make judgements on a number of content items, namely: the subject matter covered in the courses, the relevance and usefulness of the courses for the chosen specialisation, the number and variety of optional courses, the complementarity and interrelation between courses, the development of the ability to work in a team, the development of communication skills, the development of the ability to learn and understand new things, the development of the ability to work with specialised software, the development of skills such as leadership, problem solving, critical thinking, creativity, student practice activity, etc. Respondents rated positively the aspects related to the relevance and usefulness of the courses for their chosen specialisation by 55.26%, and some activities were less satisfactory, i.e., developing skills to work with specialised software by 2.63% (Fig. 2).

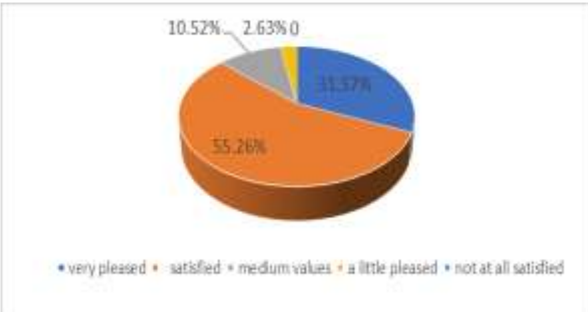

Fig. 2. The situation of students who appreciate the curriculum and the offer of courses during undergraduate studies
Source: own processing.

***Item 2*: How do you rate the programme during your undergraduate studies?** Rated with a range of ratings from very satisfied to not at all dissatisfied, it brings to respondents' attention issues related to how the programme is adapted to personal needs and pace, the weekly schedule (timetable, modularly organised courses), or the flexibility of the learning pathway (transfer, credits, etc.). Respondents rated aspects of the weekly programme (timetable, modularly organised courses) positively by 42.10%, and some activities were less satisfactory, i.e., the programme is adapted to personal needs and pace by 5.26% (Fig. 3).

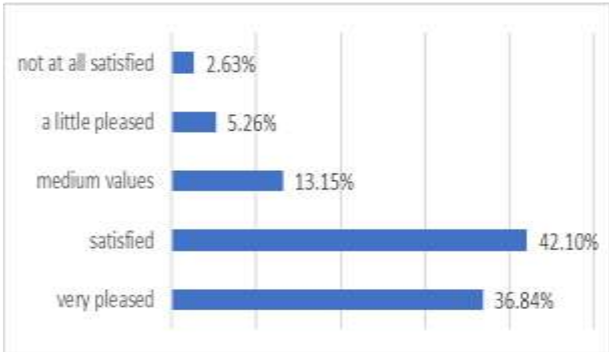

Fig 3. The situation of the appreciation of the program during your undergraduate studies
Source: own processing

Item 3: **How do you rate the teaching process during your undergraduate studies**, wanted to get ratings on the following aspects: clear and appropriate communication of concepts, timeliness and usefulness of the concepts taught, practicality of the concepts taught, interactive teaching methods, adaptation of the teaching style of the teacher to the needs and possibilities of learning, effective use of new technologies, the availability of auxiliary materials (course materials, practical workbook, etc.), the availability of teachers (consultation, guidance) or the quality of the activities in the specialist practice.

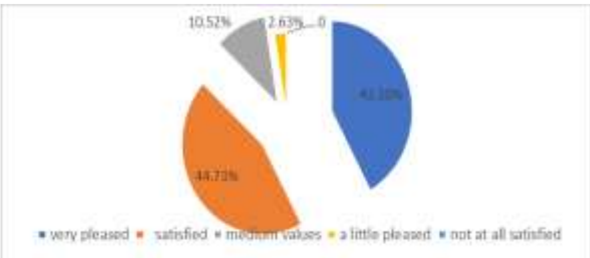

Fig. 4. The answer to the How do you rate the teaching process during undergraduate studies:
Source: own processing

Respondents rated aspects related to the topicality and usefulness of the notions taught positively at 44.73%, and some activities were less satisfactory, i.e., the practicality of the notions taught in some core subjects at 2.63% (Fig. 4).

Item 4: **How do you rate assessment and grading during undergraduate studies**, aimed at students' appreciation through transparency of the assessment process, balance between continuous assessment and final assessment, feedback provided by the teacher for formative purposes, objectivity and fairness of assessment and grading, possibility of challenging assessment and grading results, procedures for reassessment/grading. The students of the EMAB specialisation rated positively the aspects related to the balance between continuous assessment and final assessment in 42.10% and some activities were less satisfactory, i.e. re-assessment procedures/mark increases 2.56% (Fig. 5).

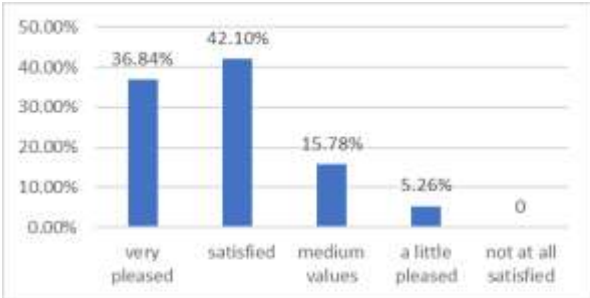

Fig. 5. Respondents rated of assessment and grading during your undergraduate studies
Source: own processing.

Item 5: **How do you rate career counselling and guidance during undergraduate studies?**

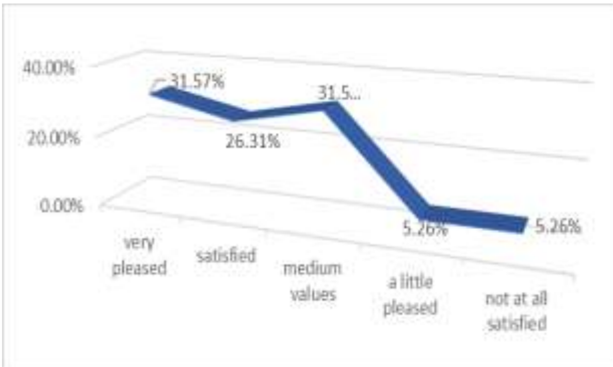

Fig. 6. Respondents rated of career counselling
Source: own processing.

With the existence of a faculty consultation programme, liaison with the tutor and year tutor, academic counselling (choice of courses, organisation of study programmes, effective learning), and advice on involvement in extracurricular activities within the university, EMAB students rated positively the aspects related to the link between the tutor and the students with 31.57%, and some activities were less satisfactory, i.e., advice on involvement in extracurricular activities within the university with 5.26% (Fig. 6).

***Item 6:* Why did you choose to attend higher education?** Students had to answer the following items: offers better chances to find a job?, offers better wages?, offers career opportunities?, provides flexibility?, offers better chances to go abroad? Nearly 69% of them seem to have understood that higher education gives them a better chance of finding a job. Moreover, 23.68% of the sample chose to answer that higher education offers them better salaries, which shows a correct knowledge and understanding of the advantages and disadvantages of vocational training and further education (Fig. 7).

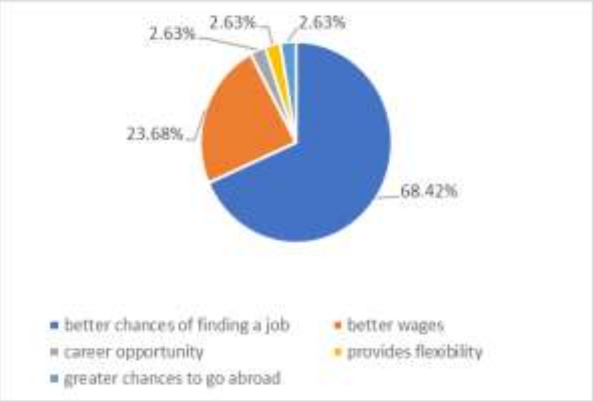

Fig. 7. Respondents rated of Why did you choose to do higher education?
Source: own processing.

***Item 7:* Does a higher education level help you to get a better job?**

In order to get a more accurate picture of the information already held by students and hence their interest in professional development, they were asked to indicate whether an advanced level of education helps them find a job or can benefit their work. Students responded as follows: faster/easier (44.73%), with decent conditions (10.52%), with a higher salary (31.57%), and with opportunities for professional growth (13.15%) (Fig. 8).

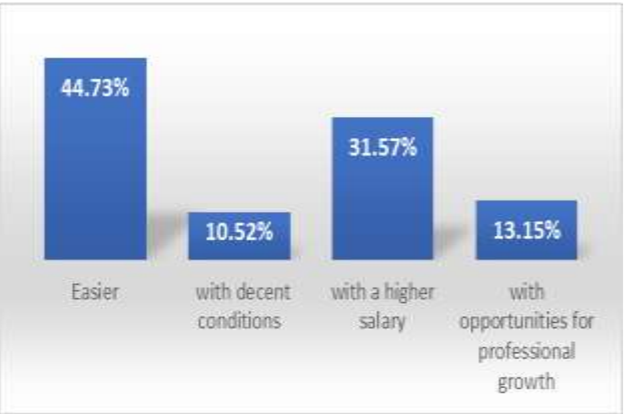

Fig. 8 Respondents rated of the answer to finding a job
Source: own processing.

***Item 8*: Does the vocational training system correspond to the requirements of the labour market (in terms of quality of studies and supply-demand ratio)?** It led to the following opinions: Yes, 78.94% and 21.06% No. A very high percentage of non-answers (10%) was also given when students were asked to define, from their own perspective, the correspondence between the demand-supply ratio on the labour market.

***Item 9:* What are your chances of employment, according to your profession, after graduation?,** students answered as follows: high chances (65.78%), low chances (21.05%), and very high chances (13.15%).

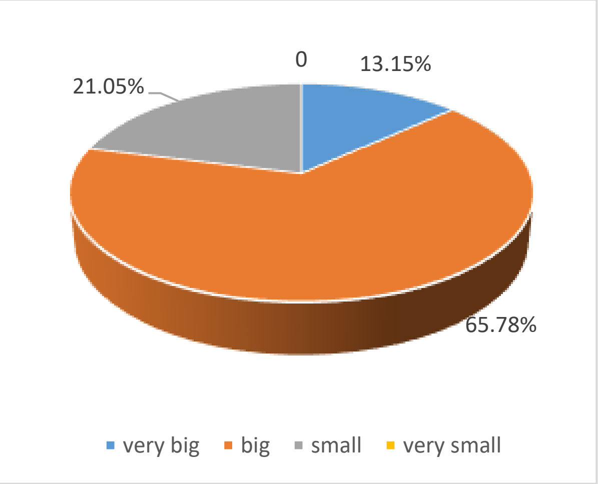

Fig. 9. Respondents rated of employment opportunities
Source: own processing.

***Item 10*: Regarding the correspondence between the work of employed students and the field of study**, 84.12% of the students had an affirmative answer, i.e., yes, and 15.79% did not agree with this aspect.

***Item 11*: How did the experience accumulated working during the years of study help you to find a job?** 39.47% of the respondents said yes, I found a job faster (due to the experience I gained), and 36.84% of the EMAB 4th year students are not working yet but are still looking for a job, being in the last semester of study and need to find a job for the near future (Fig. 10).

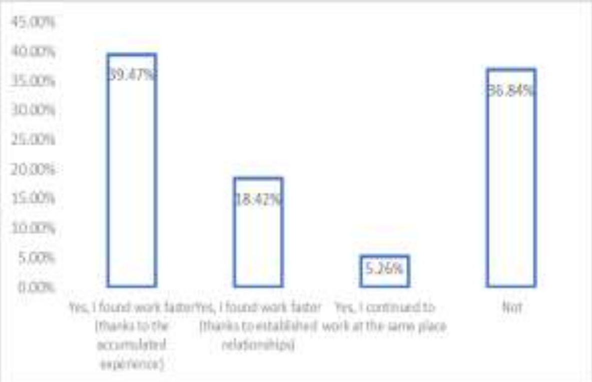

Fig.10. Respondents rated of help finding a job
Source: own processing.

***Item 12:* What actions should universities take to increase graduate employability?** referred to as including temporary jobs in degree programmes, including practical experience in courses, and revising courses to match employers' needs.

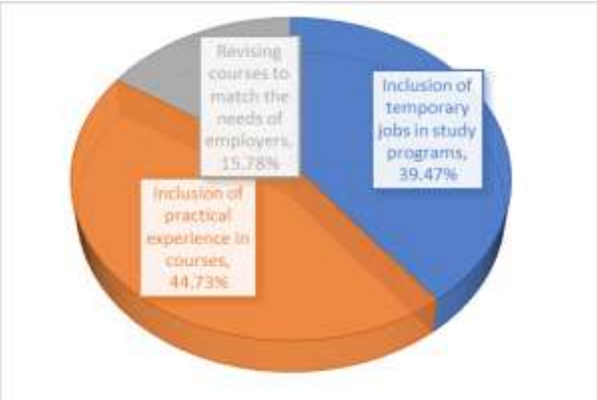

Fig. 11 Respondents rated of increase graduate employability
Source: own processing.

44.73% of students said that including practical experience in courses is a priority activity, while 39.47% of them think that including temporary jobs in degree programmes in the form of internships can bring them more practical experience and additional financial means (Fig. 11).

***Item 13:* Which are the reasons why you or your colleagues have had difficulties in finding a job?** This is the one that tried to identify the main difficulties in finding a job, such as lack of work experience, lack of jobs for your qualifications, age, lack of education or qualifications in a certain field required in the labour market, lack of knowledge of a foreign language, lack of computer or IT skills, lack of entrepreneurial skills, as well as a lack of certain professional or practical skills. According to the students, the main reasons are: lack of work experience (26.3%), lack of jobs for the qualification (23.28%), and lack of certain professional or practical skills (18.42%) (Fig. 12).

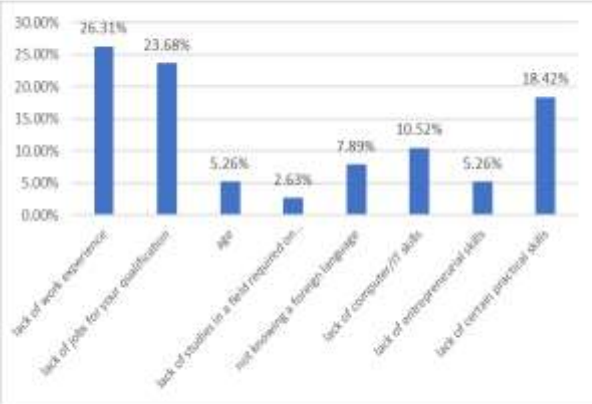

Fig. 12. Respondents rated of difficulties in finding a job
Source: own processing.

***Item 14:* Which of the following criteria do you think are given priority consideration when hiring a person?** Namely: work experience, age, education, qualifications, or professional skills or practical abilities. From the responses we received, we could see that 60.52% of the students agreed that work experience has priority when hiring a person, and 21.05% of them say that education, qualifications, professional skills, or practical skills also have a great influence.

***Item 15*: What ways/sources do you use/will you use when looking for a job**, i.e., print media, private recruitment firms, job vacancy websites, AJOFM, friends, acquaintances, and family? The students of the EMAB specialisation estimated that they would use information from job vacancy websites with 39.47%, and another way would be, in order of importance, information from friends, acquaintances, and family with 23.68% (Fig. 13).

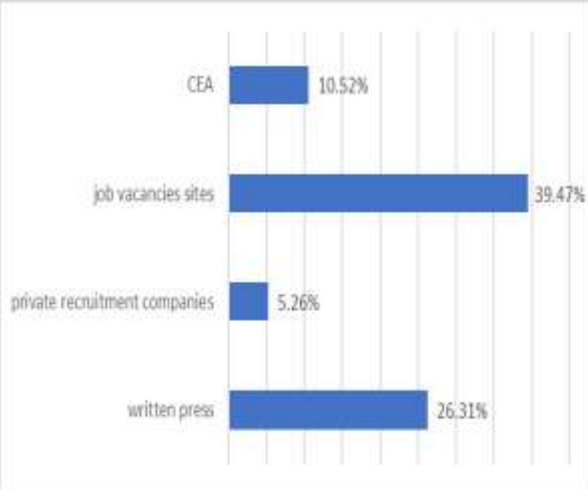

Fig. 13 Respondents rated of sources used in finding a job
Source: own processing.

***Item 16*: Did you volunteer during your years of study?** When directly questioned about volunteering actions that students may have done during their study years, we find that 60.52% have carried out such actions, especially greening the spaces on the IULS campus or carrying out charitable activities together with the teaching staff, while 39.48% of students have not had such activities.

***Item 17*: Why did you decide to volunteer?** More than 50% of IEA students stated that they volunteered to get work experience, and 39.48 of them stated that they wanted to get involved for a good cause.

***Item 18*. Did the volunteering activity correspond to the field of study?** and the answers received were negative (52.63%) and positive (47.37%).

***Item 19*. If you volunteered during your years of study, did the experience you gained later help you in your employment?** Students were asked the following questions: Yes, I found a job more quickly (because of the experience I gained); yes, I found a job more quickly (because of the relationships I made); yes, I will continue to work at the same place after graduation. No. 62.52 of the EMAB students rated Yes, I found a job more quickly (because of the experience I gained), and 26.31% of them said Yes, I found a job more quickly (because of the relationships I made) (Fig. 14).

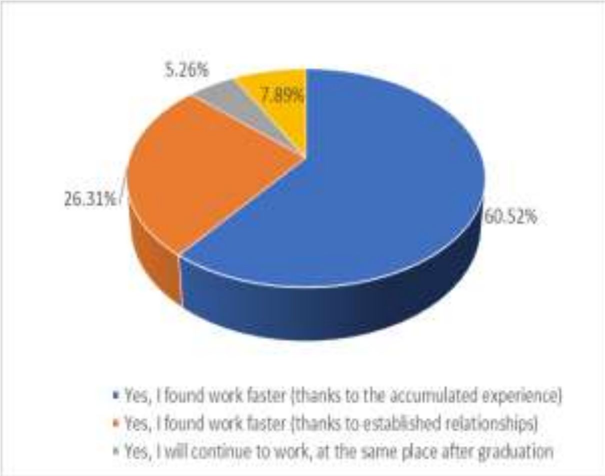

Fig. 14. Respondents rated of the importance of volunteering for employment
Source: own processing.

***Item 20.* On general aspects of the university**, with reference to questions such as: I am confident that the degree obtained will guarantee valuable professional skills on the labour market and in life. If I had to choose again, would I still choose this university? Would I recommend IULS to other people? Does IULS provide me with the necessary tools to achieve my personal and professional goals? Is IULS open to receiving feedback from students to improve? From the analysis of this item, we deduced the following opinions: 52,63% of the students of the EMAB specialisation, 4th year, appreciated that they are confident that the degree obtained will guarantee valuable professional skills on the labour market and in life, and 26,31% of them would choose this IULS in Iasi because of the study and social conditions offered (Fig. 15).

The answers from the students who were questioned were interpreted, and the results show that students in the 4th year day courses at the Faculty of Agriculture, specialisation EMAB, want to do a self-assessment of their need for guidance in order to learn more about the subject. More than half of the respondents felt that they only needed support to some extent, and only 35% were aware that without competent support they did not know how to proceed in this area. A small percentage, approx. 10%, stated that they did not need further information and that they knew how to obtain the data they were interested in, although here we met both people who said they were well informed and students who admitted to being less informed. One possible explanation is that students do not assess their need for information in relation to the knowledge they already have but in relation to the usefulness it might have for their work, and this is not well understood.

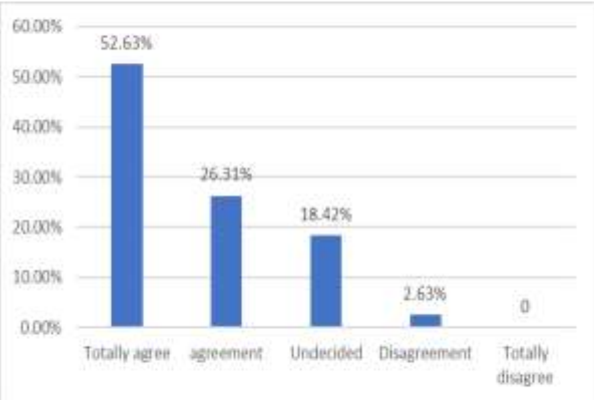

Fig. 15. Respondents rated of the general aspects regarding the university
Source: own processing.

The need for additional questions arose, and a questionnaire was applied to the students of the Faculty of Agriculture of Iasi, specialisation EMAB, 4th years, day courses, and it was revealed that more than 63% of the respondents want to start their own business in the next two years, while about 53% of the students who answered the questionnaire would prefer to be entrepreneurs and not managers.

Also, about 3% of them "are willing to work hard for what they want to achieve" and 86% "are willing to take risks", which leads us to consider that there is significant potential for possible entrepreneurs in IULS.

We noted that 79% of the surveyed students considered that they have at least one entrepreneur in their circle of acquaintances outside the family, while 47% of them have an entrepreneur in their family. Regarding the most important quality of a successful entrepreneur, 61% of student respondents indicated vision, while 42% indicated lack of capital as the most important problem in becoming an entrepreneur.

The students of the Faculty of Agriculture of Iasi, specialisation EMAB, 4th years, day courses, interviewed in the framework of the project POCU 124388 Antre_S showed that they would like additional support from higher education institutions in all the steps that need to be taken to set up a start-up, starting from the idea and during all the stages until the start of the business and, later, for the period immediately after the business takes a legal form.

Other student requests were to promote best practice models through a series of conferences and workshops, mainly with successful alumni, but not necessarily. Students considered these facilities insufficient, as they felt that access to university infrastructure was restrictive and not sufficiently developed. There was a need for the development of real business incubators, where advice on business plan preparation could be provided, contact with potential investors could be facilitated, and additional help could be offered, particularly from a legal point of view, but not only in terms of accessing funding lines.

Analysing the particularities of the form of employment of the students of the Faculty of Agriculture of IULS, we can see that 12% of undergraduate students are employed and 54% of master students. In addition, 2% of undergraduate students have a business, and 8% of master students do not. If a third of the undergraduate students are employed in a job, 65% of the master students have such a position. Approximately one-third of bachelors and masters say that their first job is a job.

Some of these measures are a reality in the university environment, but they are carried out in isolation, at a minimal level, without an overall vision, and without following up on the impact of their deployment among students. Only 48% of students mentioned that professionals with experience and know-how in the field of study were invited to the courses or seminars they attended.

Objective O2: Identify good practices on increasing young people's adaptability to labour market requirements and supporting youth entrepreneurship through youth work, we found that both the literature and the research undertaken in this paper reveal that universities only prepare young people to an average extent to become entrepreneurs.

Thus, it was possible to initiate the promotion of the acquisition by all IULS graduates participating in the project of fundamental transversal competences, such as competences in the digital environment and "learning to learn" entrepreneurship. Partnerships were developed between the business community and IULS to ensure a better focus of young people on the skills and competences needed in the labour market.

A modern society, which registers an increasingly alert pace of development, digitization becomes one of the most important elements of the development of all the society's systems, and education, as its top sector, must constantly adapt to these changes [1, 11, 14].

We present below the activities undertaken within the project POCU/379/6/21/124388, entitled "Active measures to increase participation in tertiary education of students from lack of education", Leader: University for Life Sciences "Ion Ionescu de la Brad" from Iasi, in order to support the training of additional skills of young graduates to increase their chances of employment after graduation according to the requirements of the labour market.

Concretely, a platform has been created: PILOT ON LINE "ANTREPRENOR" with 2 components: the simulator "Entrepreneur on-line" and the simulator "E_JOB," developed and operational for minimum GT students, but also 1 on-line platform, including complementary courses, developed and maintained for the provision of courses in on-line/webinar environments with databases of open educational resources. 3 plans for the development of the offer for programmes with entrepreneurial scholarships for students from disadvantaged categories (https://studentantreprenor.ro/).

The developed platforms also came to the support of students with: a link with practical studies and labour market analysis activated; a link to information and promotion of enhanced offers with an entrepreneurial component; and an online database of employers and specific services related to educational offers (e-jobs, internships, etc.).

All students in the target group have participated in the certified complementary entrepreneurial course programme. Thus, it was possible to implement in the 6 majors of the Faculty of Agriculture of IULS in Iasi 6 undergraduate programmes with complementary entrepreneurial courses for final-year students and applied courses implemented with objectives, themes, and practical components appropriate to undergraduate studies. These courses have been and will continue to be run at IULS in Iaşi in the 2 laboratories set up by the project: the ENTREPRENEURIAL MENTORING LAB https://studentantreprenor.ro/evenimente/evenimente,noutati/laborator-mentorat-antreprenorial/) and a DIGITAL COMPETENCE LAB (https://studentantreprenor.ro/evenimente/evenimente,noutati/laborator-tic-lider/

In order to provide students with concrete examples of employers' expectations, 20 university-employer experience exchanges were carried out with ESF funding, and 3 labour market partnerships were concluded.

After the students were taught how to make business plans, an "Entrepreneurship" competition was held at IULS in Iasi with 124 prizes, in which the best ones were awarded. Entrepreneurship manuals were also printed and distributed to students, but they constitute an electronic database at IULS for students, teachers, and employers.

CONCLUSIONS

We believe that all these activities carried out for the formation of entrepreneurial skills for students at the Faculty of Agriculture of IULS were very useful and that a successful model was created for future students in the final years in order to create additional skills for increasing employability upon graduation.

As long as they are motivated, students build a solid foundation of professional, including entrepreneurial, knowledge and cultivate their personal skills.

Employers believe that the current labour market offers enough opportunities for recent graduates to invest in their professional futures during their study years by participating in workshops and internships.

Universities should definitely adopt a number of measures, such as introducing courses on entrepreneurship for students, supporting extracurricular activities related to this field, improving the quality and increasing the diversity of internships, supporting the establishment of business incubators and accelerators for student entrepreneurs, and developing business plan competitions.

ACKNOWLEDGEMENTS

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SUSTAINABILITY IN AGRICULTURAL WORK - OUR SHARED RESPONSIBILITY

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Abstract

The article explores the key role sustainability plays in the agricultural sector and its impact on local communities. With climate change and economic challenges on the rise, it is vital to focus on sustainable agricultural practices to ensure food security and well-functioning ecosystems. Throughout the article we highlight global and local initiatives that encourage sustainable agriculture, as well as the benefits to the environment and society, highlighting our shared responsibility to future generations, highlighting collaboration between farmers, communities, governments and international organizations. For the representativeness of what will be presented we use the creative platform Canva, the basic statistical information comes from the National Institute of Statistics (NIS) and FAOSTAT, the descriptive analysis is performed using the advanced tools offered by Microsoft Excel 365 and in addition to standard reference sources, we have also consulted recognized specialized websites, thus strengthening our perspective and providing readers with up-to-date and verified information. The purpose of this review is to examine the depth and breadth of the implications of sustainability in the context of agricultural work, highlighting the complex interconnections between agricultural practices, the environment and society. In conclusion, this article highlights the need for a collective and integrated approach to achieving sustainability goals in agriculture and building a more resilient and balanced future.

Key words: *adaptability, agricultural education, shared responsibility, collaboration, certification, climate change*

INTRODUCTION

Agriculture, as a key link in the global food chain, faces major challenges in the context of climate change and ever-increasing food demand. In this dynamic landscape, the concept of sustainability is becoming increasingly evident, representing not only a goal but also a shared responsibility for all those involved in agricultural work.

Agriculture is an important economic sector contributing to GDP [1]. The labor force in agriculture is the premise on which we can base any further development and performance in the Romanian rural area as a whole [8]. Labor force is the most important factor contributing to the development of the economy. In the transition economies like the one of Romania, labor market is deeply influenced by privatization and restructuring [11]. In Romania's economy, agriculture one of the most important sectors as it plays a unique role to provide food for nourishing the population, raw materials for industry and forages for animal rearing [10].

Agriculture is a complex field of activity where farmers are focused every year on what kind of crops to cultivate on their land and what surface to allot to each plant. The decisions are always linked to economic efficiency of each cultivate hectare, more exactly on net returns level [7]. The role of agriculture is carried out by farms and farmers called to transform the inputs into high value products and goods for keeping life and satisfying much better humans' needs [10].

The aim of this analysis is to examine the depth and breadth of the medium and long-term implications of sustainability in the context of agricultural work, highlighting the complex interconnections between agricultural practices, the environment and society. We aim to highlight the role that each actor - farmers, local communities, governments and international organizations - plays in promoting sustainable agricultural practices and addressing contemporary challenges.

The performance in agricultural output and gross value added produced in this sector is deeply conditioned by geographical position of the agricultural land, soil quality and structure, climate conditions, technical endowment, production systems, applied technologies, farming practices, farm inputs, labor force in terms of number of working persons, training level, age and productivity [12]. As climate change becomes more evident and natural resources dwindle, significant pressure is being put on the agricultural sector. In this light, it is crucial to ask how we can make agriculture more sustainable and resilient in the face of these challenges. Our shared responsibility is to recognize this need and take collective action to transform the way we work the land.

Rural space plays an important role in preserving the landscapes which are a treasure of the splendours of nature [2].

Sustainable soil management is a major challenge, as intensive farming can lead to soil degradation and reduced fertility. Soil conservation and the adoption of sustainable agricultural practices are becoming increasingly important [6].

By exploring existing initiatives, emerging technologies and future prospects that contribute to building a sustainable agricultural future, we aim to highlight the importance of collaboration and shared commitment in the face of the complex challenges of sustainability in agricultural work. Employment in agriculture is an important component of sustainable rural development policy. There is a need to make good use of the agricultural potential that Romania has and to stabilize the rural population by ensuring incomes that ensure an adequate quality of life [14].

The sustainability started as a aspiration, but was never initiated with the necessary attention and rigour. With sustainable agriculture now central, the need for measurement is the result of a complete rethinking and reframing of the industry's mindset to recognise that our actions have direct consequences [13].

The data were processed and converted into tables, graphs and then interpreted and analyzed.

MATERIALS AND METHODS

To highlight the purpose of the analysis and the clarity of the conclusions, we have chosen to use the following:

1). We chose Canva's creative platform to create visually impressive infographics, bringing complex data to life and making key concepts easy to understand.

2). The underlying statistical information comes from the National Institute of Statistics (NIS), providing a solid basis for our analysis of changes in the agricultural sector in recent years, code used: AGR210A - Agricultural labour force volume, reference years 2019-2023.

3). We used the FAOSTAT database to gain global insights, highlighting global trends and challenges in agricultural sustainability (domain code = OAS).

4). Descriptive analysis was performed using the advanced tools provided by Microsoft Excel 365, allowing us to highlight key trends and distributions in the collected data.

5). In addition to standard reference sources, we have also consulted recognized specialist websites, thus strengthening our perspective and providing readers with up-to-date and verified information.

These elements highlight not only the tools and sources used, but also how they contribute to this article on sustainability in agricultural work.

RESULTS AND DISCUSSIONS

In order to provide an engaging and informative visual presentation of the key issues related to sustainability in agricultural work, we have chosen to use the creative platform Canva, through which, we will create a graphic image that highlights the key connections between sustainable agricultural practices, the environment and communities. Using eye-catching visuals, we will clearly

convey our message and capture readers' attention, making it easier to understand the complexity of this crucial topic.
This approach not only enriches the reader's experience but reinforces and underlines our commitment to effective and impactful communication of the proposed theme.

Fig. 1. Image created using the AI platform - CANVA.
Source: https://www.canva.com [3].

Using the Canva platform to create the image associated with the theme brings several advantages, contributing to the appealing look of the article. Here are a few reasons:
Impactful visualization - Canva offers a wide range of tools and graphic templates, allowing you to create an eye-catching and easy-to-understand image. Visually appealing layouts grab readers' attention and make complex concepts easier to understand.
Accessibility - the platform is easy to use and does not require advanced graphic design skills. This makes the creation process accessible to anyone, including those with no experience in the field.
Customization - Canva offers the ability to customize creations based on the tone and visual identity of the article. This allows you to align the image with the overall message and purpose of the materials presented.
Efficiency - Canva provides an efficient workflow, allowing you to create images quickly and easily. This is essential in the context of a project that also involves other research and writing stages.
Easy sharing - Images created in Canva can be easily shared and integrated into various online environments, including articles, presentations and social media. This maximises the visual impact and distribution of your content. Thus, we can say that by using the Canva platform we offer an efficient and accessible way to enrich the visual experience of the readers, thus enhancing the attractiveness and overall impact of the article on sustainability in agricultural work.
By analyzing the statistical data provided by the National Institute of Statistics (NIS), focusing on the category AGR210A - Volume of labour force in agriculture, we have created a deep insight into the evolution of the number of people involved in the agricultural sector over a certain period of time.
According to data extracted from the NIS database, we observe significant trends and changes in the volume of labour in agriculture. This information will help us to understand the demographic dynamics and the impact on the sustainability of agricultural work in the context of current changes in society and the economy [4]. Using this data, we will highlight key issues related to the changing numbers of workers in this vital sector to illustrate and reinforce our arguments on the sustainability of the agricultural workforce. It clearly shows the direction in which you will use specific data from the NSI database to support our arguments on the agricultural sector in the context of the sustainability of the workforce.

Table 1. The labour force in Romania's agriculture (1,000 annual work units -AWU)

List of workforce variables	2019	2020	2021	2022	2023
Overall	1,402	1,329	1,055	1,026	1,047
	-	*-5.21%*	*-20.62%*	*-2.75%*	*2.05%*
Unemployed	1,243	1,174	879	856	849
	-	*-5.55%*	*-25.13%*	*-2.62%*	*-0.82%*
Employees	159	155	176	170	198
	-	*-2.52%*	*13.55%*	*-3.41%*	*16.47%*

Source: NIS, http://statistici.insse.ro [9].

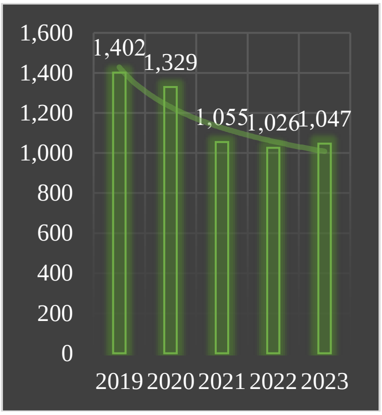

Fig. 1. Total number (employed and non-employed)
Source: Own design based on the data from NIS, http://statistici.insse.ro [9].

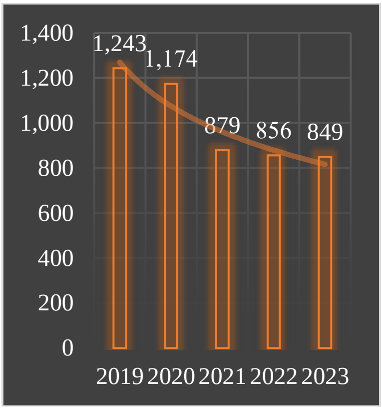

Fig. 2. Persons without employment contracts
Source: Own design based on the data from NIS, http://statistici.insse.ro [9].

Fig. 3. Persons having employment contracts
Source: Own design based on the data from NIS, http://statistici.insse.ro [9].

Under each category analyzed, we have highlighted how the agricultural labour force has increased and decreased (year 2019 versus year 2020, and so on).

This is shown in Table 1 and also in the Figures 1, 2 and 3.

Significant decrease in total workforce between 2019 and 2021 - in just two years, from 1,402 to 1,055 thousand annual work units (AWU), we see a significant reduction in the total number of agricultural workers. This trend may signal structural changes or other influences in the agricultural sector over this period.

Trend of increasing employees - instead, we see a steady increase in the number of employees, from 159 to 198 thousand AUM employees between 2019 and 2023. Such a trend may reflect changes in employment patterns and may suggest an increase in working conditions.

Resilience of the workforce in the context of the pandemic (2020) - while 2020 was marked by considerable uncertainty and change in the economy, we observe that the total labour force decreased marginally and the number of unpaid workers remained relatively stable. That indicates some resilience in the face of pandemic challenges.

Perspectives for 2023 - workforce recovery - with a slight increase in the total number of workers in agriculture in 2023 from the previous year, the outlook is for a recovery in the agricultural workforce. Such a positive development could reflect the adaptability and capacity of agriculture to regain its balance following previous changes.

These comments are intended to highlight significant aspects of the data, giving readers a deeper and more engaging understanding of the evolution of the agricultural labour force over the period [4].

In Table 2 below, it is presented the descriptive statistics for the whole labour force in the period 2019-2023 based on the empirical data processed by the facilities of Microsoft Excel 365.

Table 2. Table based on labour force data (total, reference years 2019-2023) using the Data - Descriptive statistics function in regular Microsoft Excel 365

Mean	1,171.8
Standard Error	80.0558555
Median	1,055
Mode	#N/A
Standard Deviation	179.0103349
Sample Variance	32,044.7
Kurtosis	-2.766327121
Skewness	0.686190927
Range	376
Minimum	1,026
Maximum	1,402
Sum	5,859
Count	5
Confidence Level (95.0%)	222.2706881

Source: Own design based on the data from NIS, http://statistici.insse.ro and used the command from Excel [9].

Average agricultural workforce - with an average of 1,171.8 between 2019 and 2023, we see a central value indicating the overall level of the workforce in this timeframe. This is a useful benchmark for assessing overall trends in this crucial sector.

Centrality of the data - the median, with a value of 1,055, represents the midpoint of the data. The fact that the mean and median are relatively close suggests that the distribution of the data is relatively symmetrical, with a significant concentration around these values.

Standard deviation and variability - a standard deviation of 179.01 and a variance of 32,044.7 reflect some variability in the data. This indicates that the total workforce fluctuated significantly over the range analysed, highlighting possible influences and changes.

The shape of the distribution - negative kurtosis (-2.77) suggests that the distribution of the data is flatter than a normal distribution. This may indicate the presence of periods of increasing or decreasing labour force, depending on the year.

Data skewness - positive skewness (0.69) indicates a slight skewness to the right in the data distribution. This suggests that there are several larger values influencing the data environment in this direction.

Range and extremes of the data - with a range of 376, from 1,026 to 1,402, we see significant variation between the years analysed. The extended range reflects significant changes in the total number of agricultural labour force.

Stability of trends - the data are relatively consistent in terms of count (5), and the 95% confidence interval (222.27) indicates that the estimated mean is stable and that the observed trends are more likely representative of the total population.

These values and related comments help to understand the distribution and trends of the agricultural labour force data in more detail, adding interesting and attractive context to the descriptive analysis.

The data presented in Table 3 regard the employment in agriculture, forestry and fishing worldwide, emphasizing the situation in different countries as explained below.

Table 3. Employment in agriculture, forestry and fishing by age, worldwide (15+)
Unit = 1,000 No, Flag description = figure from international organizations, Domain code = OEA

Place	Area	Year	Value
1	China, mainland	2018	195,150.00
2	India	2020	168,579.49
3	Indonesia	2022	39,595.59
4	Nigeria	2019	25,283.99
5	Ethiopia	2021	23,510.63
6	Pakistan	2021	22,871.85
7	Viet Nam	2018	20,465.12
8	United Republic of Tanzania	2020	16,376.90
9	Thailand	2018	12,168.29
10	Myanmar	2018	11,198.52
Another place	Romania	2018	1,938.11

Source: Labour force survey, https://www.fao.org/faostat [5].

Mainland China: global dominator in agricultural employment - with an impressive 195,150 in 2018, Mainland China, arguably occupies the top position in the global ranking of countries with the largest agricultural workforce. This enormous figure underlines the immensity and complexity of China's agricultural sector.

Indonesia: notable growth in agricultural employment - registering a value of 39,595.59 in the year 2022, Indonesia shows a notable growth in agricultural employment. This development may reflect rural development strategies and the focus on agriculture within the Indonesian economy.

Nigeria: key role in African agriculture - with a value of 25,283.99 in 2019, Nigeria ranks 4th in the global agricultural labor force. This underlines the critical role Nigeria plays in providing agricultural resources continent-wide, contributing to food security in Africa.

Ethiopia: sustainable growth in agricultural employment - Ethiopia, with a value of 23,510.63 in 2021, shows a significant growth in agricultural employment. This may reflect sustained efforts for rural development and economic growth in the country.

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Pakistan: significant contribution to Asian agriculture - with a value of 22,871.85 in 2021, Pakistan ranks sixth overall. This suggests a significant contribution to the Asian agricultural workforce, strengthening its position in agriculture.

Vietnam: outstanding performance in agriculture - with a value of 20,465.12 in 2018, Vietnam ranks seventh, showing outstanding performance in the agricultural sector. This reflects the adaptability and efficiency of Vietnamese agricultural workers in the face of challenges.

United Republic of Tanzania: Steady African contribution - with a value of 16,376.9 in 2020, Tanzania contributes steadily to the agricultural labour force at continental level. This underlines the stability and relevance of agriculture within the Tanzanian economy.

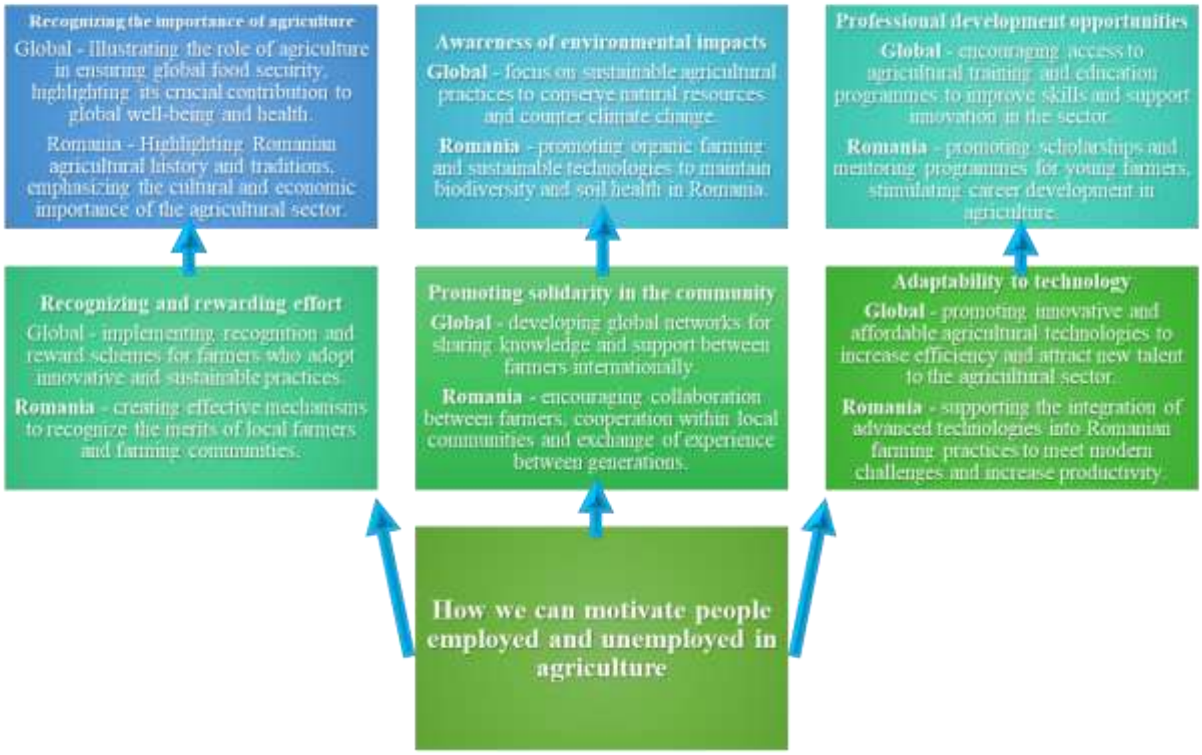

Fig. 4. Mental map for motivating employed and unemployed people in agriculture, globally and in Romania
Source: authors.

Thailand: major factor in Asian agriculture - with a value of 12,168.29 in 2018, Thailand ranks ninth in the global ranking, consolidating its status as a major factor in Asian agriculture. This shows the importance of the agricultural sector in the Thai economy.

Romania: contributing to the European agricultural workforce - with a value of 1,938.11 in 2018, Romania completed the overall top, showing a significant contribution to the European agricultural workforce. This highlights the relevance of Romanian agriculture in the European economic and social framework.

These comments add context and perspective to the FAOSTAT data, giving readers a deeper understanding of each country's position in the global agricultural labour force.

This mental map shown in Figure 4 is beneficial for several reasons:

Holistic approach - covers a wide range of issues, from global recognition of the importance of local agriculture in Romania, integrating elements such as professional development, sustainability, community and technology.

Global and local context - combines global issues with Romanian-specific concerns, ensuring local relevance and applicability, but also connecting to the global context of agriculture.

Enhancing sustainability - the mind map highlights the importance of sustainability of farming practices and environmentally friendly technology, underlining the need to protect the environment and ensure the long-term viability of agriculture.

Encourages professional development - attributes such as training and education opportunities, promotion of young farmers and recognition of effort encourage professional development and the attractiveness of farming as a career.

Encourages solidarity and collaboration - the mind map emphasizes community solidarity and collaboration between farmers, facilitating the exchange of knowledge and experience between farmers.

Reward and recognition - emphasizes the importance of rewarding and recognizing the effort put into farming, thus motivating people to devote their time and resources to this field.

Adaptability to technology - encourages the adoption of technology in agriculture, highlighting the benefits and need for adaptability to new trends and innovations in the field.

Combating stereotypes - promotes the image of the modern farmer and combats stereotypes about the profession, thus helping to change society's perception of agriculture.

Overall, this mind map provides a comprehensive and motivating vision of how conditions and prospects in agriculture can be improved, both globally and in the specific Romanian context.

There are many global and local initiatives that encourage sustainable agriculture and promote environmental and social benefits. These initiatives reflect a shared responsibility towards future generations and underline the importance of collaboration between farmers, communities, governments and international organizations. Here are some relevant examples:

Global initiatives for sustainable agriculture

Sustainable Agriculture Initiative Platform (SAI Platform):

Aim - to promote sustainable agricultural practices globally [13]

Actions - developing standards and guidelines, facilitating the exchange of best practice between members.

Global G.A.P.:

Aim - certification of sustainable agricultural production standards.

Actions - implementing and promoting global standards for safe and sustainable agricultural practices.

Local initiatives for sustainable agriculture in Romania (Sustainable Food Program):

Aim - improving sustainability in the global food supply chain.

Actions - collaboration between companies, farmers and organizations to promote responsible practices.

Initiative for Sustainable Landscapes (ISLA):

Aim - to strengthen global efforts for sustainable management of agricultural landscapes.

Actions - developing partnerships to promote farming practices that balance economic and environmental needs.

Local initiatives for sustainable agriculture in Romania

Romanian Organic Farmers Association (AAER):

Aim - to promote organic and sustainable agriculture in Romania.

Actions - supporting farmers in the transition to organic farming practices, promoting organic products.

Eco Ruralis' "Aware Farmer" project:

Purpose - educating farmers and communities about sustainable agricultural practices.

Actions - training workshops, promotion of traditional and organic farming.

National Rural Development Program (PNDR):

Aim - to support investment in sustainable agriculture and rural development.

Actions - funding projects promoting sustainable agricultural practices, biodiversity conservation.

The benefits of sustainable agriculture

Environmental protection:

Reducing the use of pesticides and fertilisers - helps prevent soil and water pollution.

Biodiversity conservation - by promoting diversity of crops and natural habitats.

Resource efficiency:

Saving water and energy - sustainable farming practices reduce resource consumption.

Food quality:

Healthy and safe food - sustainable agriculture promotes food production without chemical residues.

Climate resilience:

Adaptability to climate variability - sustainable farming practices can better cope with changing climatic conditions.

Shared responsibility and collaboration

Government commitment - governments to support legislation and policy that encourages sustainable farming practices.

Involving local communities - educating communities and promoting awareness of the benefits of sustainable agriculture.

Public-private partnerships - collaboration between governments, non-governmental organizations and the private sector to implement sustainable initiatives.

Investment in research and innovation - supporting research and development to promote innovative and sustainable farming practices.

Exchange of best practices - sharing experiences and resources between farmers, communities and international organizations.

Collaboration between all these stakeholders is essential to build a sustainable future for agriculture and to meet the needs of today without compromising the resources and welfare of future generations.

SWOT Analysis

A S.W.O.T. analysis of sustainability in agricultural work can highlight key issues that can influence the success of initiatives. Here is such an analysis in Table 4.

Table 4. S.W.O.T. analysis of sustainability in agricultural work

Strengths	**Weaknesses**
-Increase global awareness of the importance of sustainability in agriculture. -Using modern technologies to improve efficiency and reduce environmental impact. -There are global initiatives and organizations that promote and support sustainable agriculture. -Availability of knowledge and resources to implement sustainable agricultural practices.	-Implementing sustainable farming practices may initially have higher costs for farmers. -Some farming communities may be resistant to change and adopt new practices. -Farmers with limited financial resources may have reduced access to sustainable technologies.
Opportunities	**Threats**
-Availability of knowledge and resources to implement sustainable agricultural practices. -Raising consumer awareness and increasing demand for sustainable agricultural products. -Continuous development of innovative technologies to improve sustainability.	-Extreme weather events and climate change can adversely affect agricultural production. -Variations in agricultural commodity prices and market volatility can affect profitability. -Social and economic factors can put pressure on farmers to abandon sustainable practices in favor of more conventional ones.

Source: Own determination.

The S.W.O.T. analysis indicates that there is a strong basis for implementing sustainability in agricultural work, with global recognition and support for technology initiatives. However, upfront costs and resistance to change can be barriers. Opportunities are evident in government support and increased demand for sustainable products. At the same time, climate change and socio-economic pressures are threats that require attention and sustainable solutions.

This analysis can guide the development of effective strategies to address weaknesses and threats, building on strengths and opportunities to ensure a sustainable future for agricultural work.

CONCLUSIONS

Sustainability in agricultural work is a global imperative and our shared responsibility is essential to ensure a sustainable future.

The S.W.O.T. analysis highlights that there is both a strong foundation and challenges that need to be carefully addressed and collaboration between different stakeholders.

Recognizing the importance - raising global awareness of the impact of agriculture on the environment and society is a solid foundation for sustainability initiatives. Development opportunities - government support and increased demand for sustainable products provide opportunities for the development and expansion of sustainable agricultural practices. Challenges and obstacles - upfront costs, resistance to change and socio-economic pressures are challenges that require innovative solutions and adequate support.

Recommendations:

Financial investment - governments should offer subsidies and financial incentives to farmers who adopt sustainable farming practices, thereby reducing upfront costs.

Awareness and learning - agricultural knowledge and education programmes should be increased to encourage farmers to adopt sustainable practices and to inform consumers of their significance. Collaboration between farmers, governmental organizations, NGOs and international organizations can enable the exchange of best practices and lessons learned. Investment in sustainable technologies - promoting and facilitating farmers' access to innovative and sustainable technologies will help to increase efficiency and reduce environmental impacts. Constant monitoring and evaluation - implementing effective systems for monitoring and evaluating farming practices is essential to ensure compliance with sustainable standards and to make necessary adjustments.

By addressing these recommendations and actively involving all stakeholders, we can help build sustainable agriculture that ensures food security, protects the environment and offers viable prospects for future generations.

Our shared responsibility is to take concrete action and work together constantly to achieve sustainability goals in agricultural work.

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BINARY LOGISTIC MODEL FOR THE LEVEL OF RICE PRODUCTION AND ITS SIGNIFICANT PREDICTORS

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Abstract

This research article aims to give a description of the level of rice production in Albuera, Leyte, Philippines, and determine the statistically significant predictors affecting it. The study used primary and cross-sectional data from small-scale farmers (with 2-hectare rice farms or less) through a face-to-face interview with the aid of a constructed questionnaire. The gathered information was summarized with the assistance of descriptive metrics and presented in a tabular form. In addition, binary logistic modeling was constructed to extract influencing predictors of the level of rice production and tested its significance. Results portrayed that more farmers in Albuera, Leyte are experiencing a low level of rice production. The findings of the study depicted that small-scale farmers do not have enough capital to buy the necessary agricultural inputs due to their high prices in the market. Plus, farmers do not have sufficient credit facilities that they may use for their farming process and it is also shown that farmers are adversely affected by pests and diseases that destroy their rice cultivation. The binary logistic model shows that a married farmer, with a lower monthly income and with a smaller paddy farm tends to have a higher production level. Moreover, another regression model revealed that the presence of pests and diseases, and being provided with solutions by extension agents are significant predictors of high production levels in rice farming. The study suggests that small-scale farmers in rural areas must be supported regarding their capital and farming facilities, and must be guided and facilitated by expert extension agents in solving different problems.

Key words: *rice production, small-scale farmers, predictors of production, binary logistic model*

INTRODUCTION

Over the years, the most vital crop for food is rice in many countries where its demand for consumption has drastically increased [12]. The economics of rice has influenced many people in terms of culture, staple food, and even income. In [13], it is depicted that rice production has been a source of income for of millions farmers and considered as most productive and sustainable farming system in the world. In the case of the Philippines, millions of hectares (approximately 5) are devoted to rice farming with millions of metric tons (approximately 19) recorded for the production and the total value is about 404 billion (Philippine peso) [24]. The rice industry has been a great help in contributing to the gross domestic product (GDP) of the Philippines through exports and other economic activities such as the main source of income for many Filipino rice farmers [11]. In [8], it is deemed that rice cultivation and production is one of the main concentrations and paradigms of the Philippine government for betterment and enhancement by focusing on agricultural knowledge and financial support as well as a plan of action through policies.

With that, the government has implemented various laws and programs for the improvement of rice production including agricultural extension agents. Moreover, rice production has faced several problems that include flooding [20], pests and diseases [5], [7], lack of agricultural support [11], and high prices of inputs [8], among other constraints. In that case, farmers need support in regard to their economic inputs and knowledge that lead them to innovative ideas on how to improve their production and economic income as well as their well-being [11], [25]. It is worth noting that extension agents in rice production are the ones who provide valuable information and knowledge that improves the production process from planting to harvesting [9].

On the face of it, the investigation of the effectiveness of extension agents in agricultural information will give valuable insights on how to improve the production and farming system as well as give solutions to constraints. According to the findings in [3], it is portrayed that farmers who adopted new technology and agricultural innovative ideas have enhanced and improved their farming techniques which leads to higher economic yield. In fact, it is necessary that rice farmers in the Philippines must be supported by agricultural extension agents since the country lacks lack of competitive advantage as opposed to other countries due to geography location, and climate [18]. Hence, to amend rice cultivation in the country Philippines and improve the economic profitability of small-scale or poor rice farmers, it is necessary that they are guided and educated by some agricultural extension experts to solve existing farming problems and provide remedy to the farm constraints.

At present, it is depicted in [6] that the rice industry in the Philippines is getting weaker and its economic value is diminishing,hence, rice shortages exist in many poor and remote areas of the country. The causes of this low production level include a decreasing number of farmers, climate change, and a significant number of problems and constraints in the farming system. Whence, this research article is motivated to elucidate the production level of rice farming in poor and remote areas in the country Philippines to give economic solutions and promote better policies on how to mitigate and eliminate agricultural constraints. Currently, the inquiry into the rice production level of small-scale rice farmers in remote areas in the Philippines using binary logistic regression modeling is insufficient, hence, this study is pursued without hesitance.

The specific goals of this research article are as follows:

(i) to give a statistical description of the socio-demographic profile of small-scale rice farmers;

(ii) to measure and categorize the rice production level of poor rice farmers;

(iii) to construct a binary logistic model that determines the statistically significant predictors of rice production level.

The importance of this research inquiry is to supply an informative overview of the rice production level and formulate a policy that enhances the rice farmers' competitive advantage and well-being. The results of this study may give multipurpose information to enhance government programs in agriculture, provide useful insights to alleviate poverty and maintain sustainable growth in the near future. Moreover, this study might be helpful as baseline information for other agricultural economists focusing on rice production in the local and global aspects.

MATERIALS AND METHODS

Research Design

This article dealt with quantitative data gathered through a cross-sectional survey. In particular, the study employed a complex correlational research design that involves descriptive statistics metrics and regression modeling to elucidate and give a complete description of the data and explain the influence of independent variables on a single dependent variable. Additionally, the research design was used to draw conclusions and extract predictive information about the level of rice production as it is influenced by some factors.

Research Locale and Respondents

In [10], it is depicted that Barangay Poblacion is one of the significant contributors to rice supply in the Municipality of Albuera, Leyte. In addition, the Barangay has reached out to several agricultural extension agents helping the rice farmers to improve their productivity and lives. In that case, the researchers were motivated to investigate the farmers in the Barangay who were assisted by the extension agents and who are members of the farmers' association in the Municipality of Albuera. Hence, the site of the research locale is shown in Map 1 below. Being a member of the farmers' association assures that the respondents are legit rice farmers in the

Barangay. In that case, researchers have asked for the list of registered farmers in the Municipal Agriculture Office (MAO) of Albuera, Leyte.

Moreover, the study focused on small-scale farmers, thus, it only considered farmers who managed a farm area of 2 hectares or less.

Among the 79 registered farmers with a farm area of 2 hectares or less, 66 farmers were randomly selected with the aid of Slovin's formula with a 5% margin of error.

Map 1. Location of Barangay Poblacion, Albuera, Leyte, Philippines
Source: [15].

In case the chosen farmer was not available during the survey or refused to be interviewed, an alternative farmer was also chosen randomly.

Research Instrument and Data Collection

Since the study involved human beings, hence ethical procedures were properly observed. First, a consent letter was constructed and sent to the Municipal Agriculture Office (MAO) of Albuera, Leyte. After its approval, another consent letter was also constructed and sent to the Barangay Captain of Poblacion. Fortunately, the research survey was permitted and allowed the researchers to interview the farmers who were being chosen as respondents of the study. Before the interview took place, each farmer was informed that the data gathered from them did not contain sensitive information that destroyed their reputation. Moreover, the farmer was also oriented that the information gathered from them would be solely used for this research study only and would be kept private.

A structured questionnaire was constructed as the research instrument for this study. The questionnaire was used as a research survey guide for the personal interview with the rice farmers. The survey questionnaire contains four sections. For the first section, the selected farmers were interviewed about their profile including their age in terms of years, sex (male or female), educational attainment (college graduate or not), marital status (married or not), religion, household size (count), other sources of family income aside from rice farming, monthly income in rice farming (in Philippine peso (₱)), ownership of paddy farm (yes or no), and number of years as experience in rice farmers. For the second section, the rice farmers were interviewed in regard to their perception of some constraints in rice farming including high prices of inputs, lack of farm facilities, lack of credit facilities, inadequate capital for rice farming, inaccessibility to high ways, and pests and diseases. In that case, a 4-point rating scale was used with the following descriptions: 1-Not affecting, 2-Moderately affecting, 3-affecting, and 4-Severely affecting. Thirdly, rice farmers were asked about their perception of the extension agents' roles such as educator (knowledge provider), facilitator (guidance), and solution giver. For the perception of rice farmers to the extension agent's role, a 5-point rating scale was used with the following equivalents: 1-Very unsatisfied, 2-Unsatisfied, 3-Undecided, 4-Satisfied, and 5-Very satisfied. Lastly, the rice farmers were asked about the level of their production in one cropping season. The production level is just equal to the number of sacks per farm size (in hectares). If the production level is 72 or above, then it is categorized as high production, otherwise, it is low production [10].

Data Management and Regression Model

After collecting the desired data, it was encoded into Microsoft Excel and formatted to fit in the STATA program for statistical calculation. In addition, proper coding of values and their descriptions were made to give appropriate interpretation for the desired results. To summarize the data gathered, descriptive statistical metrics such as mean average (M), standard deviation (SD), maximum (max) and minimum (min) values, percentages (%), and frequency counts were computed and presented in statistical tables. Since the level of rice production as a dependent variable is a binary, then binary logistic regression model was used to predict its determinants. As a diagnostic test for the model, a variance inflation factor (VIF) was employed to determine if the model possesses a multicollinearity problem which is a possible assumption violator for the binary logistic regression model. In the paper of Allison [2], it is portrayed that a regression model does not have a multicollinearity problem if the mean VIF is less than 10. The empirical regression models are as follows:

$$\begin{aligned} Production_i = \alpha_0 + \alpha_1 Age_i + \alpha_2 Male_i \\ + \alpha_3 Cgraduate_i \\ + \alpha_4 Married_i \\ + \alpha_5 RoCatholic_i \\ + \alpha_6 HHSize_i \\ + \alpha_7 Otherincome_i \\ + \alpha_8 \log(income)_i \\ + \alpha_9 Owner_i \\ + \alpha_{10} Yexperience_i \\ + \alpha_{11} Farmsize_i + \varepsilon_i \end{aligned} \quad (1)$$

and

$$\begin{aligned} Production_i = \beta_0 + \beta_1 Hinputs_i \\ + \beta_2 Ffacilities_i \\ + \beta_3 Cfacilities_i \\ + \beta_4 ICapital_i \\ + \beta_5 Inaccessibility_i \\ + \beta_6 PDiseases_i \\ + \beta_7 Educator_i \\ + \beta_8 Facilatator_i \\ + \beta_9 Sgiver_i + e_i \end{aligned} \quad (2)$$

where: $Production_i$ represents a binary dependent variable (0-low, 1-high), i=1, 2,...,66 (rice farmers), Age_i represents the age of rice farmers measured in years, $Male_i$ is anindicator (dummy) variable that indicates a male farmer (0-female, 1-male), $Cgraduate_i$ is anindicator (dummy) variable that indicates a farmer who graduated college degree (0-non college graduate, 1-college graduate), $Married_i$ is anindicator (dummy) variable that indicates a farmer who are married (0-non married, 1-married), $RoCatholic_i$ is anindicator (dummy) variable that indicates a farmer that is a Roman Catholic as a religion (0-non Roman Catholic, 1-Roman Catholic), $HHSize_i$ refers to the farmers' household size (number of family members), $Otherincome_i$ is anindicator (dummy) variable that indicates a farmer with other source of income (0-no other source of income, 1-with other source of income), $\log(income)_i$ represents to the logarithm (base 10)of monthly income in rice farming, $Owner_i$ is anindicator (dummy) variable that indicates a farmer who owns their rice field (0-non owner, 1-owner), $Yexperience_i$ refers to the farmer's number years in rice farming, and ε_i refers to the remaining random error in model (1). In addition, $Hinputs_i$ refers to the perception of farmers on the high inputs as a constraint, $Ffacilities_i$ refers to the perception of farmers on the lack of farm facilities as a constraint, $Cfacilities_i$ refers to the perception of farmers on the lack of credit facilities as a constraint, $ICapital_i$ refers to the perception of farmers on the inadequate capital as constraint, $Inaccessibility_i$ refers to the perception of farmers on the inaccessibility to high ways as constraint, $PDiseases_i$ refers to the perception of farmers on the pests and diseases as constraint, $Educator_i$ refers to the perception of farmers on the extension agents' role as educator, $Facilatator_i$ refers to the perception of farmers on the extension agents' role as facilitator, $Sgiver_i$ refers to the perception of farmers on the extension agents' role as solution giver, and e_i represents to the random error in model (2). All statistical inference results were tested at the standard level of significance.

RESULTS AND DISCUSSIONS

Profile of Small-scale rice farmers

The summarized socio-demographic profile of small-scale rice farmers in Brgy. Poblacion, Albuera, Leyte, Philippines were shown in Table 1. The mean average age (in years) of small-scale farmers in Brgy. Poblacion, Albuera, Leyte is approximately equal to 57.48 (SD=9.41) and it ranges from 36 (youngest) to 79 (oldest) years old. There are 65% male and 35% female small-scale rice farmers in the barangay. This result is parallel to [9] that there are more male rice farmers in the barangay indicating that farming is a masculine job. Only 11% of these farmers have finished a college degree and 89% of them do not have a bachelor's degree. In [11], it is deemed that most of the rice farmers do not have good educational attainment and mostly do not finish a college degree. Most of the rice farmers are married (89%) and only 11% of them are non-married. In addition, the mean average household size of the farmers in the barangay is close to 5 (SD=1.58) where the smallest is 2 and the highest is 11. Most (85%) of these farmers are Roman Catholic believers and only 15% of them are with other religions. On average, the monthly income in rice farming of small-scale farmers in the barangay Poblacion is close to ₱4,946.97 (SD=₱ 2,148.58) and it ranges from ₱ 3,000 to ₱ 15,000. About 39% of these rice farmers own their paddy farm and most (61%) of them are tenants and rental payers.

Table 1. Small-scale rice farmers' profile

Variables	Mean	Std. Dev.	min	Max
Age	57.48	9.41	36	79
Male farmers[a]	0.65	0.48	0	1
College degree[a]	0.11	0.31	0	1
Married farmers[a]	0.89	0.31	0	1
Number of family members[b]	5.42	1.58	2	11
Roman Catholic[a]	0.85	0.36	0	1
Other income[a]	0.94	0.24	0	1
Monthly income[c]	4,946.97	2,148.58	3,000	15,000
Farm owner[a]	0.39	0.49	0	1
Years of experience	23.73	9.55	6	50
Farm size[d]	0.65	0.37	0.1	2

Note: a-indicator (dummy) variable; b-counts; c-in Philippine Peso (₱) (0.018 USD); d-measured in hectares.
Source: Authors' calculation (2024).

Approximately, the mean average number of years in rice farming of the farmers is close to 23.73 (SD=9.55) and it ranges from 6 to 50 years). Moreover, the mean average farm size that was cultivated by small-scale rice farmers is close to 0.65 hectares (SD=0.37 hectares) and it ranges from 0.1 to 2 hectares.

Farmers' Perception of Farm Constraints and Agriculture Extension Agents' Support

Table 2 depicts the subjective perception of rice farmers to their farm constraints (Scale of 1 to 4) in rice cultivation and production, and farmers' perception of agricultural extension agents' support (Scale of 1 to 5). It is revealed that small-scale farmers are moderately affected (M=2.50, SD=0.61) by high prices of agricultural inputs needed in the rice production process. This means that farmers are facing difficulties in acquiring the inputs which affects their economic profitability in rice farming. This result is consistent with the findings in [11] which portrayed that farmers' low income in rice farming is due to the high input prices from planting to growing. Fortunately, on average, farmers do not lack of farm facilities (M=1.68, SD=0.83) needed in the rice production process. This implies that they have the available materials and facilities that enable them to grow rice from land cultivation to harvesting. However, the lack of credit facilities is moderately affecting (M=2.36, SD=0.83) the rice farmers' production process. It is worth noting that farmers need financial assistance like access to credit to meet the economic requirements during the rice cultivation process which is utilized in purchasing seeds, pesticides, fertilizers, labor costs, and other agricultural inputs [1], [11]. As can be gleaned in Table 2, farmers are experiencing inadequate capital (M=3.17, SD=0.83) during the cultivation process which results in difficulty in acquiring the needed farm inputs. In [21], it is depicted that nowadays, rice farmers in the rural areas in the Philippines are suffering from the high expense of critical inputs in rice cultivation. Moreover, rice farmers are also affected by pests and diseases (M=2.58, SD=0.82) which lower down their production. In [19], it is deemed that one of the problems in rice cultivation is pests and diseases where farmers need a financial system to provide proper management. In that case, these rice farmers are affected by pests and diseases since they lack of budget to buy the necessary pesticides, herbicides, and insecticides, among others, that are needed to have a healthy paddy farm.

It is revealed in Table 2 that rice farmers are satisfied (M=3.65, SD=0.73) with the support of extension agents as educators of agricultural techniques. This implies that extension agents are doing their responsibilities as transferring necessary information for the improvement of farmers' production process. This result is parallel to the findings in [3] and [14] that agricultural extension agents are educating local farmers for sustainable development. However, farmers are undecided (M=3.41, SD=0.88) regarding their satisfaction perception with extension agents' support as farm facilitators. This indicates that extension agents do not fully facilitate the farmers in the actual farming process but only share ideas and information that may influence the farmer's decision-making skills. In [9], it is depicted that extension agents in the barangay are just focusing on transferring innovative technology in farming through training and seminars but less on the hand-in-hand farming or actual processes. Moreover, farmers are also undecided (M=3.39, SD=0.84) in regard to their satisfaction perception with extension agents' support as solution givers.

Table 2. Farmers' Perception of Constraints and Extension Agents' Support

Variables	M±SD	min	max	Description
Rice farming constraints				
High inputs	2.50±0.61	2	4	Moderately affecting
Lack of farm facilities	1.68±0.83	1	4	Not affecting
Lack of credit facilities	2.36±0.83	1	4	Moderately affecting
Inadequate capital	3.17±0.83	1	4	Affecting
Inaccessibility to highways	1.44±0.68	1	3	Not affecting
Pest and diseases	2.58±0.82	1	4	Affecting
Extension agents' support				
Educator	3.65±0.73	2	5	Satisfied
Farm facilitator	3.41±0.88	2	5	Undecided
Solution giver	3.39±0.84	2	5	Undecided

Source: Authors' calculation (2024).

This goes to infer that farmers' problems are not always given a solution by an extension agent regarding their production needs. Especially, in the capital for buying agricultural inputs and labor costs. It is worth noting that in [22], rural farmers' frequent problem is the access to credit or loans for input supplies in the production activities and other agricultural expenses.

Level of Rice Production

About 53% of the rice farmers have a low level of production and about 47% of them have high production. This means that several of the farmers in Brgy. Poblacion is experiencing problems and challenges in the production process, especially in dealing with climate change, water supply systems, pests and diseases, and management, among others [6], [8], [18]. In the study of Casinillo and Seriño [11], small-scale farmers in rural areas are suffering from the rise of agricultural inputs, hence, some farmers cannot acquire a necessary solution to the production problems which results in low productivity. In addition, it is portrayed in [17] that farmers' low productivity in rice farming is due to the high costs of fertilizers, land rent, land area, and low innovative techniques in cultivating rice plants. Moreover, most of the farmers in rural areas are traditional farmers whose farming skills are not suitable for the current climate or season and existing problems nowadays [11], [25].

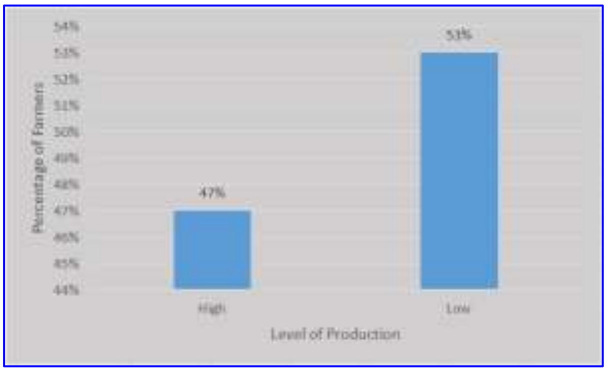

Fig. 1. Rice farmers' level of production.
Source: Authors' construction (2024).

Binary Logistic Models

Table 3 shows the first binary logistic regression model where the dependent variable is the level of rice production (high or low) and the independent variables are the socio-demographic profile of rice farmers. Based on variance inflation factor (VIF) computation, it is depicted that model (1) does not suffer from multicollinearity problems between independent variables (VIF<10). It is revealed in the table that model (1) is significant at a 5% level (X^2=23.17, p-value=0.017) and possesses a pseudo-R^2 of 0.253. This indicates that model (1) has significant factors influencing the level of production among farmers. It is revealed in the model (1) that being a married (α_4=2.094, p-value=0.078) farmer tends to have a high level of rice production and it is significant at a 1% level. Based on the marginal effect computation, the probability of being married with a high level of rice production is higher by 37.8% as opposed to the farmers who are not married. This implies that being a married farmer is more productive and eager to earn more because of the responsibilities and duties of a provider in the household [16]. In [8], it is portrayed that a married farmer is more motivated to earn money for the basic needs of their family.

Table 3. Binary logistic model (1) for the level of rice production and its predictors (socio-demographic)

Variables	Coeff.	Std. Error	p-value	Marginal effects
Age	-0.029[ns]	0.045	0.515	-0.007
Male[a]	-0.619[ns]	0.695	0.373	-0.151
College graduate[a]	-2.093[ns]	1.664	0.209	-0.378
Married[a]	2.094*	1.190	0.078	0.378
Household size[b]	-0.168[ns]	0.208	0.416	-0.041
Roman Catholic[a]	-0.600[ns]	0.964	0.534	-0.148
Other income[a]	0.217[ns]	1.473	0.883	0.052
log (income[c])	-6.854**	3.469	0.048	-1.676
Farm owner[a]	0.883[ns]	0.821	0.282	0.215
Years of experience	0.006[ns]	0.049	0.899	0.001
Farm size[d]	-2.169**	1.077	0.044	-0.530
Constant	27.399**	13.123	0.037	-
No. of respondents	66			
X^2	23.17**			
p-value	0.017			
Log-likelihood	-34.04			
Pseudo R^2	0.253			

Note: a-dummy variable; b-counts; c-in Philippine Peso (₱); d-hectares; ns-not significant; *p<0.10; **p<0.05.
Source: Authors' calculation (2024).

It is shown in the binary logit model (1) that farmers with lower monthly income (α_8=-6.854, p-value=0.048) tend to have higher production levels and it is significant at the 5% level. In addition, the likelihood of farmers with lower income having a higher level of rice production is higher by 167.6% compared to farmers with higher monthly income. This means that farmers with lower monthly incomes are eager to exert effort in improving the production level. In [26], it is deemed that poor farmers are more likely to adopt new innovative technology to somehow improve their production level and economic profit. Moreover, model (1) depicted that farmers with smaller farm sizes (α_{11}=-2.169, p-value=0.044) tend to have a higher level of rice production and it is significant at the 5% level. The likelihood of the farmers with smaller farm sizes having a higher level of rice production is higher by 53% as opposed to farmers with larger farm sizes. This implies that farmers with smaller paddy farms can easily focus on taking care the rice cultivation and are more attentive to applying technologies in agriculture [4]. Plus, the local government is supporting small-scale rice farmers in regard to their inputs to increase production [23].

Table 4 presents the second binary logistic regression model (2) where the regress and is the level of rice production (high or low) and the regressors are some possible factors in farming activity. By multicollinearity test, it is revealed that the VIF is less than 10 which indicates that no significant correlation exists in the pairwise regressors. In Table 4, it is shown that model (2) is not significant even at a 10% level (X^2=14.31, p-value=0.117) and possesses a pseudo R^2 of 0.157. This implies that model (2) has a few significant factors influencing the level of production based on the individual test for each regressor as can be gleaned in Table 4. First, model (2) revealed that if the rice planting process encounters pests and diseases (β_6=0.821, p-value=0.055), farmers are more likely to have a high level of production and it is significant at a 10% level. This indicates that if pests and diseases are present in farming activities, farmers tend to apply technologies to get rid of pests and diseases which results in increased production. Using the marginal effect calculation, it is shown that the probability of the presence of pests and diseases with higher levels of production is higher by 20.3% compared to no pests and diseases. This inverse result shows that farmers are motivated to take care of their farms if pest and diseases constraint exists by applying new innovative technology and management to enhance the yield of rice [5], [8], [28]. Moreover, model (2) revealed that if extension agents can give a solution (β_9=1.071, p-value=0.014) to the farmers' existing problems in the farming process, they tend to have a high level of rice production and it is significant at a 5% level. The likelihood of farmers being provided a solution to the problem to have a higher production is higher by 26.6% compared to farmers not being provided with a solution. This implies that extension agents' support to farmers is a great help in improving their decision-making skills and enhancing their productivity in farming. The result is consistent with the findings in [9] and [27] that extension agents provide the necessary knowledge to solve the farmers' production problems and educate them to make good decisions and management.

Table 4. Binary logistic model (2) for the level of rice production and its predictors (rice farm factors)

Variables	Coeff.	Std. Error	p-value	Marginal effects
High inputs[a]	0.027[ns]	0.508	0.957	0.006
Lack of farm facilities[a]	-0.439[ns]	0.462	0.342	-0.109
Lack of credit facilities[a]	0.208[ns]	0.404	0.607	0.051
Inadequate capital[a]	0.566[ns]	0.426	0.185	0.140
Inaccessibility to high ways[a]	0.348[ns]	0.473	0.461	0.086
Pest and diseases[a]	0.821*	0.428	0.055	0.203
Educator[b]	-0.248[ns]	0.477	0.603	-0.061
Farm facilitator[b]	0.078[ns]	0.390	0.842	0.019
Solution giver[b]	1.071**	0.437	0.014	0.266
Constant	-7.393**	3.068	0.016	-
No. of respondents	66			
X^2	14.31			
p-value	0.112			
Log-likelihood	-38.47			
Pseudo R^2	0.157			

Note: a-Scale of 1 to 4; b-Scale of 1 to 5; ns-not significant; *p<0.10; **p<0.05.
Source: Authors' calculation (2024).

CONCLUSIONS

Results indicated that there are more small-scale rice farmers in Brgy. Poblacion Albuera Leyte who are experiencing a low level of production. This means that the rice farming in the Brgy. Poblacion does not optimally maximize production due to some existing factors and constraints influencing it. It is concluded that farmers are affected by high prices of inputs needed in the farming process and they have no enough capital and sufficient access to credit to buy those agricultural inputs. It is revealed that during rice cultivation, pests and diseases exist which negatively affect the yield and economic income in rice farming. The binary logistic regression depicted that a married farmer tends to have a higher production level since they are motivated to work hard and eager to earn more income for their families' needs. In addition, the model shows that farmers with lower monthly incomes and smaller paddy farms tend to have a higher production level. These inverse results indicated that farmers with those characteristics are more focused and stimulated in farming where they can easily take care and apply suitable techniques to increase their productivity. Furthermore, the second regression model revealed that the presence of pests and diseases, and being provided with solutions by extension agents are significant factors of higher levels of rice production. This implies that farmers were provided necessary information by agricultural extension agents on how to solve problems in farming by applying new innovative technologies including to remedy pests and diseases in the cultivation process. Hence, the study recommended that small-scale rice farmers in rural areas must be supported by the local government in terms of farm capital and agricultural facilities. Furthermore, farmers must be guided and facilitated by expert extension agents in combating different problems in farming activities to improve their production levels. As for future studies, farmers' well-being must be investigated like satisfaction and resilience to support the current findings.

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ORDINAL REGRESSION MODELING FOR THE LEVEL OF ABACA PRODUCTION IN EASTERN VISAYAS, PHILIPPINES

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Abstract

This article elucidated the level of abaca production in Eastern Visayas, Philippines, and developed a statistical model that determined its significant governing factors. A cross-sectional survey and primary data collection were done to gather sufficient information through a face-to-face interview with a random sample of 349 abaca farmers. The study used standard statistical metrics to describe the data and presented it in a tabular form. In addition, ordinal regression was employed to model the factors governing the level of abaca production in the Region and tested its significance at standard level. Results portrayed that, on average, the production of the abaca industry in Eastern Visayas is considered at a moderate level. This implies that the abaca production in the region has still room for improvement. It is found that abaca farmers in the region only interact with the traders and have no engagement with other players such as enablers (PhilFIDA, SUCs, and LGU) due to some constraints. The results of the first ordinal regression revealed that the factors affecting the level of abaca production are the age of farmers (ρ_1=0.027, p-value=0.003) and the size of the farm (ρ_6=-0.564, p-value<0.001). This implies that older farmers are more knowledgeable in applying innovative techniques that enhance production activities. Moreover, the smaller size of the abaca farm is easy to manage and apply technologies to improve production levels as opposed to bigger farms. The second ordinal regression showed that farming experience (λ_4=0.015, p-value=0.038) is a significant predictor of abaca production level which indicates that experienced farmers are more productive and competitive.

Key words: *abaca fiber, production level, predictors, regression modeling*

INTRODUCTION

Abaca (*Musa textilis Née*) is one of the important plants grown in the Philippines due to its various uses and economic valuation [22], [26]. Nowadays, the abaca industry in the Philippines is significantly contributing to the abaca market globally and enhancing the gross domestic product (GDP) in the country [24]. Moreover, it is portrayed in [25] that abaca farming in the Philippines has cultural practices, values, and beliefs that change the lives of farmers both economically and socially. In fact, abaca farming is one of the major sources of livelihood for hundreds of Filipinos in many provinces in the country [22]. Abaca is a very useful fiber and a variety of products can be made that can be exported to other countries and a good source of sustainable commodities for economic activities [10], [24]. In [26] and [29], it is depicted that abaca fiber can be used as a renewable bio-resource for commercial enterprise purposes and other products that lead to sustainable and natural manner. Hence, abaca production is one of the important focuses of the Philippine government providing budget support and implementing some policies on how to improve and grow economically.

As time goes by, there are problems existing in abaca production that farmers are having difficulty facing such as climate change, lack of agricultural innovations, lack of capital, poor market roads, lack of extension agents, and pests and diseases, among others [17], [20]. How the study in [3], it is portrayed that the Philippine Fiber Industry Development Authority (PhilFIDA) is responsible for the development and growth of natural fiber in the country through research and innovation. Moreover, in [10] and [11], it is deemed that PhilFIDA has helped the abaca plantation in the country through production support, educating and training farmers, extension support, and treating pests and diseases. In addition, some state universities and colleges (SUCs) in the country are also supporting the abaca farmers through research and extension [19] as well as local government units (LGU) are aiding farmers in regard to their agricultural inputs [5]. In that case, some farmers in the country are being helped with their problems in growing abaca and being provided support in improving the production level. Moreover, the government has supported many scientists who study the structures of abaca that provide solutions to the different existing problems and challenges including pests and diseases, climate change, and the cultivation process, among others [4], [21], [25], [28]. Plus, the government also supported scientists that develop agricultural materials and products from abaca fiber which constitute the Philippine economy [6], [12], [13], [24], [29]. Hence, to enhance the abaca production in the country, it is necessary to investigate the farmers' situation in their farming activities and satisfaction with the help and support they have received.

Although there are existing studies in the literature regarding abaca fiber production in the Philippines, investigating the production level through statistical modeling is scarce. In fact, constructing an ordinal regression model to identify the predictors of abaca production in rural areas in the Philippines has never been done before. Thus, to fill in the research gap, this article study is executed. Generally speaking, this article develops an optimal statistical model that determines the significant factors influencing the abaca production level in Eastern Visayas, Philippines. Specifically, the article dealt with the following goals: (i) to construct a profile of the abaca farmers in Eastern Visayas, Philippines; (ii) to measure the level of abaca production; and (iii) to develop a regression model that determines the predictors of abaca production level. The significance of this paper is to pave an overview of the production of abaca to give possible solutions to some existing problems in farming activities. Results of the study may provide information in enhancing a policy package that improves the production of abaca and farmers' income level as well as their well-being. Moreover, the findings of this paper may recommend some ways to enhance the current production of abaca and progress the exports of various abaca products for the development of the Philippine economy. Furthermore, the article may be used as a benchmark for abaca researchers and agricultural extension agents to improve their strategies in interacting with the farmers and other stakeholders, and the paper may serve as a piece of new novel information to the global literature on agriculture sustainability.

MATERIALS AND METHODS

Research Design

This paper article employed a quantitative survey in gathering the information needed in the type of cross-sectional data. Since the study investigated the degree of influence of independent variables on dependent variables, a complex correlational was utilized as a research design. In summarizing the variables, the article used some standard descriptive metrics and presented them in statistical tables. Regarding the determination of relationships or correlations among variables, a statistical inference was computed in the form of regression modeling. In that case, necessary measures and predictions were drawn with statistical evidence.

Research Locale, Respondents, and Sampling

Eastern Visayas is known to have a wide abaca production and industry in the country [22]. Hence, this study considered all the abaca farmers in Eastern Visayas or Region VIII, Philippines as a population of interest. Official lists of abaca farmers in each municipality were secured in the Office of Agriculture. The sample size used for the survey was computed using Slovin's formula with an appropriate margin of error set by the researchers. After that, the sample size was proportionate in each province in Eastern Visayas, and the province being chosen was based on the level of how abaca cultivation is abundant. Hence, a total of 349 abaca farmers were selected in a random manner. In that case, there are 27 farmers chosen from Southern Leyte within three municipalities, 45 framers from the seven municipalities of Leyte, 46 farmers from the four municipalities of Biliran, 21 farmers from the three municipalities of Eastern Samar, and 210 farmers from the nine municipalities of Northern Samar. Map 1 presents the different provinces of Eastern Visayas and each municipality that was part of the survey study.

Map 1. Region VIII, Eastern Visayas, Philippines.
Source: [14].

Survey Instrument and Data Collection

The study used a developed structured questionnaire where the content was based on the current study in literature [8], [22]. The questionnaire has three (3) parts such as (i) demographic and farming profile, (ii) engagement of abaca farmers to the other players in the industry (PhilFIDA, SUCs, and LGU) known as extension actors, (iii) level of abaca production. As for the demographic and farming profile of abaca farmers, the following were asked: (1) age in years, (2) sex, (3) marital status, (4) number of years in education, (5) other income aside from abaca farming, (6) size of abaca farm in hectare/s, (7) tenurial status, (8) years in farming, (9) distance from abaca farm to house, (10) any agency in abaca farming that visits. As for the second part, the abaca farmers were asked about their level of engagement with the other players (PhilFIDA, SUCs, and LGU) using a 1 to 4 scaling. In that case, 1 indicates no engagement (or interaction) and 4 indicates a strong engagement. Table 1 shows the various range of values that the mean engagement perception scores will possibly fall and its corresponding verbal interpretation.

Table 1. Engagement perception scores.

Perception scores	Description
1.00-1.75	No engagement
1.76-2.50	Weak engagement
2.51-3.25	Moderate engagement
3.26-4.00	Strong engagement

Source: Authors' guide (2024).

The level of abaca production was computed as yield (kg) in one cropping season divided by the area of the abaca farm in measures in hectares. Table 2 presents the possible intervals that the level of abaca production might fall and its description.

Table 2. Level of abaca production.

Level of production[a]	Description
1 - 50	Low
51 - 100	Moderate
101 - above	High

Note: a - yield (kg) per hectare.
Source: Authors' guide (2024).

Before the survey was conducted, ethical processes were observed. The researchers have secured first a consent letter to the higher officials of each province, a letter of permission to conduct the survey, and informing them of the purpose and its significance. After the approval, a similar consent letter was sent to each municipality's offices addressed to the head personnel. Fortuitously, the study was permitted to be conducted in each targeted research locale. The survey was done through a face-to-face interview with the abaca farmers. In that case, before the interview, farmers were informed about the intent of the survey and told that no sensitive information would be collected. Moreover, they were also informed that the data collected from them will be treated as confidential which conforms to the Data Privacy Act in the Philippines and solely used for this article only.

Statistical Analysis and Empirical Model

Data collected has undergone clearing by excluding participants with missing responses and outliers. After this, qualitative responses were converted into quantitative data through the process of coding or assigning numerical values in Microsoft Excel. Additionally, the data were formatted in line with the STATA environment for statistical computations. To give an appropriate description of the data, it was summarized with standard statistical measures such as mean (M) as computed average, standard deviation (SD) as a measure of dispersion, coefficient of variation (CV) as a measure of consistency, minimum (min) and maximum (max) values, frequency counts (n) and percentages (%). The computed descriptive measures were presented by statistical tables. Note that the level of abaca production is categorically ordered, hence, the study employed ordinal regression modeling in determining the significant predictors. This study has constructed two empirical statistical models as follows:

$$\begin{aligned} AbacaProd_j = \rho_0 + \rho_1 Age_j + \rho_2 Male_j \\ + \rho_3 Married_j + \rho_4 Yeduc_j \\ + \rho_5 Oincome_j + \rho_6 AFarm_j \\ + \rho_7 TStatus_j + \varepsilon_j \end{aligned} \quad (1)$$

and

$$\begin{aligned} AbacaProd_j = \lambda_0 + \lambda_1 PhilFIDA_j \\ + \lambda_2 SUCs_j + \lambda_3 LGU_j \\ + \lambda_4 YFarming_j \\ + \lambda_5 AgriAgency_j \\ + \lambda_6 DHFarm_j \\ + e_j \end{aligned} \quad (2)$$

where $AbacaProd_j$ refers to the ordinal dependent variable (0-low, 1-medium, 2-high), j refers to the jth abaca farmer (j$\in \{1, 2, \ldots, 349\}$), ρ_j refers to the parameters to be approximated in the model (1), Age_j refers the age of abaca farmers in years, $Male_j$ represents a dummy variable that indicates a male abaca farmer (0-female, 1-male), $Married_j$ represents a dummy variable that indicates an abaca farmer who is officially married (0-non married, 1-married), $Yeduc_j$ refers to the farmers' number of years spent on education, $Oincome_j$ represents a dummy variable that indicates a farmer who has other income aside from abaca farming (0-None, 1-With other income), $AFarm_j$ refers to the farmer's area of abaca farm measured in hectares, $TStatus_j$ represents a dummy variable that indicates a farmer who owns their abaca farm (0-Not an owner, 1-Owner). Moreover, $PhilFIDA_j$ refers to the rating of farmers in their engagement with PhilFIDA (1 to 4 scaling), $SUCs_j$ refers to the rating of farmers in their engagement with SUCs (1 to 4 scaling), LGU_j refers to the rating of farmers in their engagement with LGU (1 to 4 scaling), $YFarming_j$ refers to the farmer's number of years in farming, $AgriAgency_j$ represents a dummy variable that indicates a farmer who was visited by agricultural agencies (0-Not visited, 1-Visited), $DHFarm_j$ refers to the distance from farmer's house to abaca farm measured in kilometers, and ε_i and e_j refers to the random errors in model (1) and (2), respectively. To capture that multicollinearity exists for independent variables, the variance inflation factor (VIF) was computed in each model (1 and 2) as a diagnostic test for regression analysis. The null hypothesis (H_o) of this study is that the independent variable has no significant influence on the dependent variable, otherwise the alternative hypothesis (H_a). All statistical computations were subjected to the probability of rejecting H_o with the standard level of significance.

RESULTS AND DISCUSSIONS

Profile of Abaca Farmers in Region VIII, Philippines

The descriptive statistics results for the abaca farmers' profile are presented in Table 3. Abaca farmers' mean average age is close to 51.49 (SD=12.18) years old where the youngest is 24 years old and the oldest is 90 years old. This finding is parallel to the paper in [9] that farmers are relatively old since their young ones are sent to school so that they can find a decent job with higher income. There are 73% male abaca farmers and 27% female abaca farmers. This result is consistent with the findings in [8], that there are more male farmers since farming job involves masculine activities. About 82% of the farmers were married and 18% of them were non-married (single, widower, etc.). The abaca farmers' number of years spent in education is approximately 7.81 (SD=3.47) years which indicates that, on average, they are high school level.

There exists a farmer in the survey that never experienced schooling and there are also farmers who are college-level. About 87% of the farmers have another source of income aside from abaca farming and only 13% of them are completely relying on abaca farming income. On average, the farm size cultivated for abaca farming is close to 1.88 ha (SD=2.36 ha), the minimum is 0.02 ha and the maximum is 30 ha. About 87% of the farmers owned their abaca farm and 13% of them did not own (tenants, workers, renting, etc.). The farmers' number of years in abaca farming is close to 21.18 (SD=14.52) where the minimum is 1 year and the maximum is 70 years. About 49% of the farmers said that they are visited by agricultural agencies or enablers for the production process and 51% of them said that they are never visited. The farmers' mean average distance from home to their abaca farm is close to 6.79 km (SD=16.10 km) where the minimum is 0.045 km and the maximum is 250 km.

Table 3. Abaca farmers' profile.

Variables	Mean (M)	SD	min	max
Age (years)	51.49	12.18	24	90
Male (dummy[a])	0.73	0.46	0	1
Married (dummy[a])	0.82	0.39	0	1
Education (years)	7.81	3.47	0	16
Other income (dummy[a])	0.87	0.33	0	1
Abaca farm size[b]	1.88	2.36	0.02	30
Abaca farm owner[a]	0.87	0.38	0	1
Years in abaca farming	21.18	14.52	1	70
Agency visit (dummy[a])	0.49	0.51	0	1
Distance from home to farm[c]	6.79	16.10	0.045	250

Note: a-indicator variable; b-in hectares (ha); c-in kilometers (km).
Source: Authors' statistical computation (2024).

Farmers' Engagement to Enablers

It is revealed in Table 4 that farmers have no direct engagement with the enablers in the region such that PhilFIDA (M=1.45, 0.87), SUCs (M=1.04, 0.28), and LGU (M=1.17, SD=0.57). The coefficient of variation (CV>20%) has shown that the response is not consistent which implies that farmers' perceptions can be changed depending on some factors. These results revealed that farmers do not interact with the other players in the abaca industry which is not ideal since they cannot gain information and new knowledge that is suitable for the current phenomenon. In fact, supporting actors who are extension service providers such as PhilFIDA, SUCs, and LGU play an important role, but they are not directly connected with the farmers in the value chain activities.Their direct involvement with the farmers only happens when they provide extension services such as capacity building.In this study, the researchers only made use of the frequency of meetings as an indicator of interaction between actors, thus the very minimal or no interaction result. Similar findings were also observed in [27] wherein abaca farmers in Catanduanes, Philippines sell directly to traders and it was recommended that they should connect to other actors in the value chain to reduce information asymmetry. Furthermore, the LGUs are advised to intervene in the chain through the creation of programs that would address sustainability in abaca production [23].

Table 4. Abaca farmers' engagement perception to enablers in Region VIII, Philippines.

Variables	M	SD	CV (%)	Interpretation
PhilFIDA[a]	1.45	0.87	60.00	No engagement
SUCs[a]	1.04	0.28	26.92	No engagement
LGU[a]	1.17	0.57	48.71	No engagement

Note: a-Scale 1 to 4.
Source: Authors' statistical computation (2024).

Abaca Production Level

Table 5 shows that 30.66% of the abaca farmers have experienced low production and about 22.92% have experienced a moderate level of production. This indicates that farmers need to be supported by other actors (PhilFIDA, SUCs, and LGU) to improve their abaca cultivation and production activities through innovative technologies. Unfortunately, a rapid production increase of abaca is difficult to achieve because of the Philippines' limited competitive advantages and the government initiatives have not been very successful in engaging abaca stakeholders [11].Additionally, there are 46.42% of the abaca farmers have experienced a high production level. This indicates that some farmers are fortunate regarding the production process since they have better production levels as opposed to other abaca farmers. On average, the mean production of the abaca industry in Eastern Visayas, Philippines can be interpreted as moderate level. Hence, abaca production in the region can still be improved. In [30], it is portrayed that strengthening the engagement between actors in the value chain is a broad-based approach to increasing abaca productionbecause it will not only maximize resources available but it will also synchronize the initiatives of SUCs, LGU, PhilFIDA, and other abaca stakeholders. In [11], it is stated that the convergence of abaca stakeholders allows the government to position and take advantage of possible increased demand for abaca and encourage chain upgrading into the energy and automotive sectors.

Table 5. Production level of abaca industry in Region VIII, Philippines.

Production Level	n	%
Low	107	30.66
Moderate	80	22.92
High	162	46.42
Mean production	Moderate	

Note: Production is yield (kg) per hectare (in one cropping season).
Source: Authors' statistical computation (2024).

Regression Models for Abaca Production

It is revealed in Table 6 that the first regression model (I) does not possess a multicollinearity problem based on mean VIF since it is less than 10 [2]. In that case, the model is acceptable for drawing conclusions and extracting inferences. It can be gleaned in Table 6, that model I (X^2=80.59, p-value<0.001) is significant at a 1% level and possesses a pseudo R^2 of 0.109 which indicates that there are some factors (predictors) that significantly influence the dependent variable which is the abaca production level. The model (I) showed that the following independent variables are not statistically significant: sex (p-value=0.137), civil status (p-value=0.301), educational attainment (p-value=268), other income (p-value=0.649), and tenurial status (p-value=0.840). This indicates that the said variables have minimal or no influence on the level of abaca production. On the other hand, age (ρ_1 =0.027, p-value=0.003) is highly significant at a 1% level. This indicates that the age of farmers is influencing the level of production in abaca farming. Since ρ_1>0, then this indicates that an older farmer has a higher probability of having a high level of production. In [18], it is portrayed that farmers with enough experience in farming tend to improve their knowledge, attitude, and practices in abaca cultivation which results in improved production practices and yield. The second predictor in the model (I) is abaca farm size (ρ_6=-0.564, p-value<0.001) which is highly statistically significant at a 1% level. Since ρ_6<0, this indicates that a smaller farm size in abaca is more likely to have a high production level. It is worth noting that a smaller farm can be easily managed and farmers can take care of the farm accordingly. In [16] and [22], it is depicted that a smaller farm size for abaca cultivation is more likely to be applied with new technologies and innovative approaches that improve abaca fiber production as opposed to bigger farms. Moreover, it is worth noting that bigger farms have more problems in growing abaca plants and have exhausting work to be accomplished by farmers [7], [19].

Table 6. Ordinal regression model I for the abaca production level and its possible factors.

Regressors	Coeff.	Std. Error	p-value	Interpretation
Age (years)	0.027*	0.009	0.003	Reject H_o
Male (dummy[a])	0.338[ns]	0.227	0.137	Accept H_o
Married (dummy[a])	0.286[ns]	0.278	0.301	Accept H_o
Education (years)	0.034[ns]	0.031	0.268	Accept H_o
Other income (dummy[a])	0.147[ns]	0.323	0.649	Accept H_o
Abaca farm size[b]	-0.564*	0.082	<0.001	Reject H_o
Abaca farm owner[a]	0.055[ns]	0.273	0.840	Accept H_o
Survey participants	349			
$X^2_{computed}$	80.59[ns]			
p-value (two-tailed)	<0.001			
Log-likelihood	-328.38			
Pseudo R^2	0.109			

Note: a-indicator variable; b-in hectares (ha); ns-not significant; *p<0.01.
Source: Authors'statistical computation (2024).

Table 7 depicted that the second regression model (II) does not suffer from multicollinearity problems based on mean VIF (i.e., VIF<10). This implies that there is no significant correlation exists in the pairwise of independent variables in the model (II) [2]. Thus, model (II) is accepted for making conclusions and inferences about the predictors of abaca production level. In addition, Table 7 portrayed that model II (X^2=9.60, p-value=0.142) is not significant even at the 10% level and it only possesses a pseudo R^2 of 0.013. This means that predictors in the model (II) have a minimal influence on the abaca production level. In fact, model II revealed that the following regressor variables are not significant: farmers' engagement with PhiliFIDA (p-value=0.185), SUCs (p-value=0.222), and LGU (p-value=0.796), agricultural agency visits (p-value=0.647), and farmer's distance from their house to their abaca farm (p-value=0.558).

Table 7. Ordinal regression model II for the abaca production level and its possible factors

Regressors	Coeff.	Std. Error	p-value	Interpretation
PhilFIDA[a]	0.200[ns]	0.151	0.185	Accept H_o
SUCs[a]	-0.457[ns]	0.374	0.222	Accept H_o
LGU[a]	-0.057[ns]	0.223	0.796	Accept H_o
Years in abaca farming	0.015*	0.007	0.038	Reject H_o
Agency visit (dummy[b])	0.101[ns]	0.221	0.647	Accept H_o
Distance from home to farm[c]	0.006[ns]	0.010	0.558	Accept H_o
Survey participants	342			
$X^2_{computed}$	9.60[ns]			
p-value (two-tailed)	0.142			
Log-likelihood	-356.67			
Pseudo R^2	0.013			

Note: a-Scale 1 to 4; b-indicator variable; c-in kilometers (km); ns-not significant; *p<0.05.
Source: Authors' statistical computation (2024).

This implies that the mentioned variables above are not influencing their abaca production level in a statistical sense. The findings of the study revealed that other players had no intention to increase their participating levels but relying on the value chain map alone is not enough and asking the other actors deeper questions about what is going on and why it is that way will lead back to some constraints they faced such as the case of PhilFIDA, SUCs and LGU personnel wherein the number field staff who are tasked to oversee and monitor the abaca farmers' production are inadequate [10]. However, model II has revealed that the number of years in abaca farming (λ_4=0.015, p-value=0.038) is statistically significant at the 5% level. Since λ_4>0, then it indicates that the farmers with long experience in abaca farming tend to improve their production level. This implies that the number of years of experience in abaca farming is a great help in applying innovative techniques and other competitive technologies that enhance abaca farming and improve production activities.

In [1], it is depicted that farming experience is a positive factor in adopting agricultural technologies that enhance farming techniques and maintain a sustainable production process. Moreover, in [6] and [15], it is portrayed that through farming experience, farmers become more knowledgeable about the different activities in farming which improves their practices by applying innovative technologies and competitive techniques in management systems.

CONCLUSIONS

The target of this article is to give a logical explanation of the level of production in abaca farming in Eastern Visayas, Philippines, and develop a statistical model that determines the influencing factors. Results showed that, on average, the production level of abaca farming in Eastern Visayas is considered as moderate. This concludes that the abaca production in the region is not fully enhanced and there is still room for increase given optimal processes and the right practices in farming. Descriptive statistics findings found that abaca farmers have no engagement (interaction) with enablers such as PhilFIDA, SUCs, and LGU due to some constraints and barriers. The reason behind this scenario is that there are only limitedresourcesandsupport from enablers which weakenstheabilitytoaddress manyconcerns and problems in the industry. In fact, the issue of the field technician-to-farmer ratio has been a troubling concern because abaca farmers are mostly located in mountainous barangays which are hardly reached by transportation. In addition, PhilFIDA along with SUCs and LGU field staff cover wider areas with each staff serving many municipalities, yet receives limited and delayed release of transportation incentives. Thus, farmers cannot expect field staff to visit them frequently. On top of these, field staff are burdened with other responsibilities. Hence, it is concluded that the government must support the abaca industry, particularly in Region VIII by providing more funds and agricultural extension agents to help the abaca farmers in progressing their production activities and maintain a sustainable business enterprise. In addition to that, the Philippine government must also support the PhilFIDA, SUCs, and LGU to initiate programs in the region that promote growth and development through production and extension supports, and educational training and seminar services.

The results of the statistical model concluded that the factors affecting the abaca production are the farmers' age and the size of the abaca farm. This implies that older farmer is more competitive and knowledgeable in applying innovative techniques and technologies that progress their production activities and solve agricultural problems. Meanwhile, the smaller size of abaca farms tends to give a higher yield since they can easily be managed and apply new technologies to improve production levels compared to larger abaca farms. Moreover, the second statistical model showed that farming experience is a significant predictor of abaca production level. This concludes that learned and experienced farmers are more productive and competitive in abaca farming. On the other hand, younger farmers are not that equipped in the farming system which leads to lower production. Conclusively, it is suggested that farmers should be trained and educated with different innovative discoveries in abaca cultivation techniques that solve farming problems and how to deal with agricultural constraints. It is recommended in future studies that the effectiveness of the agricultural extension and programs must be investigated and characterized by the abaca value chain analysis to enrich the current results of this study.

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THE IMPACT OF MARKET ANALYSIS IN DETERMINING THE MARKET VALUE OF AGRICULTURAL LAND IN ROMANIA

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Abstract

The purpose of this paper is to estimate the market value for the agricultural properties - agricultural lands located within the Casimcea Administrative Territorial Unit (UAT), Tulcea county, Romania. What was analyzed is the fact that a well-executed market analysis can help a lot in the evaluation process. Thus, after choosing the case study, the exact identification of the agricultural land was made. The next stage was the realization of the market analysis. Thus, the current state of agricultural land transactions was analyzed at the European, national and local level. The actual evaluation of the land was done through the market approach and all the adjustments were explained in the content of this paper. The results revealed the fact that the final market value falls within the range found following the market analysis. The analysis is carried out also at the processing level, the results indicating also a quite high coefficient of variation. This paper has achieved its goal, that is to see the impact that the market analysis has in determining the market value of an agricultural land.

Key words: *market value, agricultural lands, valuation analysis, market analysis*

INTRODUCTION

From the authors' experience, one of the most challenging parts of real estate valuation it can be the land valuation. Thus, the evaluation of a plot of land requires several stages to follow, according to the evaluation standards in Romania. Therefore, the evaluation of an agricultural land will require the following of certain steps, mandatory for the evaluation process.
This sector in Romania is less exploited and is characterized by a higher risk or a higher degree of uncertainty in the evaluation, due to the lack of information related to the transactions carried out. As a result, market value volatility is extremely high.
Currently, the evaluation activity in Romania is regulated by the National Association of Appraisers from Romania (ANEVAR). The market approach is the process of obtaining an indication of the value of the subject real estate by comparing it to similar properties that have recently been sold or are being offered for sale [1].
The market approach, one of the three evaluation approaches, mentions very clearly the fact that the first element of purchase that must be established in the market grid is the ownership right over the subject property [3].
The evolution of the market value has been investigated in many studies worldwide. As one would anticipate, the significance of agricultural land value is pivotal in driving economic development.[7].
The character of agricultural pursuits dictates that perpetual challenges in agriculture value chains are the presence of risks and uncertainties. It is essential for decision support models in farming to integrate metrics and strategies for risk management [11].
According to the latter, agricultural land belongs to the land plots of the market

segment of the “Agricultural Use” real estate [15].

Recent years in agriculture, there have been a lot of constraints such as climatic change, water scarcity, shrinking of lands due to human encroachment, labour shortage, soil nutrition, pests and diseases etc., which leads to decline in agricultural productivity [12].

Therefore, in order to estimate the market value for the analyzed land, the specific market was analyzed and the impact that this analysis has on the market value was determined.

MATERIALS AND METHODS

In this paper, the authors analyzed the evaluation process of an agricultural land. The stages are in accordance with the assessment standards in Romania.

More precisely, the stages of determining the market value for a real estate property are shown in Figure 1.

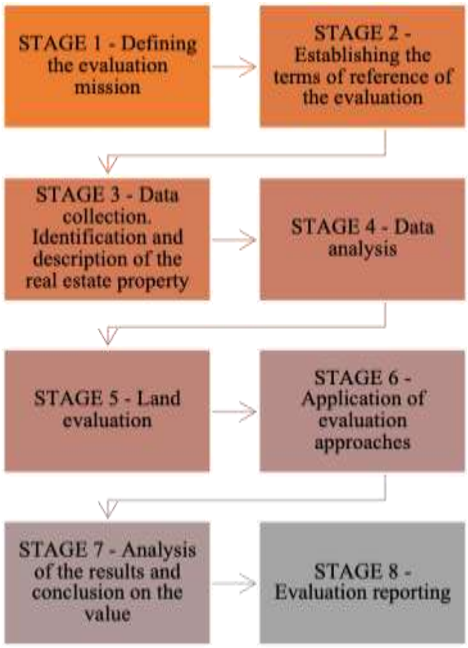

Fig.1. The evaluation process of a real estate property
Source: Own design on the basis of data from ANEVAR [1].

The evaluation mission's definition encompasses identifying the purpose and subject real estate property for assessment. The terms of reference, found in every real estate evaluation report and specified in the evaluation contract, encompass pertinent details about the client, evaluation recipient, reference date, evaluated property, and other relevant information. These aspects are addressed in alignment with evaluation standards. The analysis, collection and selection of information includes the market analysis carried out by the specialist, more precisely the analysis of demand, supply and the balance between demand and supply, but also the description of the subject real estate from the point of view of location, but also from the legal and technical point of view. The analysis of the best use is the premise of the evaluation itself. The application of approaches in the evaluation includes the decision or better said, the judgment of the specialist who decides to apply one or more approaches for the evaluation of a real estate property.

This study employs a systematic approach to estimate land value, relying on the market—specifically, the market approach.

RESULTS AND DISCUSSIONS

The components of the institutional framework are:

-legal framework;

-transferability of properties, transaction costs;

-financial markets, in particular, acces to lons as options for mortgaging land and real property;

-land register.

These elements of the institutional framework constitute the system that ensures the functioning of the market, its impact on the maturity of land relations and the importance of economic results in the sector for creating a value chain in the national economy [13].

As shown, an important role is played by knowing the transaction prices for agricultural land in Romania. And in what follows we will present the stages of determining the market value for an agricultural land.

The results are structured in several stages, as presented in Figure 2.

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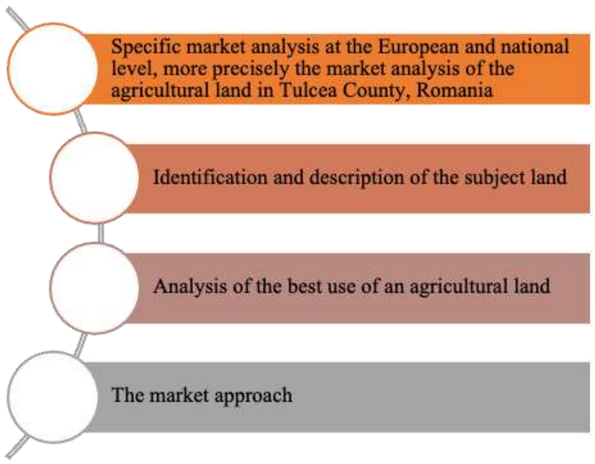


Fig.2. The stages of a real estate property valuation - the agricultural land in this study case
Source: Own design.

Specific market analysis

For the real estate in question, the specific market is that of "extra-village-agricultural land" type properties, the market whose geographic area extends to the level of Casimcea territorial administrative units, Tulcea county.

In the analysis of the specific real estate market, various aspects related to the economic situation of the mentioned areas, the trends of recent years, the specific demand, and the competitive offer for the delimited type of property were taken into account. Moreover, in the analysis of the demand on the agricultural land market, the following factors are important: the soil, irrigation and adduction systems, the climate, the potential harvest, environmental regulations, as well as other regulations.

The predominant land-use transformation in Europe is the abandonment of agricultural land, a process that has evolved over time with shifting causes, particularly in the most developed European countries [4].

In 2021, the cost of one hectare of arable land varied widely across the twenty EU Member States with available data. On average, it ranged from €3,661 in Croatia to €77,583 in the Netherlands. Notably, the price of arable land in all regions of the Netherlands surpassed the averages of other EU nations in 2021 [6].

At the regional level, Flevoland in the Netherlands recorded the highest prices, averaging €141,094 per hectare, while Övre Norrland in Sweden had the lowest, averaging €1,882 [6].

Farmers do not always own the land they cultivate; many opt to lease it, making it a short- or long-term business choice. The expense of land rental is an additional factor that farmers must factor into their operations. Similar to the fluctuations in arable land prices, the annual rental costs for one hectare of agricultural land (averaging arable land and permanent grassland) also exhibit significant variations among countries and regions within countries.

In 2021, among the EU regions, the highest cost for renting one hectare of agricultural land was observed in the Dutch region of Flevoland (€1,721 per ha), followed by Canarias in Spain (€1,119 per ha) and Attiki in Greece (€927 per ha). Considering data from 2020, Venezia Giulia in Italy (€1,714 per ha) would also be among the regions with the highest rental prices. In contrast, the most affordable rental prices were found in Mellersta Norrland and Övre Norrland (both €25 per ha) in Sweden, followed by Východné Slovensko (€42) in Slovakia [6].

Current status at the national level

The price of arable land in Romania increased from the value of 1,666 euros/ha in 2012 to 7,601 euros in 2021, according to data from Eurostat, the European statistical office [5].

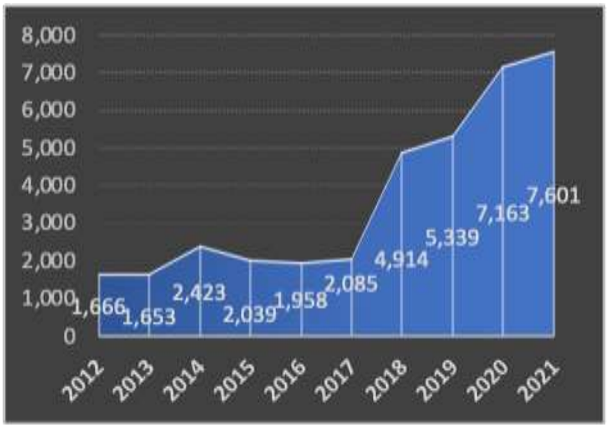


Fig. 3. The evolution of agricultural land prices in Romania (2012-2021)
Source: Own design on the basis of data from Eurostat [6].

Nonetheless, both experts in the field and the authors contend that its current value is modest in relation to its potential, and there's potential for it to rise to 10,000 euros in the near future with substantial infrastructure investments.

The cost of arable land in Romania fluctuates across geographical regions. In 2021, the priciest land, averaging 10,707 euros/ha, was found in the Bucharest - Ilfov area, while the least expensive was in the northwest area at 6,206 euros/ha, as per Eurostat data [6].

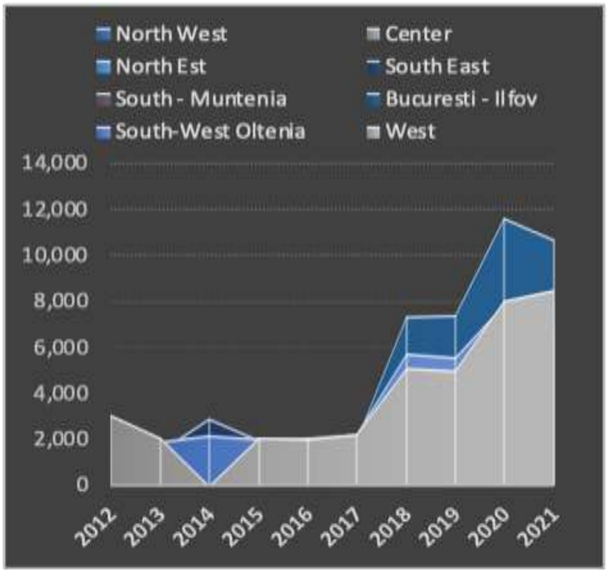


Fig. 4. The evolution of agricultural land prices in Romania by development region (2012-2021) Euro/ha
Source: Own design on the basis of data from Eurostat [6].

Current status at the local level

According to the records from the Tulcea County Council, the lands belonging to the territory of the Casimcea commune have the uses shown in Figure 5 and the surface presented in Table 1.

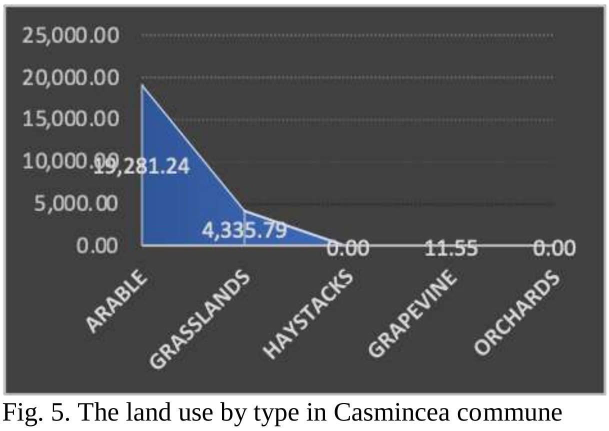


Fig. 5. The land use by type in Casmincea commune
Source: Own design on the basis of data from [5].

Table 1. Area by land type in Casimcea Commune (ha)

Type of land	Area (ha)
Arable	19,281.24
Grasslands	4,335.79
Haystacks	0.00
Grapevine	11.55
Orchards	0.00
Total agricultural land	23,628.58
Forests	2,180.20
Waters	38.55
Roads and railways	182.77
Unproductive lands	21.58
Construction lands	754.06
Total non-agricultural land	3,177.16
Total administrative territory	26,805.70

Source: Own design on the basis of data from [5].

Following the analysis, it was determined that the market values of an agricultural land in Romania are between 5,000 and 7,000 Euro/ha for land with areas larger than 3-5 ha and between 7,000-10,000 Euro/ha for land with areas between 0.5 -3 ha.

This interval varies depending on several characteristics, such as location, utilities, type of soil, degree of consolidation, the use, etc.

The geographical positioning in the South-East of Romania determines a high radiation potential (the average annual values of the global solar radiation increase from about 127.8 kcal/cm^2 in the Western extremity of the Dobrogea Plateau, to 132.5 kcal/cm^2 in the Eastern one) [5].

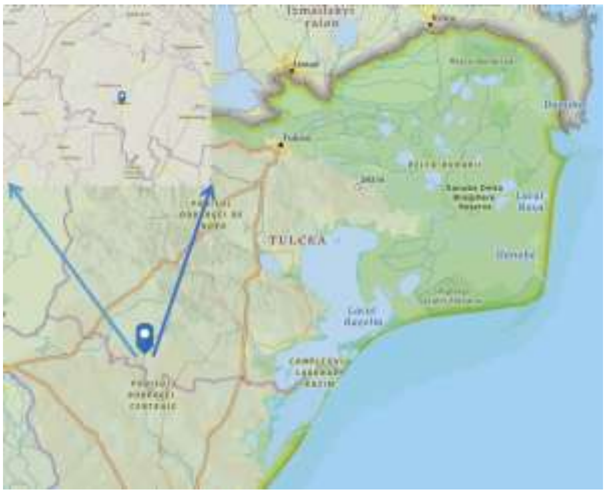
Due to the low precipitation and the presence of green shale over large areas, groundwater is poorly represented. They appear in the interfluves at the base of the loess at depths of about 30 m, in the form of a sheet or in intensively alluvial meadows, at only 3-5 m depth (Casimcea valley) [5]. The territory of Casimcea commune, Tulcea county, is part of the Central Dobrogei Plateau where the soils have specific characteristics determined by the transition from the continental climate of Eastern Europe to the temperate sub-Mediterranean climate of the Balkan Peninsula [5].

From a pedological point of view, the territory of Casimcea commune has a varied and well-developed group of soils on roughly parallel areas oriented North-West - South-East. These are favorable for agricultural crops and spontaneous vegetation, which led to the development of local agriculture and forestry. The predominant soil classes are mollisols (carbonate chernozem, chestnut chernozem, leached chernozem, balane soils) [5].

Identification and the discription of the land in the study case

The area of the studied agricultural land is 50,000 square meters. This precise area is an arable land and is situated outside the city. Casimcea commune is located on the edge of Tulcea county, in the South-West area, approximately 60 km South-West of the municipality of Tulcea, on the national road DN 22A that connects Tulcea to Hârșova (Map 1 and 2).

Map 1. The location of the Casimcea commune in Romania
Source: ArcGIS online [2].



Map 2. Casimcea commune and the location within Tulcea county
Source: ArcGIS online [2].

In the process of evaluating a real estate property, for example land, the inspection represents one of the main steps needed for the evaluating procedure. The evaluator should consider this stage as a mandatory one for a better and preciser overview on the location, neighborhood, surfaces, utilities, and other details considered relevant for the evaluation process.

Photo 1. The land from Casimcea Commune
Source: Original (taken by authors).

In the analysis performed, the location of the subject lands was identified beforehand, in consequences of the stereographic coordinates presented in the analyzed documents.

More precisely, for the land with cadastral number 37971, the identification was made by putting the coordinates in Google Maps and resulting in Map 3.

Map 3. Location of the subject land
Source: Google maps [8].

The cadastral number is 37971 and it is listed in the Land Registry no. 37971 Casimcea. The shape of the land as seen in Fig. 6 is rectangular. It represents an unfenced and flat land.

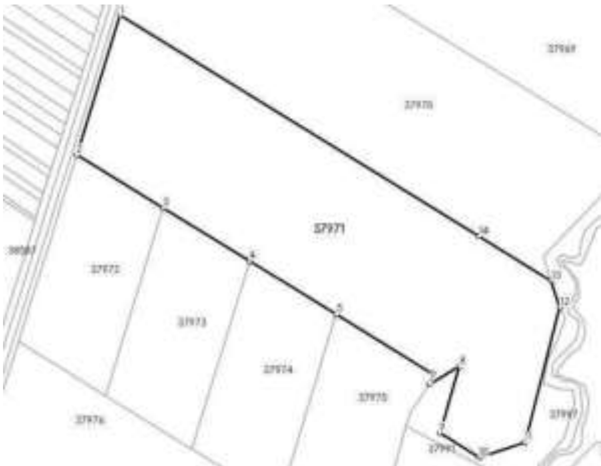


Fig. 6. Graphic representation of the subject land
Source: Extract from the Land Registry.

Table 2. The X,Y coordinates of the land boundary

Point number	X	Y
1	768,471.262	365,344.324
2	768,436.628	365,231.914
3	768,505.794	365,189.119
4	768,575.228	365,146.158
5	768,644.662	365,103.198
6	768,721.817	365,055.460
7	768,718.939	365,046.867
8	768,743.195	365,061.085
9	768,727.529	365,007.562
10	768,758.957	364,988.117
11	768,795.653	364,999.798
12	768,823.615	365,108.990
13	768,816.693	365,130.596
14	768,758.945	365,166.326

Source: Own design on the basis of data from Land Registry.

The best use analysis

According to SEV 100 - General framework - parag. 32 from de Evaluation Standards in Romania, the market value of an asset will reflect its best use, which is defined as "the use of an asset that maximizes its full potential and is possible, legally permitted and financially feasible". The best use may be the continuation of the current use of the asset, or it may be another use. This is determined by the use that a market participant would intend to give to an asset, when setting the price he would be willing to offer [9].

The best use of land

• Test of the legal permissibility of the land considered to be free. Determines which uses are allowed by the current zoning, which uses could be allowed if a zoning change is obtained and which uses are limited by the private restrictions on the land.

• The test for the physical possibility of the land considered free. Analyze the physical characteristics of the site that can affect its best use: size, shape, soil, accessibility, degree of risk in the event of natural disasters.

• Financial feasibility test of the land considered to be vacant. As long as a potential use has value compared to its costs and respects the first two criteria, the use is financially feasible.

• Test of the maximum productivity of the land considered to be free. Among the financially feasible uses, the best use is the use that produces the highest residual value of the land, in accordance with the risk accepted by the market and the rate of return claimed by the market for it.

Considering the type of assessed property - real estate - agricultural land located in Casimcea commune, Tulcea county, as well as the location of the assessed real estate - in the suburbs, it is appreciated that the best use of the evaluated property is the current one, that is, the agricultural one.

The market approach

In the market approach:

• an assessment of comparable property prices is conducted based on comparison criteria relevant to the specifics of the subject property.

• the analysis involves evaluating similarities and differences between the characteristics of comparable properties and the subject property. Adjustments are then made according to the comparison elements, as illustrated in Fig. 7.

• suggested comparison elements encompass, but are not restricted to: transferred property rights, financing conditions, sales terms, immediate post-purchase expenses, market conditions, location, physical attributes, economic attributes, property utilization, and non-real estate components, as depicted in Fig. 7;

• the selection of the conclusion on the value is determined by the comparable real estate which it is the closest from a physical, legal and economic point of view to the real estate property subject and on the price on which the smallest adjustments were made;

• all adjustments applied to the prices of comparable properties are argued in the report evaluation, with their estimation method being presented.

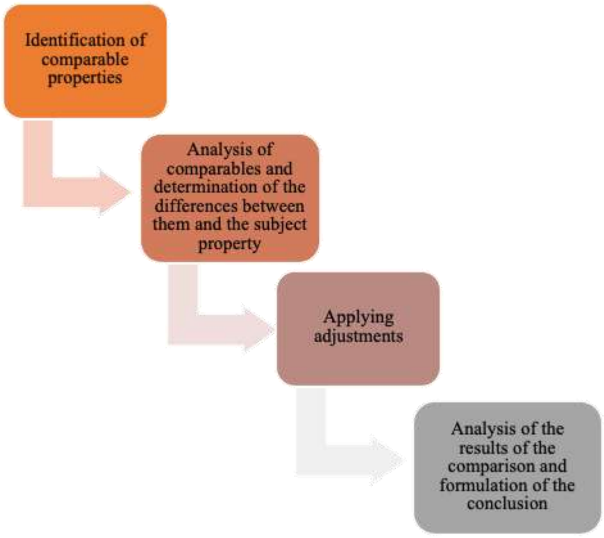


Fig. 7. The process of implementing the market approach
Source: Own design on the basis of data from ANEVAR [9].

Figure 8 presents the adjustments recommended to be applied. Regarding the determination of the market value for the subject land, a comparison grid was drawn up in which the similarities and differences between the comparable properties and the subject property were presented.

Fig. 8. The adjustments applied in the market approach
Source: Own design on the basis of data from ANEVAR [9].

The selected comparables were sourced from http://www.extravilanagricol.ro application [14], which features transactions involving agricultural land situated outside villages. Essentially, this application serves as an electronic registry for documenting offers for the sale of agricultural land located in rural areas.

We did not apply any adjustment to the first comparison elements. To be more specific, the ownership rights for both the subject property and comparable properties were absolute. Financing conditions were standard, sales conditions were impartial, and there were no adjustments required for immediate post-purchase expenses. Regarding the comparison element of location, no adjustments were made as both the subject property and comparable properties are situated in Casimcea commune, Tulcea county. Adjustments for the surface comparison element were made in line with the differences in surface area between the subject property and comparable properties. We also studied other elements of comparison related to the physical characteristics of the agricultural lands (for example, the degree of merging, the category of use), but it was not necessary to apply adjustments.

Thus, in the end we obtained a market value of 5,600 Euro/ha for the studied agricultural land. This market value aligns with the range of values derived from the market analysis.

CONCLUSIONS

The research shows that for every owner of agricultural land is important to be aware of its land market value and to be able to use this information in his advantage. As indicated by certain studies, the primary gaps in innovation for the 'social and institutional' dimension stem from insufficient knowledge and limited entrepreneurial skills among local stakeholders [9].

Furthermore, there is a recognized requirement for innovation catalysts to serve as long-term innovation brokers at the local level. The authors also highlighted concerns related to population aging and the demand for a specialized workforce, primarily driven by net migration toward urban areas [9].

Over the past decade, various works and assessments have been regarded as benchmarks from a European perspective [0, 11, 12], despite significant differences in their methods, assumptions, the nature of the work, and the outcomes.

The implementation of valuation methods to decision making in most reviewed studies were quite limited. The overwhelming majority of articles included only short, general recommendations for stakeholders, and only a few studies address implementation in decision making, these implementations included awareness raising and communication, strategic planning, and the development of tools and toolkits [16].

In agriculture, each factor of production typically garners a specific type of income: labor receives wages, entrepreneurs earn profit, capital accrues interest, and land produces rental income. Grasping the dynamics of land prices and rents is crucial for gaining insights into the future prospects of agriculture.

Land prices are contingent on several factors, encompassing national elements like laws, regional aspects such as climate and proximity to networks, and localized productivity factors like soil quality, slope, or drainage. Additionally, market forces of supply and demand, along with the impact of foreign ownership regulations, can exert influence on the price of agricultural land. Competition for land arises not only among farmers but also from individuals with intentions to utilize the land for non-agricultural purposes. Consequently, examining prices at a specific point in time and observing the variations in prices across different regions over the years proves to be intriguing [6].

Thus, the main idea that emerges from the research carried out is that the market analysis is essential in determining the market value for an agricultural land. Therefore, from the research carried out it follows that the essential stages to be followed in the evaluation of an agricultural land must be followed rigorously.

From the market analysis at the European and national level, it appears that the price for arable land varies depending on the location and other criteria, as was presented. Therefore, by analyzing a real estate market, an interval with an upper limit and a lower limit for the market value was established. This interval is very important in substantiating the market value obtained. Also, with the help of this interval, the obtained market value can be verified. This verification is very important and must be done at every valuation for a real estate property.

At the local level, the authors analyzed the existing land types at the level of Casimcea commune, Tulcea county, as well as other important details of global solar radiation and climate.

In order to properly identify the land in question, the authors analyzed the property documents and performed an on-site inspection. Following this analysis, the exact land was identified and demarcated, as can be seen in Map 3.

Regarding the analysis of the best use, the authors concluded that the best use is the current one, i.e. that of agricultural land. In this stage, several factors were analyzed such as the location and type of the property in question.

The evaluation of the land was carried out by the authors through the market approach, respecting the implementation stages recommended by the standards in use in the present.

The impact that the market analysis has on determining the economical value of an agricultural land is clearly very decisive. Without this market analysis carried out in a rigorous way, a market value cannot be issued.

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PROSPECTS OF THE HOPS MARKET IN ROMANIA THROUGH THE PRISM OF COMMON AGRICULTURAL POLICY STRATEGIC PLAN 2023-2027 FOR ROMANIA

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Abstract

The cultivation of hops, a traditional activity in the area of Transylvania, where the plants also meet good conditions for development, experienced a pronounced decline after 1990. The lack of funds for the establishment of crops and maintenance in the first years of vegetation, the special plant support system, the old varieties, the effects of climate change and the lack of an irrigation infrastructure have negatively influenced the development of hop farms. Despite the fact that processors have increased the demand for this crop, as a result of its multiple uses, in 2022 in Romania 165 ha were cultivated and a production of 191 tons was obtained, in only three counties in the heart of Transylvania, Alba, Mureș and Sibiu. Mureș County owned 75% of the areas cultivated with hops and 44% of the harvest obtained. At the same time, in the context of the decrease in local beer production, the quantitative and value imports of Romanian hop products also decreased. In order to revitalize this sector, the Common Agricultural Policy, through Strategic Plan 2023-2027 for Romania, has introduced a special Field of Intervention for hops and table grape growers (DR-17) which joins other interventions necessary for processing, for the establishment of producer groups, farmer training and consulting. Added to this is the support granted by Pillar I of the Common Agricultural Policy: Coupled income support (PD - 15), Eco-schemes (PD - 06) and Transitional National Aid (ANT - 5), which will represent an important support for farmers and will contribute to the increase of the surfaces and the production obtained

Key words**:** *hop areas, hop production, imports of hop products, CAP SP 2023-2027 for Romania*

INTRODUCTION

Hops is an important technical plant, whose female inflorescences (cones) represent the raw material for the beer industry and for the pharmaceutical industry. Approximately 90% of the production of hops and hop products is used for brewing beer [3], and in medicine the cones are used in the form of extracts or teas [11]. Thanks to the deep root system, they have because they are perennial, hop plants can prevent erosion and increase soil fertility. Thus, they can reduce the effects of climate change by preserving biodiversity and restoring soil properties, stopping degradation and desertification. In Romania, hops meet favorable conditions for growth, in correlation with the demands of the plants regarding temperature and humidity, in the central area of Transylvania, in the counties of Mureș, Sibiu, Alba, Cluj or Hunedoara, where the investments in the support systems for plants were also made.

In these regions, hop plantations (hameiști – Romanian language) have a history of 500 years and have become local brands, thanks to the landscape they create. This is the case of the area adjacent to the city of Sighișoara [11].

Currently, the problems facing the hops sector are: aging plantations, deterioration of crop support systems and insufficient farm equipment.

Due to the high costs for the establishment and maintenance of the culture (harvests are obtained 2-3 years after the establishment), respectively to the large number and complexity of the maintenance works of the culture, there is a risk of abandoning the production and the emergence of social problems, having considering the fact that some of the hop plantations are located in areas affected by natural constraints, unsuitable for other agricultural crops.

Hops began to be used also in aspects related to the circular economy, in order to get rid of post-production hop residues. They can be used in food as food additives [18].

At the same time, there was an increased interest at the European level for the expansion of hop cultures outside the traditional areas. Thus, a series of attempts were identified to increase the cultivation of hops in the Mediterranean basin, a fact that put increased pressure on the funds available at the European level [17]. The demand for hops has increased recently and as a result of the increasingly numerous uses of these plants, not only in the beer industry but also for other types of drinks, as a result of their properties. This growth was also felt in Romania, which in 2016 was on 20th place in the world in terms of areas and production of hops [19]. Although in Romania there is an increased demand for technical crops, including hops, domestic production ensured about 10% of the needs of the beer industry [10]. In the hop-growing counties and in their neighboring ones, there are microbrewery businesses, which produce craft beer according to traditional methods, known in those regions. Small brewers have an important role to play in this industry by influencing demand increasing the harvest of hops produced locally.

There is an increased national interest in local products, small producers being thus advantaged from this perspective [1].

The importance of hops domestically also results from the allocation of payment schemes for hop production, subject to the fulfillment of certain technical requirements. These aids led in the period 2014-2019 to an average increase of 0.7% in the area cultivated with hops in Romania, from 243 ha in 2014 to 252 ha in 2019. However, the number of farmers who accessed the available support was reduced - only 3 farmers [7].

The new Common Agricultural Policy 2023-2027 required each member state to develop a Strategic Plan, starting from the analysis of the strengths and weaknesses, the opportunities and threats of the agri-food sector. This plan combines both market measures and financing for rural development projects [5].

The paper aims to identify the areas cultivated with hops, the average production and the total production of hops in Romania, as well as the quantitative and value imports of hops and hop products of Romania, in the period preceding the Common Agricultural Policy (CAP) Strategic Plan 2023-2027 for Romania, (PS PAC 2023-2027) and at the same time to present the forms of support that the mentioned program will grant, for the recovery of this sector and the preservation of traditional activities in the areas suitable for the cultivation of hops.

MATERIALS AND METHODS

To obtain the data presented in this article, the bibliographic method was used, and the authors studied specialized materials on the chosen topic, which were presented in the References section.

In order to highlight some aspects related to the hops market in Romania, the article analyzed the total areas cultivated with hops at the country level as well as in the main counties where there are plantations (Alba, Mureș and Sibiu), as well as the total and average productions of hops obtained in Romania and in hop-growing counties. The statistical data available on the National Institute of Statistics (NIS) website were used, for the year 1990 and for the period 2017-2022. The information regarding the quantitative and value imports of hops and hop products was taken from the International Trade Centre (ITC) website. At the same time, the Interventions from Pillar II, as well as the

Eco-schemes, Coupled Income Support and Transitional National Aids, from Pillar I of the CAP, were analyzed within the PS PAC 2023-2027 version 3.1 from 13.12.2023, to identify all the forms of support that the hops sector will benefit from in the new Multiannual Financial Framework.

RESULTS AND DISCUSSION

In 1990, 2,346 ha were cultivated with hops in Romania, most of the plantations being located in the Macroregion One (2,130 ha), and especially in the Center Region (1,956 ha). In the year 2022, only 7.03% of the surfaces were still under cultivation.

During the analyzed period, 2017-2022, the size of the plantations decreased by 27.31%, the decline starting from 2018.

Compared to the year 1990, acknowledged counties disappeared from the map of hop growers: Cluj, Brașov and Hunedoara, and also 490 ha (Table 1).

Table 1. Areas cultivated with hops in Romania, in the period 1990-2022 (ha)

Specification	1990	2017	2018	2019	2020	2021	2022	2022/2017 %	2022/1990 %
TOTAL, of which:	2,346	227	255	252	246	171	165	72.69	7.03
Macroregion ONE, of which:	2,130	227	255	252	246	171	165	72.69	7.75
1. NORTH-WEST Region, of which:	174	-	-	-	-	-	-		
Cluj County	174	-	-	-	-	-	-		
2. CENTER Region, of which:	1,956	227	255	252	246	171	165	72.69	8.44
Alba County	203	33	66	68	66	33	28	84.85	13.79
Brașov County	100	-	-	-	-	-	-		
Mureș County	990	154	154	149	145	123	123	79.87	12.42
Sibiu County	663	40	34	34	34	14	14	35.00	2.11
Macroregion FOUR, of which:	216	-	-	-	-	-	-		
1. WEST Region, of which:	216	-	-	-	-	-	-		
Hunedoara County	216	-	-	-	-	-	-		

Source: own calculation after [12].

In 2022, 30,030 ha were cultivated with hops in the European Union. More than half of these surfaces (66.27%) were found in Germany, 19,900 ha. Other important growers were the Czech Republic 4,940 ha, Poland 1,730 ha and Slovenia 1,620 ha [8].

Romania was in 8th place and for the period 2017-2022, the largest decrease in surfaces was noted in Sibiu County - 65%, well below the average of 27.31 as recorded at the country level.

In 2022, hop plantations were concentrated in 3 counties: Alba, Mureș and Sibiu, from the Center Region - Figure 1.

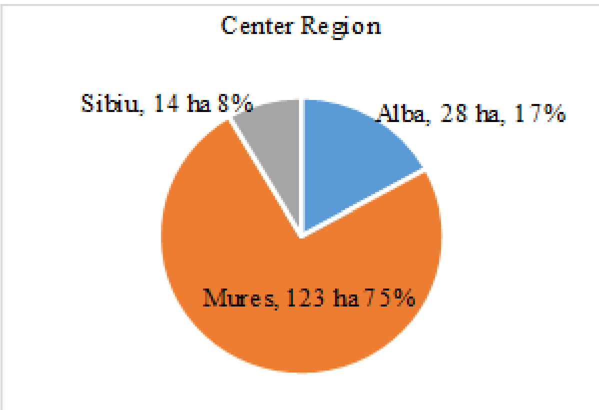

Fig. 1. The distribution of the hop cultivated surfaces in 2022, in Romania
Source: own representation after [12].

It should be mentioned that the form of ownership of the plantations is private, and Mureș County totaled three fourths of the country's hops area.

A study conducted by the authors, from 2015, showed that in 2013, the country's hop plantations were also found in the 3 counties (Mureș County - 76%, Alba County - 16% and Sibiu County - 8%), with approximately the same percentages, although in 2013 the area cultivated with hops was 239 ha [6].

Farmers believe that the main cause of the decline of hop plantations in Romania is the deterioration of the infrastructure necessary for the development of the plants (Photo 1), caused by the negligence of the state or of the new owners resulted from privatization [14].

Photo 1. Hop plantation
Source: [14].

Another reason for the decrease in areas is climate change, which Romanian hop growers have to face, collaborating with research institutes to find drought-resistant varieties [16]. At the same time, the development of irrigation infrastructures can ensure the success of these businesses in the future, because it is known that hops are a big consumer of water. The decrease in hop areas is also caused by the existence of old hop varieties, which are over 25 years old and are approaching the end of their optimal production period [11]. The reluctance of farmers to establish new plantations starts from the fact that an investment of 60,000 euros is necessary for one hectare of hops. The plantation bears fruit only from the third year after its establishment, and the annual maintenance expenses should not be neglected either, which for one hectare of hops represent 6,500-7,000 euros [16].

In terms of production, 47,580 tons of hops were harvested in the European Union in 2022, and the main producers were: Germany - 34,400 tons, Czechia - 4,450 tons, Poland - 3,420 tons and Slovenia - 2,280 tons. Romania took the 8th place again [8].

Despite the fact that the areas cultivated with hops have decreased, there is an increase in total production by 154.03% in total per country, in the period 2017-2022 - Table 2. However, the production obtained in 2022 represented approximately 8% of the harvest the year 1990.

Table 2. Hops production obtained in Romania, in the period 1990-2022 (tons)

Specification	1990	2017	2018	2019	2020	2021	2022	2022/2017 %	2022/1990 %
TOTAL, of which:	2,451	124	219	218	213	208	191	154.03	7.79
Alba County	245	20	40	53	45	26	63	315.00	25.71
Mureș County	1,263	79	118	99	96	93	85	107.59	6.73
Sibiu County	569	25	61	66	72	89	43	172.00	7.56

Source: own calculation after [12].

All 3 counties where hops were cultivated recorded increases in production, a special situation being noted in Alba County, where the increase was the highest - 315%.

Figure 2 shows that Mureș County obtained 44% of the total hop harvest of 2022, while Sibiu had 23%.

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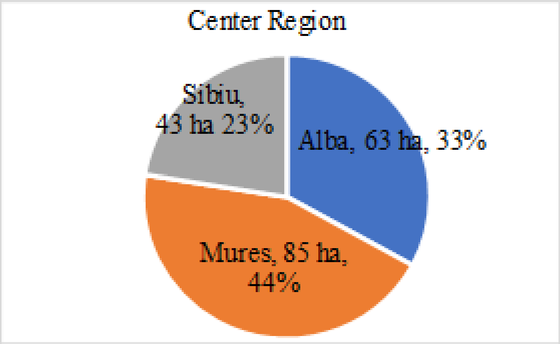

Fig. 2. The distribution of the hop production in 2022, in Romania
Source: own representation after [12].

According to Chiurciu, 2015 [6], in 2013 the hop production of 172 tons was distributed as follows: Mureș 77%, Sibiu 17% and Alba 6%. Therefore, after 9 years, Sibiu and Alba counties recorded an increase in the share of the country's total hop production, and Mures county a decrease from 77% to 44%.

The average production of hops at the country and county level registered spectacular increases both compared to 1990 (110.62%), and during the period under study - 211.72% (Table 3). Sibiu County recorded the highest increase - 477.44% in 2022 compared to 2017, and Mureș County is the exception, where compared to 1990 the average production decreased by approximately 45%.

The average production of hops (kg/ha) placed Romania in the 8th place in the European Union, but this time the first place was occupied by Italy – 3,130 kg/ha [8].

Table 3. Average production of hops obtained in Romania, in the period 1990-2022 (kg/ha)

Specification	1990	2017	2018	2019	2020	2021	2022	2022/2017 %	2022/1990 %
TOTAL, of which:	1,045	546	860	866	867	1,217	1,156	211.72	110.62
Alba County	1,207	606	605	775	678	778	2,266	373.93	187.74
Mureș County	1,276	513	764	663	662	756	691	134.70	54.15
Sibiu County	858	625	1,789	1,937	2,095	6,176	2,984	477.44	347.79

Source: own calculation after [12].

The value (Figure 3) and quantitative (Figure 4) imports of Romania, in the category mentioned by ITC "*Hop cones, fresh or dried, whether or not ground, powdered or in the form of pellets; lupulin*" recorded decreases in the period 2018-2022, by 35.24% and 34.87%, respectively.

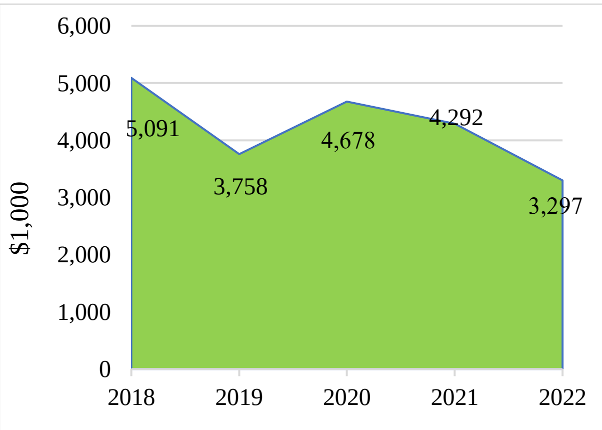

Fig. 3. Value imports of hop products of Romania in the period 2018-2022 ($ 1,000)
Source: own representation after [9].

The main partners, from which Romania imported in 2022 "*Hop cones, fresh or dried, whether or not ground, powdered or in the form of pellets; lupulin*" were: Germany ($ 2,564 thousand), Czech Republic ($ 365 thousand) and Slovenia ($ 347 thousand) [9], the main growers and producers of hops in the European Union.

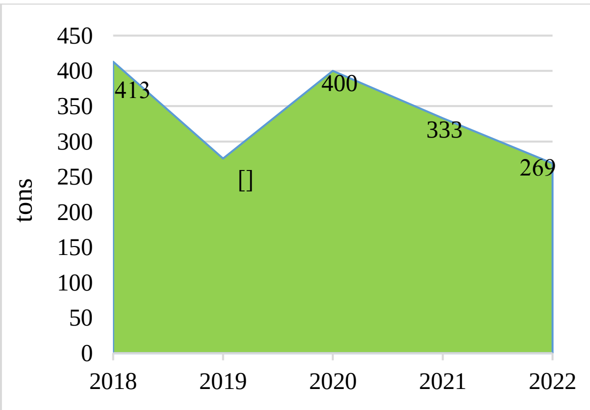

Fig. 4. Quantitative imports of hop products for Romania in the period 2018-2022 (tons)
Source: own representation after [9].

Romania is not a top importer and in 2022 it ranked 31st worldwide in terms of quantitative imports and 33rd in terms of value imports. The first places were occupied by United Kingdom, USA and Germany [9].

These decreases in imports are the result of the decrease in Romania's beer production, which in 2022 was 15.8 million hectoliters, 5% less than in 2021. 97% of the demand was covered by local factories [15]. This situation was due to the closure of some factories known for beer and the reduction of average beer consumption, from 1,673 l monthly/person in 2021 to 1,609 l monthly/person in 2022 [13].

In order to preserve the biodiversity and vocation of the Transylvanian areas, for the first time since the implementation of the National Rural Development Programs, after the accession to the European Union, an intervention addressed to hop growers was introduced within the PS PAC 2023-2027: DR-17, *Investiții în sectoarele hamei și/sau struguri de masa / Investments in the hops and/or table grape sectors*. This concerns the necessary investments for the reconversion, establishment and modernization of holdings, including conditioning, and 45 million euros have been allocated for this. It has the following provisions:

-The investment must be made within a farm with an economic size of at least 4,105 SO for hops. Considering the fact that 1 ha cultivated with hops has a SO value (Standard output coefficient) of 2,863.09 euro/ha, the economic agent that will access the funds must own at least 1.45 ha, to exceed the requested threshold of 4,105 euros [2].

-The maximum amount of public support is 1,000,000 euros/project, with the exception of projects that only purchase machinery and agricultural equipment and which will receive a maximum of 300,000 euros/project.

-The intensity of the non-reimbursable public support will represent 65% of the eligible costs [4].

DR-17 is included in Pillar II of the PAC, Rural Development, where there are also other useful interventions for hop growers, intended for:

-hop processing - DR-22 and DR-23,

-increasing the resilience of farms and stabilizing incomes - DR-31 and DR-32,

-creation of producer groups and cooperation - DR-33, DR-34 and DR-35,

-training of farmers - DR-37,

-counseling - DR-38.

Farmers who grow hops will also receive other support schemes, related to Pillar I of the CAP:

-Young farmers (*Sprijin complementar pentru venit pentru tinerii fermieri / Supplementary income support for young farmers*), up to 40 years

-CRISS 1 - 50 Ha (*Sprijin redistributiv complementar pentru venit în scopul sustenabilității / Complementary redistributive support for income for the purpose of sustainability*)

-BISS (*Sprijin de bază pentru venit în scopul sustenabilității / Basic Income Support for Sustainability*)

-Eco-schemes:

PD-06 - *Înierbarea intervalului dintre rânduri în pepiniere, plantațiile viticole, pomicole și hameiști / Planting the interval between rows in nurseries, vineyards, orchards and hop plantations* (hameiști – Romanian language) - will contribute to the conservation and increase of the biodiversity of plantations, the protection of the environment, as well as the protection and reconstruction of local habitats. It provides that at least 75% of the plantation surface must be kept grassed or will be grassed, between June 15 and October 15, without carrying out any agricultural works.

The unit amount planned for the period 2023-2027 is 85.5 euros/ha.

-CIS - *Sprijin cuplat pentru venit / Coupled income support*:

PD-15 - *Sprijin cuplat pentru venit – Hamei / Coupled income support – Hops* - involves the granting of a single payment per eligible hectare, linked to plant production, and requires the farmer to have a contract with a hop processing unit which provides the raw material for the production of beer or with a processing unit for pharmaceutical purposes.

The indicative plannable amount in 2023 was of 599.91 euros/ha.

In this way, the beer processing industry in Romania is also supported, a sector which is currently in difficulty.

-Transitional National Aid (ANT) will be an important component of support:

ANT - 5, Hops - provides the financial packages for the period 2023-2027 showed in Table 4,

Table 4. The annual financial package for hops, in the period 2023-2027 allocated through ANT – 5, decoupled payment for hops (Euro)

Specification	2023	2024	2025	2026	2027
Financial package	84,000	75,600	67,200	58,800	50,400

Source: [11].

According to Surca, 2018 [19], hops is a profitable crop even without subsidies, and the average income-cost ratio is 1.0531:1 (without subsidies) and 1.1256:1 (when grants are given). In order to obtain these results, farmers must overcome the problems related to the establishment of crops and the maintenance of the plantations until the bearing of the fruit.

With the support granted by PS PAC 2023-2027, this culture could bring significant gains to farmers and the production obtained could be easily capitalized on the national market.

CONCLUSIONS

The multiple uses of hops are likely to lead to an increase in the cultivated area, the internal potential being still far from being reached.

Hop culture is a culture with high potential both at European and national level. and it is suitable in certain favorable areas of the country, where cereals are less cultivated.

The challenge is given by the need for good harmonization between current or potential producers and other relevant actors in the field. Greater attention is thus required to the infrastructure specific to the hop culture, infrastructure often affected by the lack of interest of the new owners.

Another challenge that needs to be solved is that of climate change, which has a disproportionate effect on hop crops and requires specific adaptations.

Mureș county was the main grower and producer of hops in Romania, owning in 2022 - 123 ha of hops and obtaining a production of 83 tons.

The decrease in beer consumption also influenced the decrease in production, which led to a decrease in the value and quantity of imports of hop products, by 35.24% and 34.87%, respectively, in the period 2018-2022.

At the same time, the positive impact of European funding on hop crops is noted. The funds allocated under the Common Agricultural Policy have the role of stopping the decline and implicitly increasing the areas with hops.

PS PAC 2023-2027 will support this sector through forms of support related to both Pillar I and through interventions from Pillar II, of which DR - 17 stands out, for the recovery of traditional activities in the center of Transylvania and microbrewery businesses, which will contribute to the development of the rural area.

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AGRITOURISM MARKET IN ROMANIA: POTENTIAL, CONCENTRATION, AND DEVELOPMENT PERSPECTIVES

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Abstract

The paper proposes an in-depth analysis of Romania's agrotourism services market, highlighting its evolution and regional/counties concentration. Romania, renowned for its cultural and touristic diversity, employs agrotourism to facilitate authentic interactions with local communities, offering insights into native culture. Utilizing Clarivate, Google Scholar, and Research Gate databases, the research employs statistical processing and graphical representation. Market concentration is gauged using the Herfindahl-Hirschman and Gini-Struck indices. Findings reveal a dynamic national sector with an annual growth rate surpassing 10%. Regionally, concentration levels are notably high, with the North-West, Center, North-East, and South-East collectively contributing over 75%. County-level concentration is moderate, indicating potential development even in areas with untapped resources. Romanian authorities actively promote agrotourism, capitalizing on rural development potential.

Key words: *agrotourism, evolution, Romania, GSI, HHI, market concentration*

INTRODUCTION

Agritourism, a niche tourism sector, has seen significant growth in recent years in Romania, attracting an increasing number of both domestic and international tourists. It is centered around providing tourist services in traditional farmsteads or rural environments, allowing visitors to experience authentic rural life.

Against the backdrop of the COVID-19 pandemic, where consumers of tourist services sought to avoid urban congestion and traditional tourist resorts, agritourism has witnessed a growing preference among profiled consumers [8].

Agritourism brings benefits to rural households and serves as a means of leveraging local natural resources (landscapes, protected natural areas, local traditions, agricultural production, fauna, and flora). It promotes ecological and sustainable practices, emphasizing reduced consumption and showcasing rural lifestyles. In Romania, agritourism takes place in rural settings, featuring picturesque landscapes and well-preserved traditions. Visitors can engage in traditional agricultural activities (harvesting, milking cows, cheese-making, or preparing traditional meals) with accommodation in local households (country houses or rural guesthouses), offering them the opportunity to immerse themselves in the local community. Traditional gastronomy stands out as a highlight of agritourism in Romania, allowing for the exploration of local cuisine and the tasting of traditional beverages and foods [15].

The 2023 statistical research carried out by Industry Research Bizz (IRB) reveals that the global valuation of the agritourism market stood at USD 4,290.62 million in 2022 [7]. Forecasts predict an expected compound annual growth rate (CAGR) of 8.09% in the subsequent years, culminating in a market valuation of USD 6,841.17 million by 2028.

The surge in instant booking options has positively impacted the global agritourism market, reducing waiting times and enhancing customer satisfaction. The IRB report combines extensive quantitative and qualitative analyses, offering a comprehensive view of the market, from macro dynamics to micro details.

KBV Research (2023) [9] presents an even more optimistic forecast, expecting the Global Agritourism Market to reach $10.7 billion by 2028, reflecting a robust 10.7% CAGR. The predominant cause of this growth is the substantial share of direct bookings, exceeding 80% of total sales. The market is categorized according to tourist activities into On-farm Sales, Outdoor Recreation, Entertainment, Educational Tourism, Accommodations, and other segments.

Marian (2017) underscores that agritourism in Romania represents a significant form of sustainable tourism, minimizing its impact on the natural environment while capitalizing on and preserving local natural and cultural resources. The transition of the Romanian economy from a centralized system to a market economy has fostered the development of rural areas and agritourism [11].

An evaluation of Romania's inherent potential in agritourism and tourism, conducted by Călina, Călina, and Iancu (2017), indicates a qualitatively high value, suggesting Romania can largely meet the diverse expectations of potential clients [1]. The study forecasts a substantial increase in the number of accommodation units, from 3,236 in 2020 to 7,113 units in 2030, alongside a growth in sector employment (5,072/2020 compared to 5,409/2030) [2].

The high absorption rate of European funds can significantly impact business development in agritourism. Funding initiatives targeting rural development and agritourism have led to a significant expansion of services within the sector [10].

Galluzzo (2020) presented analogous results, indicating that during the 2007-2016 timeframe, decoupled payments significantly influenced the expansion of agritourism in rural Romania more than other financial subsidies provided by the European Union through the Common Agricultural Policy [6].

The provision of agritourism services represents a business opportunity for Romanian entrepreneurs and a necessity for rural communities with tourism potential. This form of tourism offers tourists a high-quality experience at a reasonable cost, promoting sustainable development and environmentally friendly activities [2].

Effective sustainable tourism management strategies should be based on relevant and consistent information about factors influencing the decision of agritourism consumers. A study by Dumitraș et al. (2017) highlighted that the decision to visit tourist parks in a protected area, crucial in the tourist offer's choice, can be influenced by existing facilities in the area, including the availability of agritourism accommodations [5].

In their study, Stanciu, Popescu, and Stanciu (2023) systematically analyzed specialized literature sourced from the Clarivate database. They employed the VOS Viewer software and focused their analysis on five specific keywords: "Rural Tourism," "Agrotourism," "Agritourism," "Ecotourism," and "Romania." The examination encompassed 440 articles, exposing that research concerning these keywords and their influence on the advancement of rural areas in Romania has constituted a noteworthy and evolving research subject in the last decade. Eight primary research themes associated with rural tourism, agrotourism, and ecotourism in Romania were discerned [14].

The research conducted by Drăgoi et al. (2017) revealed that economic indicators, including regional GDP and the extent of the national road network in the area, exert a positive influence on the presence of economic entities participating in agritourism [4].

Additional industry-specific factors, such as the number of employees and corresponding salary incomes, the overall volume of tourists, the proportion of tourism-related enterprises, and their contribution to the region's overall business activity and revenue, alongside tourists' inclination toward agritourism, contribute positively to entrepreneurial endeavors in agritourism. The study's findings underscore a direct correlation between resilient entrepreneurship in agritourism and the sustainable development of the region [4].

In this context, the purpose of this research is to make an analysis of Romania's agrotourism services market, pointing out its evolution and regional/counties concentration, using the Herfindahl-Hirschman and Gini-Struck indices.

MATERIALS AND METHODS

The bibliographic research was conducted through open-access articles from Clarivate, Google Scholar, and Research Gate, as well as official information provided by relevant ministries and professional associations.

To conduct this research, data concerning the agrotourism sector were obtained from the National Institute of Statistics and the Ministry of Agriculture and Rural Development.

The pertinent information collected was processed using statistical methods, followed by graphical representation and interpretation.

Evaluating the market concentration of agritourism services in Romania can be done through the Herfindahl-Hirschman Index (HHI), calculated by the sum of the squared market shares of all factors in the sector.

In this research, HHI represents the value of how a small number of regions can account for a large share of the traditional products market (formula 1).

$$HHI=\sum G_i^2 \quad ....(1)$$

In formula 1, G_i represents the market share of development region i, and N represents the total number of regions (8 in this case).

The higher the HHI market value, the more the production is concentrated in a small number of factors. Generally, when the HHI value is below 1,000, the market concentration is considered low; at values between 1,000 and 1,800, it is considered moderate, and when the HHI value is over 1,800, the market is considered concentrated [3].

An assessment of market concentration at the county level can also be conducted using the Gini-Struck Index (GSI). Formula 2 was applied by Stanciu et al. (2015) for assessing the concentration of the meat processing sector [18].

The analytical method was proposed by the team of authors Săvoiu, Crăciuneanu, and Țaicu (2010) [13].

$$GSI=SQRT((N\sum G_i^2-1)/(N-1)) \qquad (2)$$

where: G_i represents the share of county ***i*** in the total, and N=41 is the number of counties.

If the GSI value tends to 100, this indicates a high value of market concentration, and if the coefficient tends to 0, it suggests a low concentration value of the analysed market structure.

To validate the results, they were compared with other relevant findings in the specialized literature.

RESULTS AND DISCUSSIONS

According to data provided by the National Institute of Statistics (NIS) [12] in 2023, the number of accommodation units has increased significantly in recent years, rising by 87.45% from 400 in the year 2000 to 3,498 in 2023 (Figure 1).

The post-COVID-19 pandemic period has seen a relatively constant number of agritourism guesthouses, with a 15% growth compared to 2019.

This growth can be attributed to factors such as lockdown measures and changes in consumer behaviour, including within the tourism services sector [16], [17].

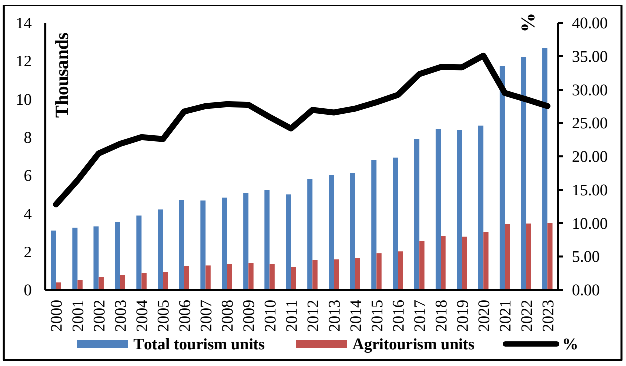

Fig. 1. Evolution of agritourism versus tourism units
Source: Authors, by using NIS (2023) [12].

As a percentage, the number of agritourism-oriented units relative to the total number of tourist units has varied, reaching a minimum of 12.85% in 2000 and a peak of 35.10% in 2020. In 2023, this segment constituted

27.55% of the total registered tourist units at the ministry.

The distribution of the 3,498 registered guesthouses in 2023 across development regions is depicted in Figure 2.

Notably, the year 2020 marked the peak development of agritourism guesthouses due to the COVID-19 pandemic, restricting air travel and prompting Romanian tourists to seek more isolated locations, preferably in mountainous areas or the Danube Delta at the national level.

Ranked last nationally, the Bucharest-Ilfov Region, with a mere 0.03% share, has only one registered agritourism guesthouse in Ilfov County. Leading the national chart is the Center Development Region with 988 units, followed by North-West with 835 units, and South-East with 377 units. These regions benefit from favourable geographical conditions (the Carpathian Mountains or the Danube-Delta Danube), cultural and culinary traditions, potential for sports activities, and a historical presence of accommodations in mountainous areas, fostering the development of these businesses.

In fact, these regions, housing over 52% of the total profiled units, are home to counties with the highest number of agritourism accommodations.

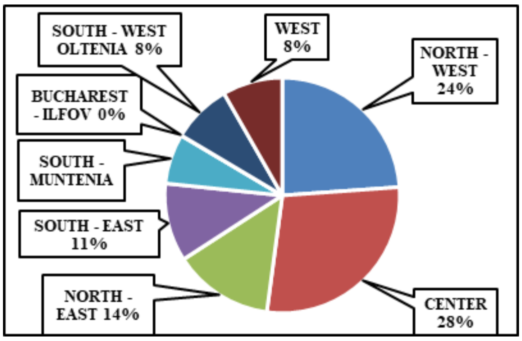

Fig. 2. Agritourism units by development region
Source: Authors, by using the data from NIS (2023) [12].

The counties with over 100 agritourism units are illustrated in Figure 3. Topping the list is Brasov with 372 units, followed by Suceava (271), Maramures (254), Tulcea (241), and Harghita (231).

With 1,368 guesthouses, these counties account for over 38% of the national total (figure 3).

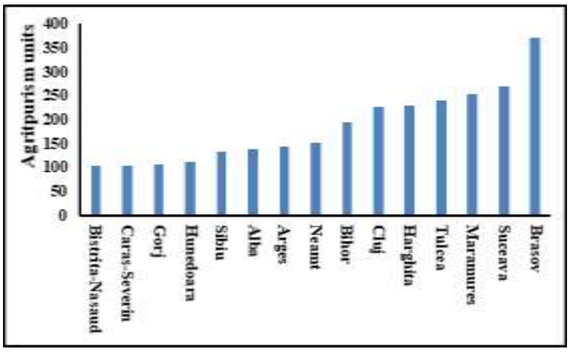

Fig. 3. Top 100 agritourism units by counties
Source: Authors, by using the data from NIS (2023) [12].

At the opposite end are Braila and Ilfov counties (1 agritourism unit each), along with Ialomita and Teleorman (2 units), and Botosani (3 units).

The market concentration of agritourism services in Romania at the regional development level

Based on the information outlined in Table 1, the computed HHI value stands at 1,855.4670, signifying a notable level of concentration within the agritourism services market.

The utilization of the market concentration evaluation technique on a national scale across development regions implies a market with a significant degree of concentration. This calculation holds precision, as two development regions collectively account for more than 50% of the total entities providing agritourism services on a nationwide scale.

Table 1. HHI Calculation

Development Region	Unit	G_i(%)	G_i^2
North - West	835	23.87	569.8143
Center	988	28.24	797.7637
North - East	481	13.75	189.0822
South - East	377	10.78	116.1564
South - Muntenia	240	6.86	47.07419
Bucharest - Ilfov	1	0.03	0.000817
South - West Oltenia	287	8.20	67.31691
West	289	8.26	68.2584
Total	3,498	100%	1,855.467
HHI=Sum (G_i^2)			1,855.467

Source: Authors, by using the data from NIS (2023) [12].

There is a correlation between the income of the population and the development of agritourism. Regions with a high GDP per capita, such as Center and North-West, have a significant number of agritourism guesthouses. An exception can be considered for Bucharest-Ilfov, where the characteristics of the area, marked by a high degree of urbanization, do not offer favorable conditions for the development of businesses in this field.

Despite the South-East Region having areas with high agritourism potential, such as the Danube Delta, the Black Sea, and the Carpathian Mountains, the lack of infrastructure, absence of local measures encouraging agritourism development, or low population density result in a limited number of guesthouses. With the exception of Tulcea County, where local specificity and tradition have led to numerous establishments in this field, the other counties are poorly represented. The South-East Region also experiences limited development in railway transportation infrastructure, and there is no highway connecting the mountainous area to economically prosperous regions. The construction of a bridge over the Danube River at Braila has the potential to rejuvenate the sector in the adjacent counties.

The market concentration of agritourism services in Romania at the county level

The calculated values of Gini-Struck index are presented in Table 2.

Table 2. GSI Calculation

No.	County	Units	G_i	G_i^2	No.	County	Units	Gi	Gi^2
1.	Braila	1	0.0286	0.0008	22	Arad	52	1.4866	2.2099
2.	Ilfov	1	0.0286	0.0008	23	Mures	62	1.7724	3.1415
3.	Ialomita	2	0.0572	0.0033	24	Mehedinti	71	2.0297	4.1198
4.	Teleorman	2	0.0572	0.0033	24	Buzau	75	2.1441	4.5971
5.	Botosani	3	0.0858	0.0074	26	Valcea	91	2.6015	6.7677
6.	Galati	4	0.1144	0.0131	27	Bistrita-Nasaud	103	2.9445	8.6703
7.	Calarasi	4	0.1144	0.0131	28	Caras-Severin	103	2.9445	8.6703
8.	Giurgiu	4	0.1144	0.0131	29	Gorj	108	3.0875	9.5325
9.	Olt	4	0.1144	0.0131	30	Hunedoara	112	3.2018	10.2517
10	Satu Mare	11	0.3145	0.0989	31	Sibiu	134	3.8308	14.6747
11	Vaslui	13	0.3716	0.1381	32	Alba	139	3.9737	15.7903
12	Dolj	13	0.3716	0.1381	33	Arges	145	4.1452	17.1829
13	Iasi	14	0.4002	0.1602	34	Neamt	152	4.3453	18.8820
14	Constanta	18	0.5146	0.2648	35	Bihor	195	5.5746	31.0763
15	Timis	22	0.6289	0.3956	36	Cluj	227	6.4894	42.1126
16	Bacau	28	0.8005	0.6407	37	Harghita	231	6.6038	43.6098
17	Dâmbovita	37	1.0577	1.1188	38	Tulcea	241	6.8897	47.4673
18	Vrancea	38	1.0863	1.1801	39	Maramures	254	7.2613	52.7264
19	Salaj	45	1.2864	1.6550	40	Suceava	271	7.7473	60.0204
20	Prahova	46	1.3150	1.7293	41	Brasov	372	10.6346	113.0957
21	Covasna	50	1.4294	2.0432	Sum	**N=41**	**3,498**	**100%**	**524.2300**

Source: Authors, by using the data from NIS (2023) [12].

The calculated GSI value is 23.18, indicating a moderate level of concentration in the market of tourism services at the county level. This indicates that there is no singular dominance of a small number of providers or players in the market, but neither is there a total dispersion of offerings. Instead, there is a balanced distribution of businesses and tourism services among multiple providers or actors, contributing to a relatively or moderately competitive environment in the county-level tourism sector.

The calculated values are accurate, considering that in the North-East development region, there are two counties, Suceava with 271 agritourism units, and Neamț with 152 units, as well as Argeș (142 units) in the South Muntenia Region, which somewhat reduces the concentration level observed in the Center and North-West Regions.

Hilly and mountainous areas have the highest potential for practicing rural agritourism due to their landscapes of rare beauty and the high quality of air and water.

Considering the climatic conditions and the nature of relief factors, these areas often face challenges in plant agricultural exploitation. The development of rural tourism in these regions would represent, alongside animal husbandry, a significant step towards their economic development.

The major issue in this sector is not the facilities for investors but rather the precarious state of physical infrastructure, without which the potential of these areas cannot be fully realized.

Thus, many localities in hilly and mountainous areas grapple with issues related to road infrastructure and utilities, such as the absence of natural gas supply, lack of running water, and sewage systems.

Population density can be a disadvantageous factor for the development of the sector in some regions of Romania. Counties like Vrancea, Sălaj, or Timiș, characterized by a limited number of residents, also face reduced opportunities for practicing agritourism.

The absence of online promotional tools for agritourism potential, such as online tourist maps, serves as an explanation for the limited development of the sector in counties ranked lower in the standings.

The government should give increased attention to improving airport and road infrastructure and focus on updates to address issues related to connectivity, congestion, and safety on access roads. A viable partnership between the Romanian Ministry of Transport and the Ministry of Tourism can expedite the development of transportation infrastructure, contributing to the enhancement of spatial accessibility at both national and regional levels.

CONCLUSIONS

The agritourism services market in Romania has undergone a remarkable and consistent growth in recent years, witnessing an almost 900% increase in specialized units since the baseline year of 2000.

This expansion has been particularly pronounced in the Center and North-West regions, characterized by favourable geography, significant tourism, and sports potential, as well as the preservation of rich cultural and culinary traditions.

Examining the concentration of tourism services at both regional and county levels reveals high concentration values at the regional scale, while the county-level concentration remains moderate.

Factors influencing market concentration include historical tradition, the entrepreneurial spirit of local communities, the development of transportation and utility networks, and the average income per inhabitant.

This comprehensive analysis provides valuable insights for crafting superior strategies to capitalize on Romania's agritourism potential, fostering the development of best practices that can serve as effective business models for entrepreneurs in less developed regions, particularly in terms of tourism services.

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PROMOTING ROMANIA'S CULINARY HERITAGE. CASE STUDY: LOCAL GASTRONOMIC POINTS

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Abstract

The paper proposes an analysis of the local gastronomic services market in Romania. The growing interest in culinary tourism through Local Gastronomic Points is evident both globally and nationally. Gastronomic tourism can provide unique culinary experiences, especially in rural households. Clarivate, Google Scholar, and Research Gate articles were used for bibliographic research. The necessary data for the research were selected from the reports of the National Agency for Mountain Areas and the statistics of the National Veterinary Sanitary and Food Safety Authority. The information was statistically processed and graphically represented. The assessment of market concentration was conducted using the Herfindahl-Hirschman and Gini-Struck indices. The research results highlighted the dynamism of the sector against the backdrop of the COVID-19 pandemic but also revealed some deficiencies at the local authorities' level. HHI and GSI values indicate a low market concentration at the county level. Local Gastronomic Point businesses have high development potential, significantly contributing to increasing people's income and rural area development.

Key words: *tradition, gastronomic heritage, Romania, local gastronomic points, tourism, market concentration*

INTRODUCTION

Culinary tourism is a niche business that emphasizes experiencing local cuisine and culinary traditions.
The target market segment includes tourists seeking to discover new flavours, ingredients, and dishes specific to the regions they visit, specializing in this purpose.
Tourists could actively engage in preparing and tasting local dishes, learn about traditional ingredients, and participate in cooking classes.
In many instances, culinary tourism intersects with cultural aspects such as traditions, history, and local craftsmanship [9].
Culinary festivals and gastronomic events are increasingly sought after by consumers of tourist services, providing an opportunity to experience a variety of dishes in one place.
Organizing guided tours with a culinary theme can offer tourists interesting destinations, allowing them to explore the city or region through the lens of local cuisine [17].
The popularity of social media platforms has contributed to the growing interest in culinary tourism, with influencers sharing culinary experiences and recommendations.
In wine regions or those specialized in the production of certain alcoholic beverages, the products from the menus of gastronomic points can be associated with wine tastings, vineyard tours, and themed events.
Local gastronomic points can be key factors in promoting and preserving traditional Romanian cuisine, offering customers authentic experiences of local culinary services.
According to Bădic and Ispas (2021), a tourist destination aiming to strengthen its market position through the development of gastronomic tourism must, first and foremost, identify its own resources and capabilities, define them, and then proceed with concrete actions for protection and enhancement, incorporating them into the region's tourism development strategy [4]. The authors explore

the prospect of establishing a network of Local Gastronomic Points in Brașov County, with the goal of incorporating the region's distinctive gastronomy and tourism into the local economic development.

Numerous European regions have implemented local initiatives to stimulate regional growth through culinary heritage, as seen in cities like Burgos in Spain, Fermo in the Marche region of Italy, and L'Hospitalet de Llobregat in Spain. Food and beverage festivals, along with routes featuring diverse culinary products, are transformed into tourist attractions catering to specific segments of tourists.

The study carried out by Karaman and Girgin (2021) regarding the behavior of foreign tourists concerning local gastronomic services in Turkey revealed that motivational factors, food neophilia, food neophobia, cultural influences, exposure, and gastronomic shopping experience exerted a positive and significant impact on the attitude towards local gastronomic products [10]. However, the research found that experience and health-related factors had no effect on the attitude towards local gastronomic products.

Toader et al. (2021) [21] demonstrate that culinary tourism has experienced significant growth in Romania in recent years. The gastronomic uniqueness of a destination has the potential to attract tourists seeking authenticity and novel culinary experiences.

Romania boasts a rich and diverse gastronomic heritage, serving as a key element of the country's cultural identity. Gastronomy, as an integral component of the national cultural profile, can serve as a catalyst for local economic development through the establishment of local gastronomic points, thereby fostering gastronomic tourism.

Despite the potential, gastronomic tourism in Romania is not yet well-established. However, local and regional gastronomy represents a valuable resource for promoting lesser-known tourist destinations, a potential that can be harnessed through Local Gastronomic Points (LGPs). The implementation of a strategy to promote LGPs, coupled with the development of mobile applications accessible on smartphones to provide tourists with information about locations, availability, and more, is deemed essential.

Stanciu et al. (2022) [16] proposed an analysis of LGPs, examining their impact on local economies and their role in rural development. The authors conducted a case study of a local gastronomic point and investigated the knowledge of young people regarding local gastronomic points and their contribution to village development.

In this context, the goal of this study is to analyse the local gastronomic services market in Romania, legal aspects, characteristics, dynamics and concentration.

MATERIALS AND METHODS

For bibliographic research, open-access articles from Clarivate, Google Scholar, and Research Gate databases were utilized. Official information presented by the Ministry of Agriculture and Rural Development, the National Sanitary Veterinary and Food Safety Authority (A.N.S.V.S.A), the Chamber of Deputies, European forums, and professional associations were used for specific legislative regulations in the field.

Data related to Local Gastronomic Points (PGL) is officially furnished by the County Departments of the National Sanitary Veterinary and Food Safety Authority (ANSVSA).

The collected information was processed through statistical methods, graphically represented, and interpreted.

The degree of concentration of the local gastronomic services market in Romania at the county level can be analyzed through the calculation of the Herfindahl-Hirschman Index (HHI), which is equal to the sum of the squares of the market shares of the factors in the sector (formula 1).

HHI represents an assessment of how a small number of regions can have a high share of the market for traditional products.

The higher the value of HHI, the more the production/distribution is concentrated in a small number of factors.

For HHI values below 1,000 units, the degree of market concentration is low; for values 1,000 - 1,800, medium, and for values over 1,800, the market is considered concentrated (Consiliul Concurenței, 2020) [6].

$$HHI=\sum Gi^2 \qquad (1)$$

where: ***Gi*** is the market share of county ***i***,

The market concentration level at the county level can also be carried out using the Gini-Struck Index (GSI), calculated using Formula 2, as applied by Stanciu et al. (2015) for assessing the degree of concentration in the meat processing industry [20]. This method was initially proposed by the author team Săvoiu, Crăciuneanu, and Țaicu (2010) [15].

This index ranges from 0 to 1, where 0 indicates perfect equality (each county has an equal share) and 1 indicates perfect inequality (all market share is concentrated in one county).

It's worth noting that a higher GSI value suggests a higher degree of market concentration or inequality among counties in terms of market share.

$$GSI=SQRT((N\sum Gi^2-1)/(N-1)) \qquad (2)$$

where: Gi it is the share of the number of LPGs.

For validation, the results were compared with other relevant findings from the specialized literature.

RESULTS AND DISCUSSIONS

Legislative regulations on local gastronomic points

At the European level, the provision of public catering services and the functioning of Local Gastronomic Points are governed by food safety regulations (European Parliament and The Council of the European Union, 2004) [8]. At the national level, the establishment and operation of local gastronomic points are regulated by Law 412/2023, published in the Official Gazette No. 1147 on December 19, 2023 (Parliament of Romania, 2023) [13]. According to this law, a local gastronomic point is defined as an establishment in a rural area that promotes local production, where food products are prepared and served exclusively by the owner or family members. These individuals undergo regular health checks, and the dishes adhere to specific regional recipes. The prepared food is directly served to the end consumer within a maximum of 12 hours from the time of cooking. (Zamfir, 2023) [22].

Local gastronomic points first appeared in Romania in 2017, considered an opportunity for opening a family-type public catering unit where visitors can consume food products specific to a certain region, primarily sourced from the owner's own gastronomic point.

The initiative for this family business concept belongs to the Ivan Patzaichin - Mila 23 Association in 2016, with the first local gastronomic points established in 2018. These small public catering units provide families with the opportunity to promote small-scale tourism activities and capitalize on their own or local community food products

The sector's development contributes to maintaining gastronomic identity, offering visitors the chance to consume homemade dishes they would not normally have access to. These modest gastronomic enterprises play a role in fostering the growth of the local food industry by promoting and enhancing the value of local food production. (Dediu Panaete, 2023) [7].

In 2017, an effort was undertaken to establish a nationwide network of Local Gastronomic Points, drawing inspiration from a best practices model within the European Union. The concept of Local Gastronomic Point (LGP) is relatively new to the domestic tourism sector. LGP serves as a facility dedicated to promoting local primary production, situated in a rural area, where food items are prepared and served based on specific regional recipes, directly to the end consumer, with a maximum capacity of serving 15 people simultaneously [11].

The rural locality includes commune centre villages, component villages of communes, and villages belonging to municipalities or cities.

The local plan encompasses the administrative-territorial unit to which the

Local Gastronomic Point is affiliated, the residence of the individual owning the Local Gastronomic Point, and the adjacent administrative-territorial units.

The food products offered by the Local Gastronomic Point are prepared from locally available raw materials, mainly from primary production at the owner's own farm, from producers, fishermen, hunters, gatherers, and collectors of non-wood forest products.

Local Gastronomic Point can operate in existing premises in private homes, agricultural farms, fish farms, mountain pastures, apiaries, cellars, fisherman's shelters, hunting reserves, game farms, mushroom and wild berry collection centres, hunting centres, forestry offices, monasteries, as well as other constructions and facilities in a rural locality, where one or more activities related to primary agricultural production, fishing, hunting, harvesting, or collecting non-wood forest products take place," as stated in the legislative initiative.

The establishment of a Local Gastronomic Point is open to both individuals and legal entities, subject to compliance with existing legal regulations regarding sanitary-veterinary registration and food safety. Such compliance must be verified through the Sanitary Veterinary and Food Safety Directorate in the county where the Local Gastronomic Point operates [11].

The Ministry of Agriculture and Rural Development (MADR), operating through its subordinate units at the national, county, and local levels, may organize complimentary professional training courses for individuals or legal entities interested in establishing a Local Gastronomic Point. This initiative falls within the competencies established by relevant legislation.

MADR puts forth measures to provide support for the establishment or assistance of activities related to Local Gastronomic Points, subject to budgetary allocations. These measures are implemented through the National Mountain Zone Agency.

Through the National Mountain Zone Agency [12], The ministry compiles and oversees the Register of Local Gastronomic Points, utilizing data from the publicly accessible list on the website of the National Sanitary Veterinary and Food Safety Authority (ANSVSA) [3].

In a broader context, facilities used for handling food items must adhere to cleanliness standards and be maintained in good condition to mitigate the risk of contamination. They should be equipped with appropriate hygienic-sanitary and refrigeration facilities to ensure a clean working environment and the safe handling of products, as well as to maintain and monitor suitable food temperatures.

Local gastronomic points present a valuable choice for enthusiasts of rural and gastronomic tourism, accentuating the authenticity of culinary experiences. Remarkable is the emergence of specific forms of rural tourism promotion in Romania, exemplified by platforms like Localm.ro.

This booking platform goes beyond the somewhat traditional accommodation section: ("Rest") (“Odihna”), also includes the "Food" (“Bucate”) sections (including local gastronomy points and "Customs" (“Obiceiuri”) (village traditions and activities).

These culinary establishments also serve as an opportunity for the sustainable development of rural environments, contributing, among other things, to job creation in rural areas, fostering community cohesion, and preserving culinary traditions.

Local gastronomic points in Romania

Data related to Local Gastronomic Points is officially furnished by the County Departments of the National Sanitary Veterinary and Food Safety Authority (ANSVSA) [3].

The information was updated in most county agencies in November/December 2023. Publicly available information is challenging to access on the websites of the County Sanitary Veterinary and Food Safety Directorates (DSVSA).

There are differences between the figures reported by ANSVSA and the reports of the National Mountain Zone Agency, although both institutions are under the Ministry of Agriculture and Rural Development.

On some agency websites, the list of

authorized economic operators is displayed directly, while on others, it is available through a search using the keywords "local gastronomic points" in the dedicated search field. At other agencies, it needs to be identified by going through successive steps: Economic Operators/Animal Origin Products/ List of retail units for animal origin products registered for sanitary veterinary. Files with authorized operators may be available on one or multiple pages, but each must be reviewed (usually located in positions 32-33 on the list of files).

Official information regarding ANSVSA awareness campaigns about Local Gastronomic Points conducted in 2017 is present on all verified agency websites. Some agencies also provide additional information about prevention and awareness campaigns for LGP operators regarding potential food born diseases, especially those of animal origin.

In some situations, such as in Brașov County, no information about authorized LGPs was found on the agency's website. The information was collected from the Gastro Local Association website (https://gastrolocal.ro/#) [2] by searching in specific fields (Photo 1).

Photo 1. LGP search using the site of "Asociația Gastro Local"
Source: Authors, by using "Asociația Gastro Local" site: https://gastrolocal.ro, 2023 [2].

In the introduction, the location can be searched based on basic criteria: county, locality, menu categories (including vegetarian), places with children's playgrounds, accommodation options etc.

The locations are available in a catalogue or can be searched on the associated map of the website. The information is presented on the association's website (www.gastrolocal.ro), on social media platforms Facebook and Instagram (facebook.com/gastrolocal.ro), or can be obtained additionally through phone calls or email messages (Photo 2).

Access to new LGPs aiming to join the association is easily achieved by completing membership forms available on the website in the "Join Us" section (https://gastrolocal.ro/formular-pasul1) [2].

Exploring the "Catalogue" section of the website provides the necessary information to pique the tourist's interest, including details about the reservation process (direct phone reservation is an option under "Call the Location").

A detailed presentation of the LGP operator, including the use of a map with satellite orientation information directly to the targeted point, is available by accessing the "More Information" section.

Photo 2. LGP at the Asociation Gastro Local, Section "Catalog"
Source: Authors, by using Asociația Gastro Local site, 2023. https://gastrolocal.ro [2].

On the website, events of common interest for the association are also promoted under the "Events" section, with the latest promoted event being the National Conference of Local Gastronomic Points in Romania, which took place in the tourist resort of Vama Buzăului in Brașov County, from October 21st to October 22nd, 2023 (https://gastrolocal.ro/evenimente) [2], [14].

From the perspective of English-speaking users, the presence of an English version would be beneficial, given the increasing influx of foreign tourists, primarily interested in authenticity and local traditions.

The progression of Local Gastronomic Point (LGP) openings in Romania, as per the Activity Report of the National Agency for Mountain Products for the year 2022, is illustrated in Figure 1. The data indicates a

substantial increase compared to 2018, marking the emergence of the first initiatives in this field.
The remarkable growth in the number of registered operators at the national level can be attributed to the availability of non-reimbursable grants, without co-financing, ranging from 50,000 to 70,000 euros.
This funding opportunity is made possible through the National Rural Development Program (PNDR), falling under Measure 6.2, which supports the establishment of non-agricultural activities in rural areas (Agency for Financing Rural Investments AFIR, 2023) [1].The dynamics of the number of local gastronomic points (LGP) in Romania is presented in Figure 1.

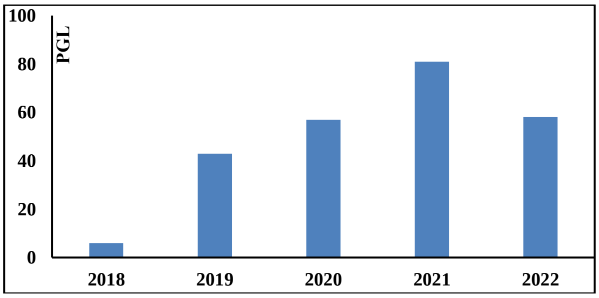

Fig. 1. Local Gastronomic Points in Romania
Source: Authors, by using National Agency for Mountain Products Report, 2022 [12].

COVID-19 pandemic has facilitated the opening of new LGPs, as tourists sought to avoid crowds and the risk of contamination (Stanciu et al., 2020) [19].
Romanians have been searching for more isolated locations nationally, preferably in rural, mountainous, or Danube Delta areas (Stanciu, 2022) [18].
In 2023, the statistics gathered from the 42 County Sanitary Veterinary and Food Safety Directorates (DSVSA) revealed the registration of 251 Local Gastronomic Points (LGPs) across Romania.

The data was compiled from the websites of the respective county agencies (ANSVSA, 2023) [3].
Analysis of the information available on the agencies' websites revealed the following aspects: Most agencies update their information in December/November.
7 agencies had up-to-date information at the time of querying the platform (Arges, Bistrita Năsăud, Bucharest, Dâmbovita, Dolj, Galați, Suceava).
Some agencies haven't updated PGL information for several months: Giurgiu (April 6, 2023), Mehedinți (May 19, 2023), Covasna (August 28, 2023), Sălaj (September 1, 2023), Harghita (September 15, 2023), Timis (September 30, 2023).
Most agencies without updated information have 0 registered operators.DSVSA Brașov has no registered PGL operators on its site, while the Gastro Local Association platform mentions 16 functional points.
Ten counties have 0 registered PGL operators (Bacău, Bihor, Bucharest, Călărași, Dolj, Giurgiu, Ialomița, Iași, Ilfov, Teleorman).
8 counties have 1 PGL (Botoșani, Brăila, Dâmbovița, Galați, Mehedinți, Olt, Vaslui, Vrancea), 4 have 2 PGL (Constanța, Mureș, Sălaj, Timiș), 2 counties have 3 PGL each (Covasna, Vâlcea).
About 60% of Romania's counties have fewer than 5 registered PGL operators at the county level. Only 9 counties have over 10 registered PGL, with Tulcea leading the list (42), followed by Alba and Sibiu (25), and Brasov (16) (Figure 2).
With 174 registered PGLs, these 9 counties concentrate around 70% of the total registered at the national level.
Most operators are concentrated in these 9 counties. In Brașov, gastronomic points are established in Vama Buzăului, Fundata, Sâmbăta de Jos, and Drăguș [5].
In Tulcea, tourists can access gastronomic points in Sulina, Murighiol, Mila 23, and Crișan. In Sibiu, meals can be enjoyed in families in Cisnădie, Cristian, Arpașu de Sus.

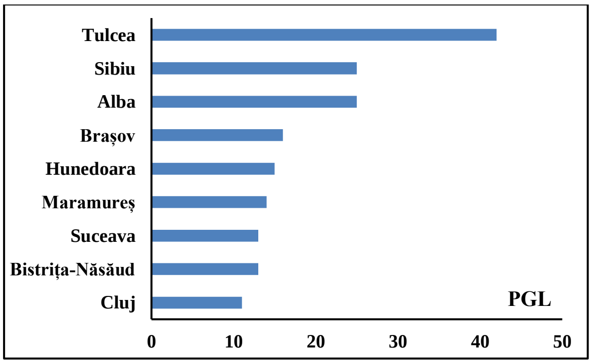

Fig. 2. PGL by county in Romania (2023)
Source: Authors, by using ANSVS (2023) [3].

Local Gastronomic Points are also present in Alba (Roșia Montana, Rimetea, Câmpeni) and Maramureș (Borșa, Vișeul de Sus, Suciu de Sus, etc).

The concentration level of the local gastronomic services market in Romania at the county level can be assessed by calculating the Herfindahl-Hirschman Index (HHI). According to the data presented in Table 1, the calculated HHI value is 741.4171, indicating a low degree of market concentration. The action is taken within county ***i*** in the total registered at the national level (251), and N=42 is the number of counties in Romania.

The calculated values of HHI and GSI are presented in Table 1.

If the GSI value tends to 100, this indicates a high value of market concentration, and if the value of the coefficient tends to 0, it indicates a low concentration value of the structure of the analysed market.

The calculated value for GSI, according to Formula 2, is 27.18, indicating a low degree of concentration in the market of local gastronomic services at the county level, similar to the HHI calculation.

Table 1. HHI and GSI Calculation

No.	County	Units	G_i	G_i^2	No.	County	Units	Gi	Gi^2
1.	Alba	25	9.96	99.2048	22	Harghita	5	1.99	3.9682
2.	Arad	5	1.99	3.9682	23	Hunedoara	15	5.98	35.7137
3.	Argeș	7	2.79	7.7777	24	Ialomița	0	0.00	0.0000
4.	Bacău	0	0.00	0.0000	24	Iași	0	0.00	0.0000
5.	Bihor	0	0.00	0.0000	26	Ilfov	0	0.00	0.0000
6.	Bistrița-Năsăud	13	5.18	26.8250	27	Maramureș	14	5.58	31.1106
7.	Botoșani	1	0.40	0.1587	28	Mehedinți	1	0.40	0.1587
8.	Brașov	16	6.37	40.6343	29	Mureș	2	0.80	0.6349
9.	Brăila	1	0.40	0.1587	30	Neamț	7	2.79	7.7777
10	București	0	0.00	0.0000	31	Olt	1	0.40	0.1587
11	Buzău	6	2.39	5.7142	32	Prahova	8	3.19	10.1586
12	Caraș-Severin	5	1.99	3.9682	33	Satu Mare	4	1.59	2.5396
13	Călărași	0	0.00	0.0000	34	Sălaj	2	0.80	0.6349
14	Cluj	11	4.38	19.2060	35	Sibiu	25	9.96	99.2048
15	Constanța	2	0.80	0.6349	36	Suceava	13	5.18	26.8250
16	Covasna	3	1.20	1.4285	37	Teleorman	0	0.00	0.0000
17	Dâmbovița	1	0.40	0.1587	38	Timiș	2	0.80	0.6349
18	Dolj	0	0.00	0.0000	39	Tulcea	42	16.73	279.9956
19	Galați	1	0.40	0.1587	40	Vaslui	1	0.40	0.1587
20	Giurgiu	0	0.00	0.0000	41	Vâlcea	3	1.20	1.4285
21	Gorj	8	3.19	10.1586	42	Vrancea	1	0.40	0.1587
						Total	251	100%	721.4171

Source: Authors, by using ANSVSA (2023) [3].

CONCLUSIONS

The market of local gastronomic services in Romania is a dynamic sector with a spectacular evolution since the establishment of the first establishment in 2018.

The main areas where Local Gastronomic Points (LGP) have developed are the Danube Delta and regions in Transylvania located in the center of the country, characterized by specific and diversified culinary traditions. The leading position of Tulcea County in the LGP hierarchy can be explained by the association of these small local businesses with the initiative of Patzaichin, the lack of other dining alternatives, and the specific nature of the area where meals rich in aquatic products are prepared in a traditional fishing style.

The analysis of the concentration level of tourist services at the county level resulted in moderate values of HHI and GSI, indicating the absence of concentration processes.

An analysis of the factors influencing the market concentration should also consider the historical tradition, entrepreneurial spirit of the residents, development of transport and utilities networks, and the average income per capita.

The analysis conducted provides valuable insights into the development of strategies for superior exploitation of the national culinary potential and the creation of best working practices.

These can serve as business models for small enterprises in less developed regions, particularly in terms of tourist services.

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THE CONTRIBUTION OF NATIONAL RURAL DEVELOPMENT PROGRAMME (NRDP) FUNDS TO THE DEVELOPMENT OF HUMAN RESOURCES FROM THE RURAL ENVIRONMENT IN THE SOUTH-WEST OLTENIA REGION, ROMANIA

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Abstract

The rural area has faced and continues to face countless challenges regarding the lack of financial resources, the way to use material and human resources, labor productivity and labor mobility. Although Romania is a rich country in natural resources, the rural environment being predominant and having an old tradition in agriculture, certain factors stop or make rural development quite difficult. The present study aims to identify and analyze these factors that make rural development less than desired, ways to finance human resources through programs dedicated to the rural environment so that people who earn income from subsistence agriculture can also develop in non-agricultural fields, can achieve a performing agriculture and helps the economic and social growth of the Southwest Oltenia region. An important source of financing for the rural environment is funds from the European Union, which also contribute to the development of human resources in the area. To begin with, we considered the statistical analysis of the data on the evolution of the resident population in the region, the employed population, the net monthly salary that people in the region obtain according to the branches of the national economy, but also statistical data related to unemployment. Thus, for an overview of the existing situation, we continued with a SWOT analysis of the regions in order to establish investment priorities. Another important point in the paper, which helps us to observe the contribution of European funds to rural development, is the degree in care of the measures of the National Rural Development Program accessed as well as certain factors that made submeasure 1.1. to be poorly accessed. The conclusions of the study show that the South-West Oltenia region has one of the highest unemployment rates in the country, with a population that, living mostly on the income obtained from subsistence agriculture, is in acute need of funds, additional training and development.

Key words: *human resources, European funds, rural area*

INTRODUCTION

The rural environment is predominant in the Southwest Oltenia region. Sustainable and sustainable development of the region can successfully deal with the challenges and difficulties that this region is facing. At county level, a series of disparities can be noted at the level of human resources, both in terms of structure and volume, depending on the degree of industrialization of each county and the extent to which the relief allows the practice of agriculture. The main activities in the countryside are predominantly agricultural, the employed population being the one in subsistence agriculture [1]. The meager financial resources that can thus be obtained from agriculture are insufficient for a decent living. Thus, European funds represent the most important source of financing agricultural and non-agricultural activities and, at the same time, a financial resource that farmers can benefit from [2]. In these conditions, the human resource is of particular importance, being its number and structure, but also its availability.

The economic and social development of rural areas in our country can be achieved through the National Rural Development Program (NRDP) which grants non-refundable funds in this regard [5].

14 rural development measures can be financed through this program, granting support of 9,363 billion euros, of which 1,347 billion euros are national contributions and 8,015 billion euros are granted by the European Agricultural Fund for Rural Development. All these are based on three strategic objectives [9]:

- The first objective considers restructuring and increasing the viability of agricultural holdings;
- The second objective aims to combat climate change and, at the same time, the sustainable management of natural resources;
- The third objective contributes to diversifying economic activities in the region, creating jobs and increasing employment, creating infrastructure and services related to the quality of life of rural people.

Through the NRDP measures, to achieve specific objectiv1, the following categories of intervention were financed [3]:

• Improving the quality of equipment at the farm level by expanding it, modernizing or even establishing new facilities that help both the farm infrastructure and the entire technical-economic circuit of the products they obtain;

• Investments in the production of products and their marketing, including activities aimed at contributing to the reduction of energy consumption, the creation of optimal storage conditions and the storage of products or those who take care to refer to the adaptation of products to the standards in force;

• Help to restructure farms of all kinds, with an emphasis on small farms, and support for younger generations of farmers;

• Help to ensure risk management in the agri-food sector;

• Counseling and training activities, carried out including through producer groups.

To achieve the SO2 objective, the following categories of intervention were financed through the NRDP measures:

• Afforestation actions of agricultural and non-agricultural lands;

• Compensatory payments to farmers applying in the field of agri-environment and climate commitments;

• Compensatory payments to farmers who will practice organic farming and implement specific practices and methods;

• Compensatory payments to farmers who voluntarily undertake to continue the activity in areas designated as areas facing natural constraints or other specific constraints.

To achieve SO3, the following categories of intervention will be financed through the NRDP measures:

• Support for making investments among micro-enterprises and their small enterprises in the rural environment operating in non-agricultural fields;

• Financial support for the creation of local infrastructure such as those related to water supply systems, sewage networks, local roads. Support is also provided for educational, medical and social infrastructure in rural areas;

• Support for the maintenance or restoration of cultural heritage;

• Financial support for the development and implementation of local strategies that ensure integrated support for local development.

In this context, the purpose of this article is to analyze and present the extent to which non-reimbursable European funds contribute to the development of human resources in the rural area, leads to an increase in the living standards of the population and helps to the general development of the South-West Oltenia development region.

MATERIALS AND METHODS

The paper makes a two-level analysis: a part that is based on the statistical analysis of the South-West Oltenia region, as a starting point in the further development of the study, and a descriptive analysis of the program that finances the training of human resources in the rural environment as well as the impact generated by financing human resources through this program. The analysis presents the limits and factors that led to poor access and difficult implementation of the measures from National Rural Development Program, in order to avoid such ineffective practices in the future. The statistical analysis was based on the online tempo data series to observe the evolution over time of the situations relevant to the analysis as well as the structural changes over time of the component elements. The purpose of the statistical analysis is to identify the factors that led to changes in volume and structure of human resources.

RESULTS AND DISCUSSIONS

The evolution over time of the components that characterize the rural environment in the South-West Oltenia region is of particular importance in the present analysis of development of human resources in the rural environment of the region, as well as in the analysis of its efficiency.

The starting point of the analysis is the presentation of the evolution of the rural resident population in the region analyzed during the period 2015-2022 [8].

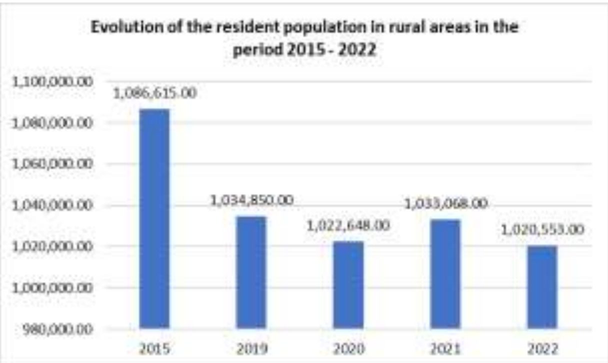

Fig. 1. Evolution of the resident population in rural areas in 2015 – 2022 period (number of people)
Source: Personal processing based on the data from Tempo on-line.

As we can see in Figure 1, the rural population was decreasing during the analyzed period, with the exception of 2021 when a slight increase was recorded.

This increase from the year 2021 is due to the restrictions imposed by the Covid-19 pandemic when, due to the restrictions imposed by the authorities, economic activities were reduced, leaving many people without occupation or being sent to technical unemployment.

The only survival solution, for certain people, was to retreat to the countryside and practice subsistence agriculture [6].

Considering the age categories of the rural and urban resident population in the Southwest Oltenia region, we can see that the rural population is more numerous than the urban one, the largest age category being 50-54 years followed by of 45-49 years and 40-44 years, in both areas of residence (Fig. 2).

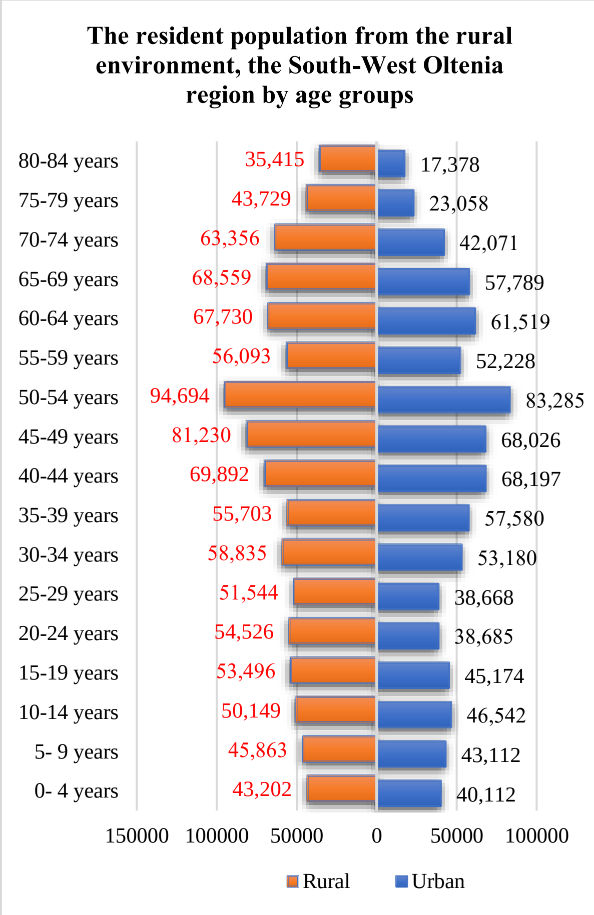

Fig. 2. The resident population of the rural area of SV Oltenia, by age groups in 2022
Source: Personal processing based on the data from Tempo on-line.

Due to the existing industry in the region, the civilian population in the South-West Oltenia region is employed in the manufacturing industry, followed closely followed by that employed in agriculture [7].

The third branch of the economy in which the population of the analyzed region has a job is trade, followed by construction.

The least represented branches of the economy are financial intermediation, information and telecommunications, and production and supply of electricity and heat (Fig. 3).

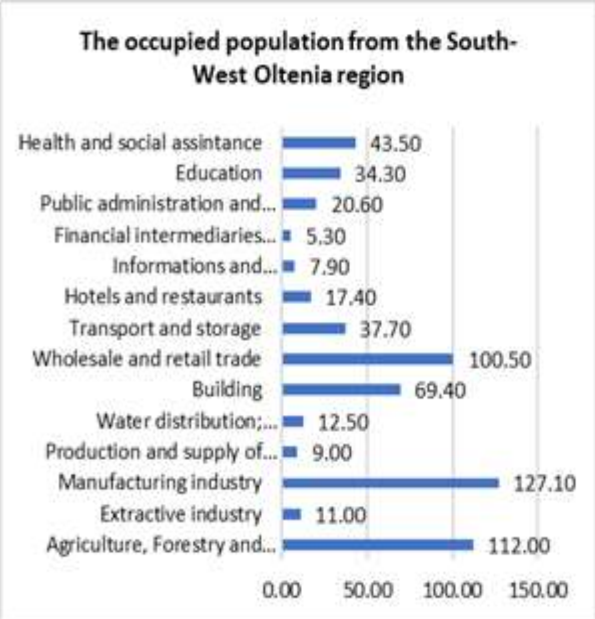

Fig. 3. The civilian employed population of South West Oltenia in 2022 (Thousand persons)
Source: Personal processing based on the data from Tempo on-line.

Although the population employed in agriculture is large, the net salary earned in this field is low, of only 2,552 lei compared to public administration and defense where the highest average net salaries are (4,868 lei), production and energy supply (4,811 lei) and the extractive industry with 4,503 lei. This explains the fact that, although in rural areas the population is larger, the fact that they are employed in fields with lower average net wages, the standard of living is lower and the degree of poverty is higher (Fig. 4).

The data from Figure 5 show that the most unemployed belong to the 25-54 age category (unemployment rate 23.8 in rural and 15.8 in urban) years and the fewest in the 55-64 age category (unemployment rate 2.7% in the urban and with 5.5% in the rural areas). As a result of the fact that the number of jobs is lower than in the urban environment, there is a greater number of unemployed in the rural environment, the jobs being predominantly those occupied in agriculture and animal husbandry [4].

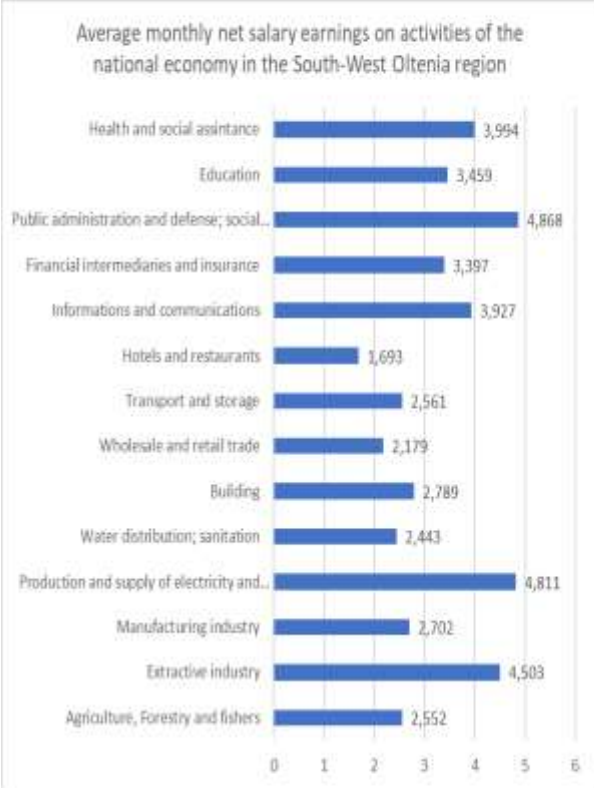

Fig. 4. The net salary gain on activities of the national economy in the South-West Oltenia region in 2022
Source: Personal processing based on the data from Tempo on-line.

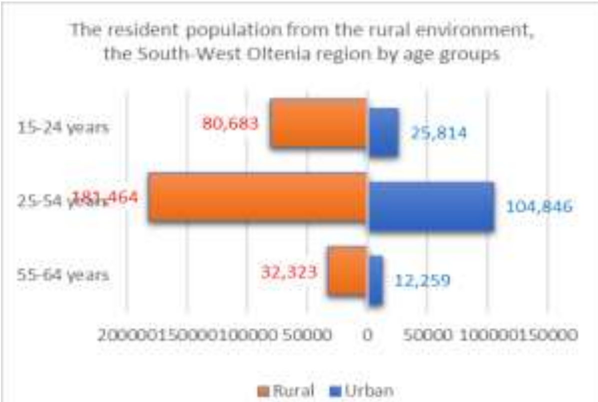

Fig. 5. Number of unemployed people by age group and residence in the South-West Oltenia region in 2022
Source: Personal processing about Tempo on-line data

Although the situation of unemployed people in the region is worrying, the unemployment rate being quite high, there are, however, some strong points that can be exploited in order to reduce unemployment: the existence of qualification centers within the County Employment Agency; the existence of the Regional Center for Professional Training of Adults; the improvement of the job offer, the existence of accredited providers of professional training and counseling/labor mediation.

Occupying a place on the labor market in the region is quite difficult to achieve due to the high share of the population employed in subsistence agriculture, an inflexible workforce due to lack of training, or due to low access and poor adaptability of the population to high-performance technologies. In addition, we have identified other problems such as: the professional offer is not correlated with the labor market, the labor force shows poor flexibility between sectoral activities, insufficient facilities for the continuous professional training of the active population and the poor insertion on the labor market of the young population from the environment rural.

However, a good distribution of European funds in the key areas of the rural economy and in the labor force can mitigate, on the one hand, the migration of the population from the rural to the urban environment, the reduction of school dropouts, the creation of new jobs and the maintenance and modernization of existing jobs.

The evolution of the volume of labor in agriculture in the period 2018-2022, in Oltenia is shown in Figure 6.

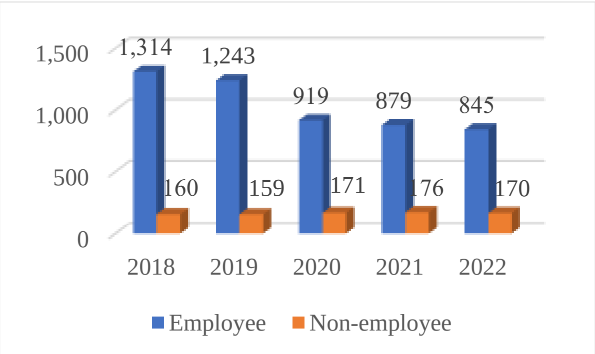

Fig. 6. Evolution of the volume of labor in agriculture in Oltenia in the period 2018-2022 (UM: 1,000 annual work units).
Source: Tempo on-line data.

As can be seen, in agriculture, the largest workload is for the unemployed to the detriment of the salaried. It is worrying that this volume of work is decreasing year by year (by 35.69% unpaid work decreased in 2022 compared to 2018).

The people from rural area who benefited from PNDR funding through professional training programs on M01 - Actions for the transfer of knowledge and information actions in the period 2014-2022 are shown in table 1:

Table 1. The situation of training actions through NRDP

Mea-sure	**Interv-ention area**	**Sup-ported Actions**	**Training days**	**Training persons**	**Public expenditure**
M01.1	2A	61	2,305	10,498.00	3,568,727.71
M01.1	2B	33	1,025	4,634.00	1,424,510.17
M01.1	4C	8	357	3,192.00	546,180.94

Source: National Rural Development Programme.

The human resource is the one that contributes to the greatest extent to the development of the area and to the well-being of the population. Therefore, it is the investment in the human resource that ensures a healthy and sustainable living environment. However, serious investments are needed in the training and improvement of human resources in the rural environment.

Given this general picture of the area, the funding obtained through the National Rural Development Program is the most appropriate opportunity for funding human resources and for the development of agriculture in this region.

The measure through which funds are allocated to increase the quality of the human resource is Measure 01 "Knowledge transfer and information actions" which meets the needs of target actors, farmers and people active in the agri-food sector, financing activities such as professional training, demonstration activities and information actions. These will contribute to the creation and implementation of an efficient management of exploitations and will participate in the adoption of environmentally friendly practices. The measure will lead to the development of the technical and economic skills of farmers, will bring to the fore practices specific to the management of agricultural and food activities, will contribute to the realization, by farmers, of the fact that they must contribute to the sustainable development of the area. could adopt an efficient management of natural resources.

Also, the measure will contribute to informing farmers about the introduction and implementation of innovative technologies in their business.

Through the actions related to the transfer of knowledge and information actions, it is possible to contribute to the increase of competitiveness and diversification in agriculture and, at the same time, it is possible to contribute to the restructuring and modernization of the agricultural sector. At the same time, the actions will encourage businesses to be oriented towards the needs of the market, towards modern and sustainable methods of processing and marketing agricultural products, they will contribute to product games, to the diversification of economic-financial and management skills. Achieving the objective of sustainable land management and environmental protection can be achieved with the help of this measure through the application of environmentally friendly technologies and practices, good agricultural production practices, and the use of renewable energy, as well as the application of technological and practical agricultural solutions, which offers alternatives to fight drought through irrigation methods [11]. The measure supports professional training and the acquisition of skills, demonstration activities and information actions, which have contributed to the creation and implementation of efficient farm management and the adoption of environmentally friendly practices.

The measure aims to:

- improving farmers' knowledge through short-term professional training courses (eg: initiation, improvement), with differentiated training periods, depending on the training level of the final beneficiaries, as well as the subject of the professional training program.
- improving basic knowledge among farmers/small processors operating in the agri-food sector by extending the scope and supporting other short-term actions such as demonstration activities and information actions.

The purpose of the support granted through submeasure 1.1. is to contribute to:

- Improving specific technical and economic knowledge for the practice and management of farmers' agricultural and agri-food activities, as well as the general management of the farm. As a result, young farmers supported by sub-measure 6.1, smallholder farmers and supported by sub-measure 6.3 are expected to implement agricultural techniques and technologies, including research results.
- Acquiring and improving knowledge and skills regarding environmental aspects, climate change, effective management of natural resources, as well as the implementation of agri-environment and climate commitments and ecological agriculture. As a result, the beneficiaries of the agri-environment and climate measures are expected to acquire production methods compatible with the maintenance and improvement of the landscape, i.e. the protection of the environment, compliance with the conditions of eco-conditionality and adaptation to the effects of climate change and the reduction of the concentration of GHG in the atmosphere.

The measure supports professional training and the acquisition of skills, demonstration activities and information actions, which will contribute to the creation and implementation of efficient farm management and the adoption of environmentally friendly practices and aims:

- improving farmers' knowledge through short-term professional training courses (eg: initiation, improvement), with differentiated training periods, depending on the training level of the final beneficiaries, as well as the subject of the professional training program.
- improving basic knowledge among farmers/small processors operating in the agri-food sector by extending the scope and supporting other short-term actions such as demonstration activities and information actions.

Also, Measure 1, submeasure 1.1 Support for professional training and the acquisition of skills, aimed at:

- Call no. 1/2016 - Professional training for farmers who have commitments on measure 10 - Agro-environment and climate, in order to carry out short-term professional training courses, 3 days (24 hours)

- Call no. 2/2016- Vocational training for farmers, especially beneficiaries of support of sub-measures 6.1 "Support for the installation of young farmers" and 6.3. "Support for the development of small farms" in order to carry out short-term vocational training courses, 5 days (40 hours) addressed to farmers, especially the beneficiaries of support of sub-measures 6.1 and 6.3.

At the level of the South West Oltenia region, the situation of projects on Measure 1 was as follows:

Call for projects no. 1

80 submitted projects, of which 55 are eligible
Total value of submitted projects: 6,590,496.15 Euro
Total value of eligible projects: 4,506,898.63 Euros
- South-West Region - 6 projects, worth 480,887.29 Euro
- Trained persons: 15,132

Call for projects no. 2

174 submitted projects, of which 138 are eligible
Total value of projects submitted: 12,755,405.02 Euro
Total value of eligible projects: 10,080,985.74 Euro
- Dolj - 4 projects, worth 391,606.41 Euro
- Gorj – 4 projects, worth 297,614.32 Euro
- Mehedinti – 3 projects, worth 215,333.77 Euro
- Olt – 5 projects, worth 357,364.92 Euro
- Vâlcea – 4 projects, worth 266,237.78 Euro
- Trained persons: 3,192.

Sub-measure 1.1 Support for professional training and the acquisition of skills is appreciated as being to a large extent relevant, and that this measure corresponds in a high way to the needs of potential beneficiaries. This sub-measure was included in the Program from the beginning, but along the way it underwent some adjustments, in the sense that, in the fifth amendment of the program, a new type of support was introduced – unit costs standard - an aspect that contributed to an efficient use of European funds. By reducing the administrative tasks, the human resources involved in the management of European funds will be able to focus with priority on achieving the objectives of the measure, thus reducing the time lost with the collection and verification of financial documents, thus achieving a simplification of the payment methods for the eligible expenses for the projects deformation [10].

A series of impediments determined the poor access to the sub-measure, namely the contracting of only 38 projects (29%) out of the 130 selected, out of a total of 324 submitted projects, within 3 calls for project proposals:

• Call for project proposals no. 1/2016 - Professional training for farmers who have commitments on measure 10 – Agro-environment and climate.

• Call for project proposals no. 2/2016 - Vocational training for farmers, especially beneficiaries of sub-measures 6.1 and 6.3.

• Announcement regarding the registration of vocational training providers in order to be registered in the "Register of vocational training providers" as well as the selection of funding applications submitted under sM 1.1 "Support for vocational training and skills acquisition", using the standard unit cost starting from 14.02.2018. The call was launched on 29.12.2017 – Support for vocational training and skills acquisition using standard unit costs.

The factors that contributed to poor access to submeasure 1.1 are, on the one hand, the difficulty of identifying the target group covered by the documentation of the 3 calls, and on the other hand, the failure to meet certain eligibility conditions and criteria for granting support. In addition, the interviews conducted with some of the beneficiaries and non-beneficiaries highlighted the fact that the period of evaluation, selection and contracting takes quite a long time, an aspect that implicitly leads to difficulties in identifying the potential final beneficiaries of the trainings, who reorient themselves towards other training providers (for a fee). Thus, among the main factors identified that determined the poor access to sM 1.1 are:

- Identifying the target group was a frequent problem among training providers. Although there was a database with them, at the time of the implementation of the projects, many people from the target group had already attended training courses within the Agricultural Directorates or at different professional training providers on the market (for a fee), so that, can respect the commitments within the contractual terms.

- Maintaining the target group in the project throughout the duration of the training sessions was another problem that influenced the way the projects were implemented, as there were no specific mechanisms in this regard.
- The length of the evaluation - selection - contracting period, which definitely influenced the identification of the target group.
- Non-compliance with the deadline for uploading documents according to the Applicant's Guide. Another element is represented by the non-uploading in the platform of any participant in the courses proposed by the project and none of the mandatory documents related to each participant in the courses.
- Training providers either had difficulty identifying the target group in the time available or had to terminate contracts due to low ability to identify the minimum target group provided for in the funding applications.
- Certain eligibility criteria for granting support could not be met by the vocational training providers who applied under calls 1 and 2. The lack of relevant experience of the applicants, the lack of qualified staff, led to a poor access to these funds for training.
- It was quite difficult to involve some educational institutions as partners in the project, and, implicitly, their staff. The low involvement of teaching staff is mainly due to the unattractive/low cost in terms of trainers' salaries, correlated with the trainer's offer to implement the project.
- Another criterion that created problems in project implementation refers to the principle of efficient and accelerated project implementation. To obtain a score of 10 points, some of the providers/beneficiaries committed to implement the project within a maximum of 75% of the maximum implementation time set for a project.
- The necessary (bulky) documentation that must be submitted to prove the qualification requirements, especially in the case of public educational institutions, which have submitted projects, either as a project leader or in partnership with other companies.
- The project audit is also a potential cause that contributed to the unattractiveness of this sub-measure.
- The lack of pre-financing was another cause that negatively affects the attractiveness of this sub-measure. The training providers had to, in the first phase, ensure the expenses generated by the identification of the target group, the payments regarding the rental of the rooms for the organization of the first training sessions and other expenses.
- Technical problems regarding the online platform (functional for projects that provide for the option of standard unit costs) led to poor access to the measure.

The impact of the use of non-reimbursable funds on human resources

The research followed the impact of the use of non-reimbursable funds allocated through the PNDR on human resources in the Oltenia Region in the current economic and social context. The main objective of the research was to identify the extent to which people from the South West Oltenia region participated in activities in the projects financed by PNDR (during the programming period 2014-2021), as well as the degree to which they managed to implement the knowledge and skills acquired to training programs or information activities.

The work tool used to collect the data necessary for the research was a prospective questionnaire placed in the field, distributed to 384 people aged 15-64 from the rural environment of the SV Oltenia region. 62.24% of them were male and 37.76% female. Among them, 173 have primary education, 139 people have secondary education, and 49 people have no education. Only 23 of those surveyed graduated from a university or college. From the point of view of occupation, the majority of respondents, 225 people, are farmers/farmers, at the opposite pole are unemployed or unemployed people. Among the people who benefited from professional training courses are self-employed (49) but also workers (53) or employees with higher education (32). Out of the total number of people surveyed, only 296 participated in the activities of the projects with non-reimbursable European funding, and only they were asked to continue answering the questions of the questionnaire. From the total of 296 people who stated that they participated in activities in projects with non-reimbursable funding, 158 people participated in HCOP projects, 114 in NRDP program projects and only 24 stated that they participated in the activities of other types of projects (Programs of cross-border cooperation in particular). Selecting only the questionnaires of the beneficiaries of the activities from the NRDP projects, we find that all 114 respondents participated in information activities within the projects, and 77.19% participated in various professional training programs. The training programs they took part in were refresher courses, in the areas of competence of the measures financed by NRDP. The usefulness of these training programs and other activities financed by the NRDP in which the beneficiaries participated will be reflected in the quality of human resources in the region, in the correct use of technologies, in the number of agricultural workers who access European funds. Beneficiaries who took part in the activities financed through the NRDP were useful to the extent that: 47% accessed further funds for the development or modernization of the farm or for agricultural crops, 10% used the certificates obtained at the workplace, and for 34% they were beneficial in the sense that they performed agricultural activities more correctly. However, about 9% of respondents said that they did not use the information for anything and that they attended the courses because they had some short-term advantages.

CONCLUSIONS

The economic situation of the South-West Oltenia region is one that requires quality human resources, trained from a professional point of view in accordance with agricultural specifics.

The declining population of the rural environment, high unemployment, low incomes and the rate of risk of poverty and social exclusion of the area according to the statistical analysis of the region, bring to the fore the need for investment in human resources, in the agricultural activities of the population of the region.

Thus, the NRDP represents a "breath of air" for the population of the region and especially for the rural population, providing financing both for the agricultural and zootechnical activities that the population carries out and for the training of human resources in the region.

The low degree of technology in the sector, the lack of professional training and the application of the latest technologies or a high degree of employment in subsistence agriculture, make the branch of agriculture, one with extremely low productivity, the 30.66% of people employed in agriculture in the region in 2021, contributing only 7.37% to the formation of VABR (Regional Gross Value Added). Human resource training can contribute to increasing labor productivity, to the use of new technologies in the activities carried out and to increasing the incomes of the rural population by accessing new jobs.

The rural population of South-West Oltenia accessed European funds through the Rural Development Operational Program for the training and development of human resources through specific measures. The impact of the use of these funds is a positive one, the funding leading mainly to the opportunity to access. further, European funds for the development and modernization of farms, for the purchase of machinery and agricultural equipment, for better productivity at work or for finding a new job.

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CONTRIBUTIONS TO THE LOCAL DEVELOPMENT STRATEGY OF THE MUNICIPALITY OF SNAGOV, ILFOV COUNTY, ROMANIA

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Abstract

A local development strategy allows the active coordination of the development process taking place in the territory, taking into account local characteristics, changes in the external environment and allowing a positive approach to territorial development in an innovative way. Local development strategies are characterized by at least seven characteristics recommended to local managers responsible for development: vision for the future, creativity, flexibility, activity, created for action, orientation to change and orientation to sustainable gain. The purpose of this paper is to highlight both the needs and requirements of the inhabitants of the Snagov commune, respectively the degree of satisfaction with the public services they benefit from, as well as the development vision of the Snagov commune. To obtain the information necessary for the study, the questionnaire method was used, and the group of people related to the sample filled in the requested data and expressed their opinions regarding public services, infrastructure, community projects. The key challenge is to ensure a balanced and sustainable development of the territory based on polycentric development, providing services to the surrounding rural areas, avoiding the decline of the rural population and ensuring the continued attractiveness of these areas.

Key words: *Snagov Commune, development, administration, economy*

INTRODUCTION

Snagov commune is located in the north of Ilfov county, about 40 km from Bucharest, Romania's capital, and almost the same distance from Ploiești City, Prahova County. On its territory, we find extensive areas of forests (remains of the Codris of Vlăsia), lake areas and agricultural lands.
Snagov commune (constituted in 1968 in its current form) is composed of the following villages: Ciofliceni; Ghermănești; Snagov (Dobroşeşti until 1938); Tâncăbești; Vlădiceasca. In 1988, the village of Vlădiceasca and part of the village of Ciofliceni were demolished. They were completely rebuilt after 1990. The villages of Ciofliceni, Ghermăneşti, Snagov and Vlădiceasca are located on the southern shore of Lake Snagov, and the village of Tâncăbeşti is located on the northern shore of the lake.
According to the data provided by the National Institute of Statistics, the population of Snagov commune on January 1, 2023, was 8,064 inhabitants.

Map. 1. Administrative Map of Snagov Commune
Source: Snagov Town Hall [14].

The share of the number of inhabitants in the villages, at the beginning of 2023, was as follows: Snagov - 2,122, Ghermăneşti - 2,962, Ciofliceni - 1,224, Vlădiceasca - 244, Tâncăbeşti - 1,512 (Figure 1). From the given situation it follows that the village of

Ghermăneşti has the largest number of inhabitants.

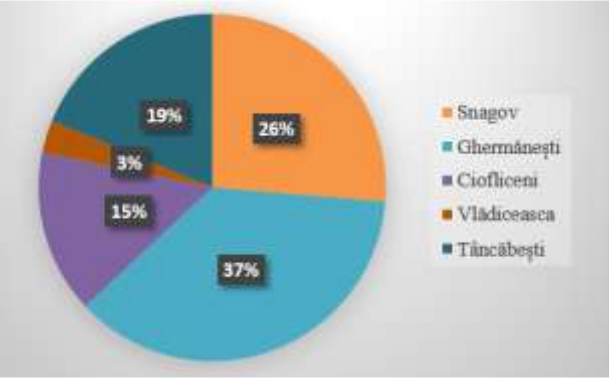

Fig. 1. The share of the population in the composition of villages
Source: NIS [10].

The local economy is supported by private commercial or production companies. In the commune's economy, tourism is a predominant activity, followed by agriculture, represented by the private property of individual peasant households or agricultural associations.

According to the data from the National Office of the Trade Register next to the Ilfov Court, in the Snagov commune, 803 economic agents have their headquarters.

An important place in the economy of the commune of Snagov is occupied by commercial companies from different economic sectors such as transport of people, transport of goods, industrial constructions, tourism (through the tourist reception structures in the commune), public catering and trade, car maintenance, etc.

The agricultural area of Snagov commune is 4,089 hectares, being used in general for the cultivation of cereals, plants producing oilseeds and fodder plants.

In Snagov commune, agriculture is generally focused on the cultivation of cereals - wheat, barley, corn, plants producing oilseeds - sunflower and rapeseed, and peas are cultivated from the leguminous category. Regarding the animal husbandry sector, there are small family pig, cattle and poultry farms in the locality.

The agricultural specificity of the commune offers tourists, first of all, the opportunity to get to know some cultural traditions of the commune of Snagov, to spend their vacation in an authentic rural environment, where they seek peace, fresh air and want to practice hiking, sports or other activities.

Tourist attractions such as churches and monasteries, forests, lakes and the hospitality of the villagers involve various social and age categories and provide the opportunity to visit historical monuments, museums or to participate in traditional celebrations or customs, practices related to the agricultural calendar or social events in the life of the community, contemplation nature. Among the elements of the local tourist heritage, we can mention the Lake Snagov Nature Reserve, the Snagov Forest, the Snagov Monastery (Vlad Ţepeş), and the Snagov Palace [13].

In this context, the purpose of the paper is to highlight the needs and requirements of the residents of the Snagov commune, as well as the degree of satisfaction with the public services they benefit from.

MATERIALS AND METHODS

Rigorously carried out sociological investigations can bring to light important aspects of social reality, allowing decision-makers and institutions to adopt suitable ameliorative strategies for the identified problems.

The present study is destined to a social survey interested in getting information and making an analysis about what needs and requirements have the residents of the Snagov commune regarding the public services and also their satisfaction degree [2].

In order to obtain the information necessary for the study, it was used a field survey based on the questionnaire method. This is a method or technique often used in descriptive research. Through the questionnaire, the selected group of people (called the sample) filled in the requested data and expressed their opinions regarding public services, infrastructure, and community projects [8], [9].

The questionnaire is a technique and at the same time an investigative tool that consists of a set of written questions, logically and psychologically ordered, which, through the administration of the investigation operators, determine answers from the investigated to be recorded in writing [2].

In the case of our research, the indirect survey through the questionnaire was used, considering the advantages of this opinion polling tool, namely the opportunity offered to the subjects to think enough before answering, the elimination of the disturbing influence of the survey operator, the elimination of mistakes recording and interpretation of data etc.

In creating the questionnaire, we had in mind the creation of factual questions, as well as opinion questions that usually probe the inner universe of the individual, more precisely the opinions of individuals and the subjective evaluations regarding the studied topic.

We built closed questions, starting from the premise that they ensure greater rigour and solid validity of the research instrument, but also open questions with short answers. In formulating the closed questions, the criterion of completeness was taken into account, i.e. the possibility offered to each respondent to find a satisfactory answer for himself, from those proposed, the necessity of classifying the answer variants into distinct categories and the possibility of providing univocal answers [12].

The formulated questions are: introductory, passing and with a moderate degree of abstraction. In making them up, I tried not to make them too demanding or boring. Through the form and content of the formulated questions, through the language used, we wanted these investigative tools to be easy to understand and complete.

When checking the questionnaires, I mainly looked at three aspects: their completeness, accuracy and uniformity. Completeness refers to the fact that each question must receive an answer, and in the case of non-answers, their cause must be analyzed. In the case of the present research, we only faced this problem to a small extent, considering the fact that some of the questions were closed [12].

As a rule, closed questions make completing and analyzing the questionnaire easier. But, open questions have the advantage that they make available to those who propose to research a certain phenomenon, a multitude of alternative answers that give an overview of the studied phenomenon.

The received responses from the questioned interviewees have been statistically processed and the results were interpreted.

RESULTS AND DISCUSSIONS

The sociological survey was conducted on a sample of 812 respondents, which represents approximately 10% of the population of Snagov commune. The residents of the commune of Snagov, who participated in the investigation, highlighted the most important problems of the commune.

During the investigation, the citizens were questioned about their level of satisfaction with some aspects of the commune. Regarding the road infrastructure in Snagov commune, a percentage of 63% declared themselves satisfied and very satisfied. Residents expressed their dissatisfaction with a percentage of 37% (Fig. 2).

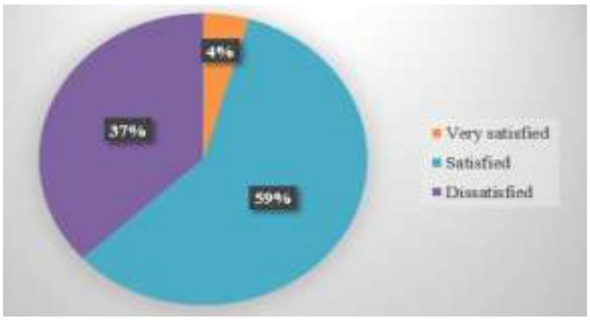

Fig. 2. The public opinion regarding the road infrastructure in Snagov commune
Source: own contribution.

The respondents were also asked to appreciate the aspects related to the state of the utilities in Snagov commune. The inhabitants of the commune expressed their dissatisfaction with the state of the utilities, in a percentage of 60%, while 40% of the respondents are satisfied and very satisfied (Fig. 3).

The technical condition and degree of coverage of the natural gas network, as well as the technical condition and degree of coverage of the electricity and street lighting network, are satisfactory for all the citizens of the commune.

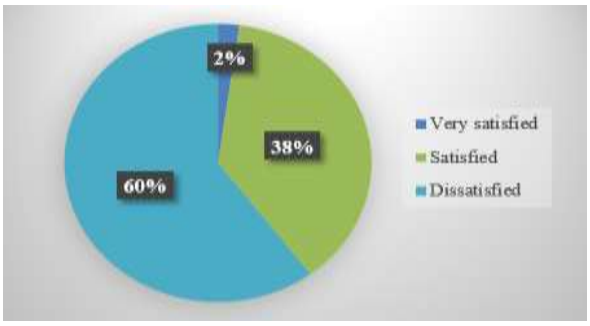

Fig. 3. The public opinion regarding the state of utilities in Snagov commune
Source: own contribution.

Citizens' dissatisfaction concerning the state of utilities comes from the low level of coverage of the sewage network, as well as because of the state of the water supply network.

Questioned about the provision of medical services in the Snagov commune, 53% of the respondents declared that they were satisfied and very satisfied, while 47% of the respondents claimed that they were dissatisfied with the level of provision of medical services at the level of the commune (Fig. 4).

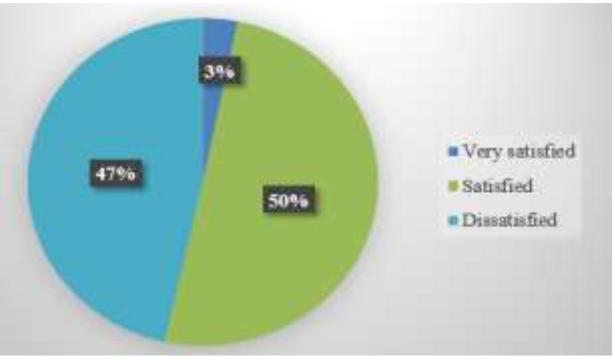

Fig. 4. The public opinion regarding the adequacy of medical services in Snagov commune
Source: own contribution.

In the survey, respondents were asked to express their level of satisfaction with the educational services provided in Snagov commune. To this question, 52% of respondents claim that they are satisfied and very satisfied with the degree of provision of educational services in Snagov commune, while 48% of respondents expressed their dissatisfaction with the degree of provision of educational services (Fig. 5).

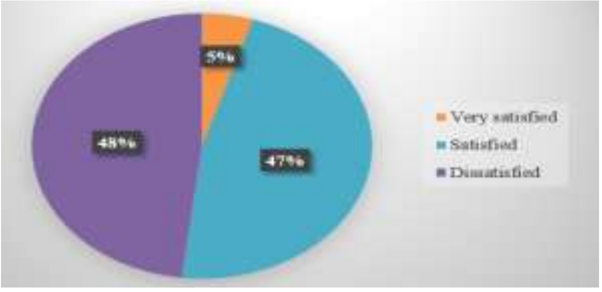

Fig. 5. The public opinion regarding the adequacy of education services in Snagov commune
Source: own contribution.

When asked about the degree of provision of public transport services in Snagov commune, a percentage of 69% of respondents showed that they were satisfied and very satisfied, while 31% of respondents declared themselves dissatisfied with the degree of provision of transport services (Fig. 6).

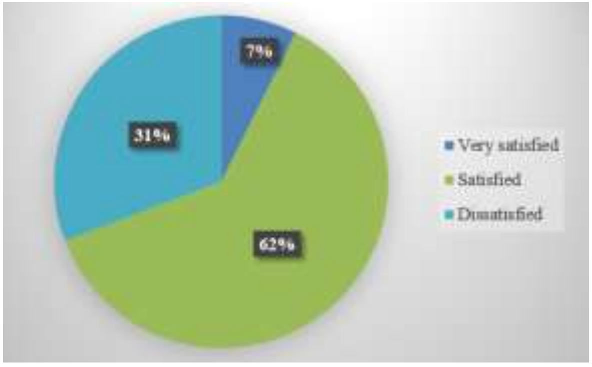

Fig. 6. The public opinion regarding on the adequacy of public transportation services in Snagov commune
Source: own contribution.

Asked about the opportunities offered by the commune of Snagov, from an economic point of view, 72% of the respondents are dissatisfied since the chances of finding a job in the commune are very small.

Also, in terms of attracting young people to the Snagov commune, 80% of the respondents claim that the Snagov locality is not of interest to young people.

Asked about the most important fields that they believe should be encouraged in Snagov commune, the respondents stated that the main field on which attention should be focused is tourism, this being expressed by 72% of the respondents (Fig. 7).

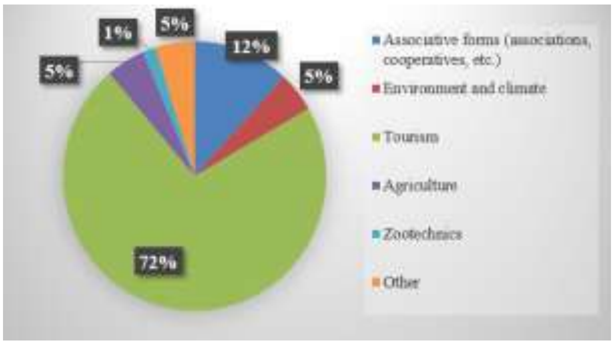

Fig. 7. The public opinion regarding the economic activities that should be encouraged in Snagov commune
Source: own contribution.

A percentage of 12% believe that associative forms (associations, cooperatives) should be encouraged, 5% believe that activities related to the environment and climate require attention, 5% support that agricultural activities should be encouraged, while 1% support activities in the sector of animal husbandry (Fig.7).

When asked about the projects that should be solved urgently in the Snagov commune, 24% of respondents claim that the most important project for the community is the connection of households to utilities, followed by the repair/equipment of educational institutions, this being desired by 23 % of respondents. A percentage of 16% of the people who answered the questionnaire claim that attracting entrepreneurs is important for the commune of Snagov, and 10% of respondents claim that attracting tourists is important for the commune. The other proposed options did not show a great interest among the respondents (Fig. 8).

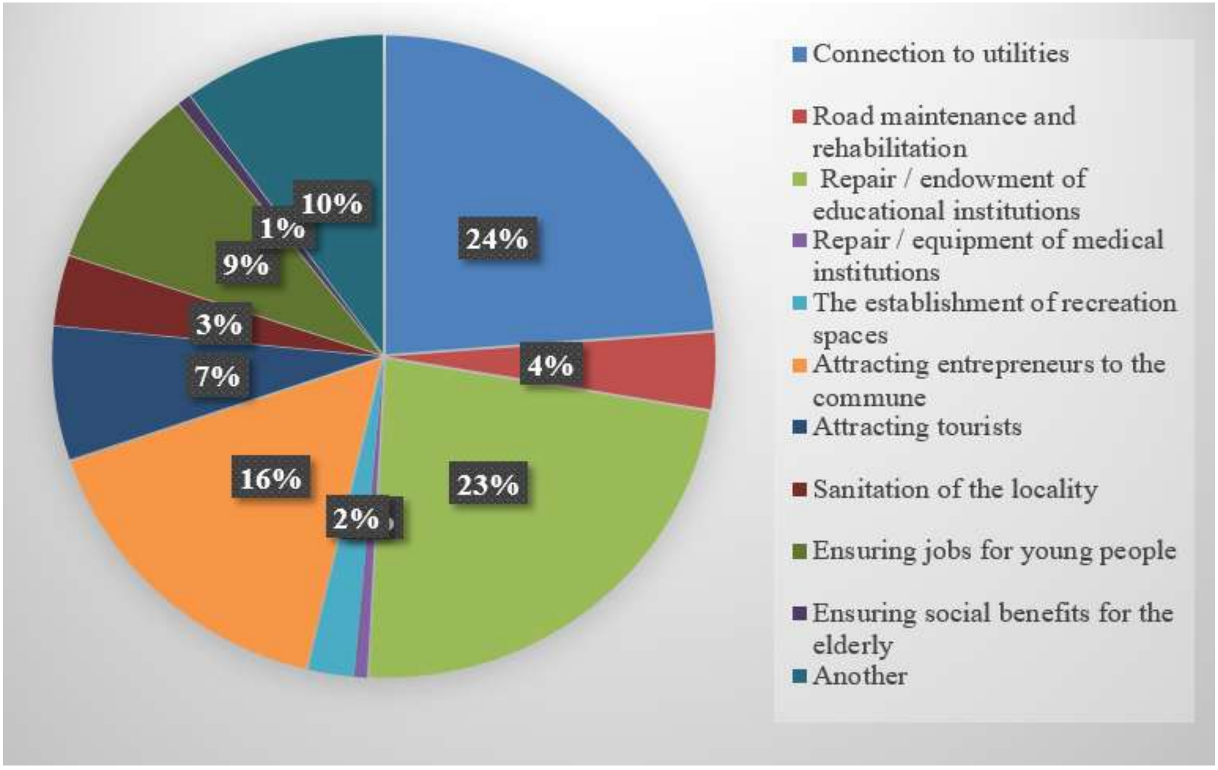

Fig. 8. The residents' opinion on the projects that should be urgently addressed
Source: own contribution.

Regarding the development of the Snagov commune, the respondents were asked to specify a project that would have a positive impact on the citizens. They largely proposed projects for the development of tourism in the locality, the reconstruction of the "Mihail Kogălniceanu" High School, the rehabilitation of schools and the construction of kindergartens with extended hours, the development of utility networks, greening measures, the development of medical infrastructure and the attraction of entrepreneurs to diversify the job market in the commune.

To this question, a percentage of 28% of the respondents proposed tourism development projects in the locality. Among the projects proposed by the citizens, there can be mentioned: the development of promenade spaces on the shore of Lake Snagov, circuits with steamboats on Lake Snagov, tourist routes for cyclists through the Snagov Forest, the rehabilitation of the railway that runs through the Snagov Forest and the creation of tourist circuits by train, the development of parks and recreation spaces.

A percentage of 26% of the respondents proposed projects for the development of the educational infrastructure in Snagov commune. Among them, 21% want the reconstruction of the "Mihail Kogălniceanu" High School, which entered into a rehabilitation process at the beginning of 2015 and was left in disrepair due to project management-related problems. The other 5% propose the modernization of the educational institutions in the commune and the construction of kindergartens with an extended program and nurseries.

Among the respondents to this question, 25% support the utility network development projects in the Snagov commune. The main dissatisfaction of the inhabitants comes from the poor functioning of the drinking water network, and the non-existence of the sewage network in the villages of Ciofliceni, Vlădiceasca and Tâncăbeşti.

A percentage of 8% of the respondents proposed projects to green the area. Among these, we can highlight the selective collection of waste, the sanitation of the forest and the Snagov Lake, and the tightening of sanctions for residents who deposit household waste in the surroundings of these two ecosystems.

Another percentage of 8% of the respondents support the projects related to attracting entrepreneurs and investors to the Snagov commune, to diversify the labour market at the local level. Along with attracting entrepreneurs, citizens can benefit from stable jobs in the commune, and the degree of attraction of young people would be higher.

Analyzing the results of the questionnaire, we notice that a percentage of 5% of the respondents support projects to modernize the medical units in the commune and propose the establishment of a medical clinic to benefit from specialized medical consultations in several fields, medical tests and other medical operations near the home which currently cannot be achieved together.

The local development strategy of the commune of Snagov is an approach that considers the mutations that have appeared permanently in the local horizon and at the level of the regional area in which it falls, spatially and functionally, at the national and European level. The strategy proposes a balanced, integrated approach, which is based both on increasing the quality of life in a stimulating, prosperous and balanced framework for all residents, as well as on increasing the economic competitiveness of the locality by referring to the relationship with the Municipality of Bucharest [5], [7].

The development vision of the Snagov commune is based on the principles and guidelines promoted by the European Union within its policies and strategies, in the context of the globalization of the knowledge-based economy and society (Fig. 9). The vision is based on the main distinctive competencies of the locality and aims to capitalize on them to ensure sustainable development of the commune by attracting entrepreneurs to develop new economic activities based on innovation, promoting quality public services and improving mobility [3], [4].

Fig. 9. The pillars of development for Snagov commune
Source: own contribution.

With the aim of fulfilling the vision of local development, the local administration of Snagov commune will focus on achieving the following strategic objectives:

OS1. Snagov commune - competitiveness through entrepreneurship and innovation

The local economy, being based to a large extent on trade activities, must be encouraged in development directions whose integrated effect brings well-being, mainly to the inhabitants. In order to increase the competitiveness of the local economy in the long term, it is necessary to build a strong economy by maximizing the workforce and local potential [1].

This particular objective has been categorized into three main priorities:

1.1. Attracting investors and capital so as to develop the business environment

The current priority aims to define the profile of the Snagov town as an investment point, as well as to identify the instruments for attracting investors from the key sectors of the economy. Also, this priority aims to attract well-trained human resources to support the local economy.

1.2. Creating an attractive, competitive and innovative socio-economic environment

This priority aims to support the local environment by organizing events and communication platforms that support the establishment of partnerships, promoting products related to the cultural identity of the locality, as well as the creation of support infrastructure for entrepreneurs in creative industries.

1.3. Supporting the development of human resources

This priority is a result of the intensification of competition at the national and international levels regarding the efficient administration of human resources. Investments are needed in the development of human resources so as to improve the training and professional development system that can quickly adapt to the dynamics of the labour market.

OS2. Snagov commune - cultural identity

Cultural heritage represents a grouping of resources inherited from their ancestors, which people identify and consider as a reflection and expression of their values, knowledge, beliefs and traditions. Cultural heritage includes all aspects of the environment, as a result of the interaction between people and places over time.

The history of each locality is unique and represents an irreplaceable quality that makes a vital contribution to the quality of life of each resident. Historic areas define local history, generate income from tourism activities and add distinctive local character to our sense of place and belonging [7].

The proposed objective comprises of two distinct priorities that have been structured accordingly:

2.1. Tourism capitalized and promoted through attractive activities and high-quality services in Snagov commune

Tourism represents a branch of the national economy, with complex functions, which brings together a set of goods and services offered for consumption to people who travel outside their usual environment for less than one year and whose main reason is other than exercising an activity remunerated within the visited place. The commune of Snagov has a remarkable tourist potential, linked to its location on the site of the Vlăsia woods and surrounded by the remaining forests, as well as the presence of the Snagov Lake and the Orthodox monasteries together with their museums. A special attraction is the possibility of practising fishing, water sports, hunting and access to cultural heritage values [15].

2.2. Integration and valorization of heritage objectives in the local circuit through public spaces and representative leisure areas

Within the commune of Snagov, the existence of heritage buildings of particular value can be noted, represented by the Monastic Ensemble on the island of the Snagov monastery, the Constantin Băicoianu School in the village of Tâncăbeşti, as well as the churches of the commune that have a special architecture. The preservation and valorization of cultural resources, represented by immovable heritage (archaeological and architectural ensembles, monuments, sites), movable heritage (archives, museums, collections), intangible heritage (traditions, crafts, customs) and cultural landscapes, constitute an important strategic direction of development at the level of the Snagov commune, but also of the Ilfov county, emphasizing the importance of using the cultural heritage in a sustainable and balanced way.

OS3. Snagov Commune – Planned territorial development and sustainable mobility

Mobility has a significant impact on the functioning of cities. For example, citizens tend to use personal cars as their primary means of transportation, leading to high motorization rates and traffic jams. Motorized traffic is associated with significant emissions of noise and other pollutants, including greenhouse gases, and high costs associated with time, fuel and deterioration of public health. To minimize the external effects of transport system performance, the influence of motorized vehicles in urban mobility should be reduced [11].

The previously stated aim is organized into three primary areas of focus:

3.1. Transport infrastructure adapted for non-motorised or low-CO2 journeys

An alternative, coherent and well-structured transport system is essential for the economic and social viability of the county. These considerations, as well as a reasonable structure and a well-designed network of bicycle paths and sidewalks, can promote the choice of transport methods that are not conducive to the use of personal cars, thereby reducing emissions of toxic and greenhouse gases, and thus have a positive impact on the quality of the environment, and associated with other forms of transport, can improve the mobility of residents, road traffic safety and the safety of cyclists and pedestrians.

Like most localities in Romania, the commune of Snagov has not yet fully adapted to the new urban traffic trends, which prioritize trips with vehicles without a motor or with low CO2 emissions.

Therefore, the specific objective dedicated to travel with vehicles without a motor or with low CO2 emissions includes projects designed to encourage walking and cycling.

3.2. Efficient and attractive public transport system that provides balanced services for the residents and business environment of Snagov municipality

In contemporary society, public transport services must be analyzed from all aspects of daily life and the normal flow of the population, because the flow of the population is not limited to the family-service-housing relationship and is closely related to society, economy and culture. To deal with these difficulties, the objective is mainly to develop a public transport system according to the Sustainable Urban Mobility Plan of the Bucharest - Ilfov Region, as well as to modernize the stations and increase the frequency of public transport for passengers [11].

3.3. Planned territorial development

Planned territorial development supports local economic development and is one of the main pillars underlying a sustainable economy. Transport planning and land use must be studied comprehensively along with their interaction. The impact determined by the interaction between the two factors may be different from the impact expected by treating the two subjects separately. The results obtained depend on the size, density and structure of the territory, as well as on the characteristics of the transport system. Land use regulation, in terms of its potential to affect average journey times, can also be seen as a factor in determining the level of energy consumption in a region [11].

OS4. Snagov Commune – High-performance and high-quality public services

The structure of this objective revolves around four main priorities:

4.1. Diverse and effective social assistance services to meet the needs of all types of persons

Local policies in the field of social assistance aim to adopt a series of measures for the effective management of the fight against social exclusion and the promotion of social inclusion in building a coherent system, aimed at the permanent improvement of various measures of financial support for families, children and persons in the categories of risk, as well as strengthening and developing the network of social services.

The purpose of this priority is to promote social inclusion by diversifying social facilities and services and through programs that integrate people with difficulties in the labour market and society

4.2. Invest in education, skills and lifelong learning

A performing and effective education system requires an appropriate combination of highly qualified and well-trained staff, sufficient educational resources and facilities, and pupils and students willing to learn.

This priority aims to invest in education and training, including vocational training for the acquisition of competencies and skills, as well as lifelong learning, through the development of education and training infrastructure [7].

It also aims to support the establishment of new educational units, offering investors the land needed to develop the educational infrastructure or through public-private partnerships.

4.3. High-performing public health services at the level of Snagov commune

For the medical act to be carried out successfully, the priority element is represented by the modernization and appropriate equipment of the medical units. Therefore, this priority aims to develop the medical infrastructure and public health services in Snagov commune, so that citizens can benefit from high-quality medical services, at European standards.

4.4. High-performance public utility services that meet people's needs

Public utility services are the responsibility of the local public administration authorities, they are established, organized and managed according to the degree of urbanization, the economic and social importance of the locality and the decisions adopted by the deliberative bodies of the administrative region. The degree of development of the public service system indicates the standard of living of the citizens, so it is necessary to accelerate the modernization process to comply with European standards. This priority aims at the modernization and expansion of the technical-building network to ensure the access of the entire locality to high-quality basic public utility services [7].

OS5. Snagov Commune – Integration into nature

Two key priorities form the structure of this objective:

5.1. Integrated waste collection and management system at the commune level

Due to the significant benefits for environmental quality and human health, ensuring a sustainable waste management system is an absolute priority. If the structure is reasonable and effectively implemented, it will have an effective sanitation effect on the commune and the rational use of household waste and absorbed household waste. An important element pursued by waste management in Snagov commune is the separation of waste directly at the source, the reduction of the amount of non-renewable waste and its proper storage [4].

5.2. Improving the quality of environmental factors - air, water, and soil by reducing pollution and its impact

The combined effect of population growth and urbanization has put tremendous pressure on resources and the environment. Citizens' value system and expectations for quality of life indicate that people's intolerance of harsh environmental conditions has increased; they tend to show increased expectations regarding the activities of the local public administration, rather than changes in personal behaviour [4].

The purpose of this priority is to improve the quality of environmental factors by reducing pollution and pollution sources in the administrative area. Therefore, a series of measures are proposed to monitor and evaluate environmental factors, improve water quality, reduce air pollution, and educate people about environmental protection measures.

OS6 – Snagov Commune – Performance in local public administration

High administrative capacity

In the coming years, one of the main factors that the Snagov commune will rely on for competitive differentiation at the county level will be the quality of local government actions and the ability to build partnerships and collaborations with local participants, citizens and civil society to ensure political strategy, general planning and coordinated development [6].

The work in this direction aims to rationalize the administrative structure in order to improve the absorption capacity of European funds and to improve the quality and attractiveness of the services provided to citizens and the business environment at the local, county and regional levels.

The development of Snagov commune aims to follow the development trend of modern cities, gradually adopting new technologies and developing innovative measures in their functions. In other words, it aims to be defined by the "Smart City" concept.

The concept of a smart city has emerged recently and involves the provision of services based on ICT technologies that are incorporated into the functions of the entire city and the active participation of the community in solving local problems. The approach of the local public administration regarding this concept is to assume the intention that the project will be implemented at the local level, and the principles and models established by the smart city concept will be gradually adopted in the local development measures.

Similar case studies regarding the sustainable development in the rural areas at the local level in important communes were made by [8, 9].

CONCLUSIONS

The development strategy of the municipality of Snagov is a guiding document that must go through a process of continuous reassessment and optimization of the development options of the municipality to adapt to the evolution of economic and social realities.

The implementation of development strategies fundamentally depends on the ability of the local government body to attract community and/or private funds to finance the selected actions and to manage the local budget funds wisely. To implement this strategy, local public authorities need to strengthen the management and execution capacities of institutions at all levels.

Due to the long implementation process, the local administration must adopt clear working procedures in all functional departments, paying special attention to the structure responsible for implementing the strategy.

The following work analyzes the results of the questionnaire that was given to the citizens of Snagov commune, which aimed to gather the opinion of the population about certain projects, the degree of satisfaction with local public services, but also it sought to involve the citizens in proposing new projects for the community. Regarding the development of the Snagov commune, the respondents were asked to suggest a project that would have a positive impact on the citizens. They largely proposed projects for the development of tourism in the locality, the reconstruction of the "Mihail Kogălniceanu" High School, the rehabilitation of schools and the construction of kindergartens with extended hours, the development of utility networks, greening measures, the development of medical infrastructure and the attraction of entrepreneurs to diversify the job market in the commune.

The key challenge is ensuring a well-balanced and sustainable evolution in the territory through the adoption of a polycentric development strategy, avoiding the decline of the rural population, providing services to the surrounding rural areas, and maintaining their ongoing attractiveness.

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QUALITY ANALYSIS OF PRACTICAL TRAINING IN VOCATIONAL AND TECHNICAL EDUCATION. CASE STUDY: ILFOV COUNTY, ROMANIA, ACADEMIC YEAR 2022-2023

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Abstract

In an environment characterized by change and diversity in the labour market, vocational and technical education is undergoing a significant transformation. Vocational and technical educational institutions are obligated to adopt approaches that align with reality when faced with challenges in a social environment where employment opportunities and the demand for specialized workforce are diversified. This article presents the results of a qualitative research conducted at the pre-university education level in Ilfov County, based on the questionnaire that was administered to 502 students enrolled in educational institutions in Ilfov County, at the following specializations: Tourism and public food, Economics, Environmental Protection, Agriculture, Mechanics, Electronics and Automation, Construction, Installations, and Public Works. The purpose of this research was to understand how educational institutions, affected by industry regulations, adapt to the requirements of the labour market and the needs of direct beneficiaries. The present research utilized an indirect survey through a questionnaire, as the advantages of this opinion-sampling tool include allowing subjects to think thoroughly before responding, reducing the disruptive influence of the surveyor, and minimizing errors in data recording and interpretation. The questionnaire was addressed to students in vocational and technical education with the aim of determining to what extent the respondents are satisfied with the practical training courses completed in the 2022-2023 school year. Conclusions were drawn from the answers recorded on the entire sample which can later be translated into measures to improve the quality of internships.

Key words: *education, practice, traineeship*

INTRODUCTION

Traineeship is the activity carried out by students following the curriculum plan, aiming to verify the practical applicability of the theoretical knowledge acquired within the framework of supervised practical training. Traineeship forms the foundation of a young person's future career, and in its absence, the beginning of a career is fraught with numerous obstacles and difficulties [2], [10].

The traineeship period represents a stage of improvement or acquisition of practical knowledge that a student undergoes in a factory, company, institution, etc. Through traineeships, students acquire the skills and abilities necessary for integration into the labour market, providing an extra chance for employment, as the practical training hours serve to apply the theoretical knowledge accumulated during the school [4].

Traineeships prepare students attitudinally, aptitudinally, and emotionally to start their professional activity. Thus, the development of a set of knowledge, skills, and attitudes that allow for the full development of each individual's personality, social integration, and entry into the labour market is considered the way education responds to contemporary challenges [5], [14]. On the other hand, traineeships provide a space for exploring the practitioner's abilities and possibilities. In this way, the student identifies their strengths as well as areas that require more attention, obtaining a much more accurate self-image. All this information provided by practical experience contributes to the consolidation of a strong sense of self-esteem [12], [15].

In this context, the purpose of this paper is to analyze the quality level of practical training courses held in pre-university education, from the perspective of the direct beneficiary - the student.

MATERIALS AND METHODS

The practical training stages related to the specializations subject to the present research vary depending on the form of education, specialization, and class, as follows:

1. ***High school education, technological profile***, four-year study duration: In the lower cycle of high school (9th and 10th grade), practical training extends over a period of 3 weeks, totalling 90 hours. In the upper cycle of high school, in the 11th grade, the duration of practical training stages can vary depending on the specialization, ranging between a period of 4 weeks, totalling 120 hours, or 5 weeks, totaling 150 hours. In the 12th grade, practical training stages span over 5 weeks, totaling 150 hours [6], [7].
2. ***Vocational education and dual-system vocational school***, three-year study duration: In this form of education, we encounter weekly practical training and consolidated practical training stages. In the 9th grade, weekly practical training is 3 hours per week, and consolidated practical training stages span over five weeks, totaling 150 hours of practical preparation. In the 10th grade, weekly practical training is 12 hours per week, and consolidated practical training stages have a duration of 9 weeks, totaling 270 hours. In the 11th grade, there are 12 hours of weekly practical training, and consolidated practical training stages extend over a period of 10 weeks, totaling 300 hours [8]. Within Ilfov County, technological high schools offer various specializations such as Tourism and public food; Commerce; Economics; Environmental protection; Agriculture; Forestry; Mechanics; Electronics and automation; Healthcare; Wood product manufacturing; Aesthetics and hygiene of the human body; Textile and leather industry; Construction and public works. A particular case is represented by "Mihail Kogălniceanu" Theoretical High School in Snagov, where both technological high school education and dual-system vocational school are provided, making it the only theoretical high school that offers technological education.

To obtain the necessary research information, the questionnaire method was utilized. This method is often used in descriptive research. The research questionnaire is a technique and, accordingly, an investigative tool consisting of a set of logically and psychologically ordered written questions and possibly graphic images. Administered by survey operators or self-administered, it elicits responses from the respondents that are to be recorded in writing. It is noteworthy that the validity of the questionnaire survey method depends largely on factors such as the clarity of question formulation or phrasing, the proposed research sample, and its representativeness. When properly designed, questionnaires prove to be an efficient method of collecting a large amount of information about people's attitudes, beliefs, and behaviours, often accompanied by the use of other research techniques [13], [9].

In terms of how responses can be formulated, questions included in a questionnaire can be grouped into several categories [1], [3], [11]:

a) *Open-ended questions:* These are questions to which respondents can answer using their own words. They are often used in the exploratory stage of the survey, aiming to identify and describe a complete range of situations, behaviours, attitudes, etc., rather than determining their frequency (responses to these questions are often impossible or very difficult to code).

b) *Closed-ended questions*: These are questions that can only be answered with predetermined options and can be classified as dichotomous, multiple-choice, semantic, or hierarchically structured.

c) *Control questions:* These questions serve to verify whether the responses to other questions are correct or not, whether they are well-founded, or if they result from insufficient information.

d) *Filter questions:* These are questions depending on the received answers, and which are used either to eliminate subjects who are not of interest from the survey or to remove unnecessary questions from the questionnaire.

In creating the questionnaire, there were used both factual and opinion-based questions, which typically delve into an individual's inner thoughts, specifically opinions and subjective evaluations regarding the studied subject. Closed-ended questions were destined to maintain the rigour and validity of the research. Open-ended questions with short answers have been the criterion of completeness, referring to each participant's ability to choose a satisfactory response. The questions were introductory, transitional, and moderately abstract, aiming to avoid being overly demanding or tedious. The form and content of the questions, and the used language were investigation tools easily understandable and completed by the participants.

RESULTS AND DISCUSSIONS

This research aimed to assess the satisfaction of respondents with the practical training stages undertaken during the academic year 2022-2023.

Through the questionnaire, students provided the requested data and expressed their opinions regarding the conditions of practical activities, the fulfilment of organizational aspects, the competencies gained through participation in practical training stages, and suggestions regarding evaluation methods.

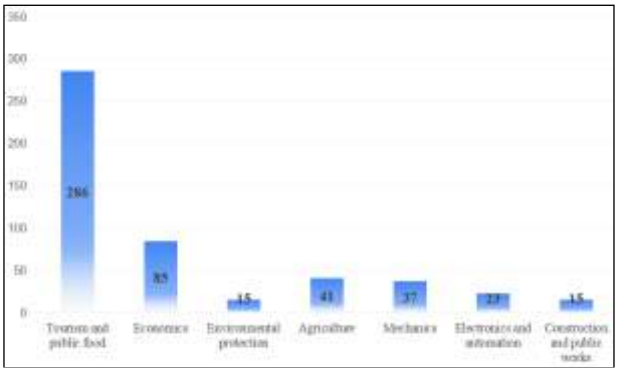

Fig. 1. Distribution of the respondents based on the enrolled specialization
Source: Own contribution.

Table 1. Respondent distribution based on enrolled specialization

Educational Unit	Profile	No. of valid answers
Theoretical High School "Mihail Kogălniceanu", Snagov, Ilfov	Tourism and public food	91
Technical High School "Vintilă Brătianu", Dragomirești-Vale, Ilfov	Economics	6
	Environmental protection	15
	Agriculture	22
Technical High School "Nicoale Bălcescu", Voluntari, Ilfov	Tourism and public food	12
	Economics	12
Technical High School "Barbu Știrbey", Buftea, Ilfov	Tourism and public food	72
	Economics	44
Technical High School "Pamfil Șeicaru", Ciorogârla, Ilfov	Tourism and public food	15
	Economics	12
	Mechanics	16
	Electronics and automation	11
Technical High School "Doamna Chiajna", Roșu, Chiajna, Ilfov	Tourism and public food	59
	Electronics and automation	12
Technical High School "Cezar Nicolau", Brănești, Ilfov	Tourism and public food	37
	Economics	11
	Mechanics	21
	Construction, installations, and public works	15
	Agriculture	19
Total respondents		**502**

Source: Own contribution.

Section A. In the first section of the questionnaire (questions 1 to 4), dichotomous and semi-open questions were employed, where students provided information regarding:

1. Age category (14 - 16 years; 17 - 19 years; 20 - 26 years)

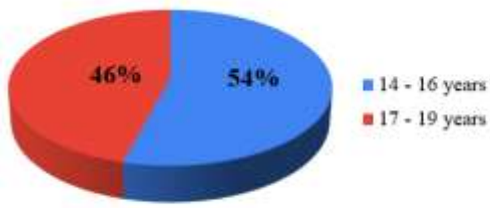

Fig. 2. Distribution of respondents by age groups
Source: Own contribution.

2. Grade level (9th grade; 10th grade; 11th grade; 12th grade)

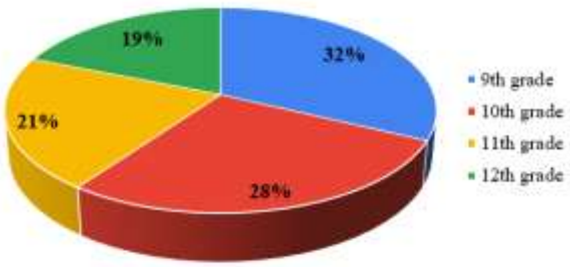

Fig. 3. Distribution of respondents by enrolled grade
Source: Own contribution.

3. Origin environment (rural/urban)

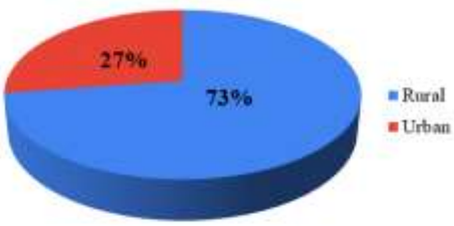

Fig. 4. Distribution of Respondents by Origin Environment
Source: Own contribution.

4. The specialization in which they are enrolled

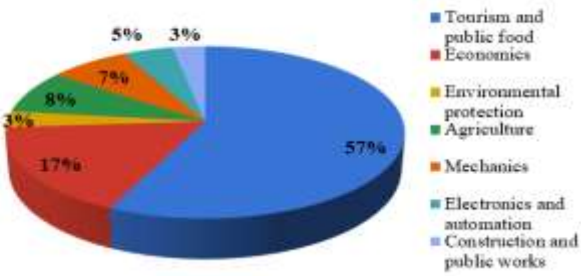

Fig. 5. Distribution of respondents by enrolled specialization
Source: Own contribution.

Section B. In the second section of the questionnaire (questions 5 to 15), questions from the category of ranked response questions were formulated, requiring respondents to specify the order of priority given to the provided response options. In some classifications, questions aiming to capture attitudes, beliefs, and expectations of subjects are also included in this category, but we consider this scope to be too broad. The quality characteristics of practical training stages were operationalized into several variables, each described by a series of questionnaire items. For each item, formulated as a statement, we asked each respondent to express their level of satisfaction on a scale with the following response options: (1) - totally unsatisfactory, (2) - unsatisfactory, (3) - average, (4) - good, and (5) - very good. To each response on this scale, we assigned a corresponding value (the numbers in parentheses). This coding corresponds to the logic that a higher agreement for the respective item indicates agreement or a closer alignment with the overall characteristic being pursued. In the following, we analyze each variable in accordance with the students' responses to questions and, based on these, the averages obtained.

5. Conditions of the Practical Training Activities:

a) working conditions (space, atmosphere, etc.)

b) to what extent was the equipment provided by the business operator suitable for carrying out practical training activities?

c) evaluate the level of guidance provided by the mentor appointed by the hosting company.

d) evaluate the level of intercollegiate collaboration during the practical training activities.

The conditions of the activities represent a variable constructed based on four items that refer to working conditions, the provided equipment, the guidance given by the mentor, and intercollegiate collaboration.

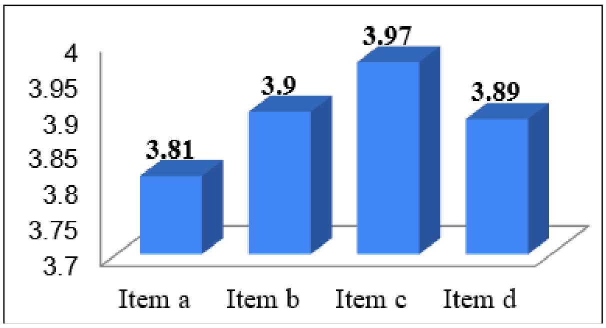

Fig. 6. The conditions for carrying out practical training activities
Source: Own contribution.

Figure 6 shows the variable *conditions of conducting activities* records the highest average satisfaction concerning the level of guidance provided by the mentor, while the lowest level of satisfaction is noted for working conditions (space and atmosphere).

6. The fulfilment of organizational aspects:

(a). the traineeship period and daily schedule
(b). the partners' activities met the students' expectations
(c). the partners' activities did not create problems in the program's implementation.

The fulfilment of organizational aspects is a variable based on three items constructed to reflect the importance of the traineeship dimension and daily schedule, as well as the integration of practising students into the daily activities of the practice partner operators.

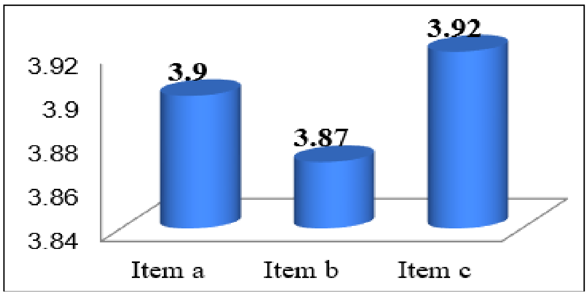

Fig. 7. The fulfilment of organizational aspects
Source: Own contribution.

From the data presented in Figure 7, it can be observed that the partners' activities did not create problems in the implementation of the practical training stages, with this item obtaining the highest satisfaction average. Meanwhile, the item related to participants' expectations recorded the lowest satisfaction level.

7. Business operators met students' expectations regarding:

(a). availability
(b). cooperation
(c).encouraging active participation in practice
(d).flexibility/diversity of the proposed program
(e). creating a suitable environment
(f). communicativeness
(g). adequate logistics.

Students' satisfaction with collaboration with business operators is a variable constructed based on seven items referring to availability, cooperation, encouragement, flexibility of the program, environment, communicativeness, and logistics.

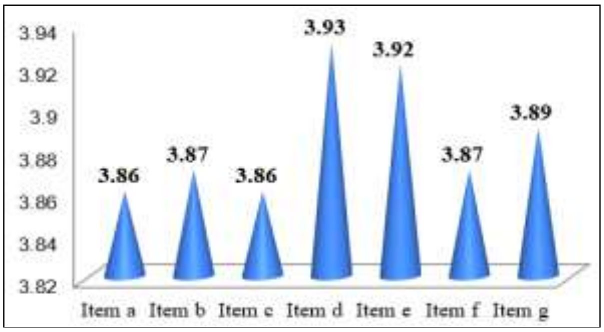

Fig. 8. Students' Satisfaction with Business Operators' Performance
Source: Own contribution.

Analyzing the data presented in Figure 8, we observe that students' maximum satisfaction was recorded for the flexibility/diversity of the program, while the minimum satisfaction level was represented by the encouragement of active participation in practice.

8. To what extent does the students' traineeship contribute to:

a. developing practical skills
b. developing teamwork skills
c. applying practical knowledge acquired
d. increasing responsibility towards assigned tasks
e.employability in the job market as a graduate

The contribution to the development of students' skills and work capacities is a variable that has been analyzed from the perspective of five items constructed based on the development of practical skills and teamwork skills, the practical application of theoretical knowledge, the increase in responsibility for practitioners, and their integration into the job market.

Fig. 9. Contribution of traineeships to the development of skills and work capacities
Source: Own contribution.

From the data presented in Figure 9, it can be observed that the majority of respondents consider that traineeships contribute to an increase in responsibility towards assigned tasks, while a smaller number of respondents believe that they are less important for the development of practical skills.

9. To what extent do you believe that the training of students before the traineeship should include:

a. a career counselling and guidance module

b.basic elements of organizational communication, teamwork

c. specialized training in the field of activity of the company/institution

d. information about the organizational and decision-making structure of a company/institution

e. concepts related to organizational culture and corporate social responsibility

Another studied variable is the importance of theoretical preparation before traineeships, which was constructed based on five items that draw respondents' attention to career counselling and guidance, elements of organizational communication, training in the field of activity of the business operator, receiving information about its organizational and decision-making structure, as well as concepts related to organizational culture.

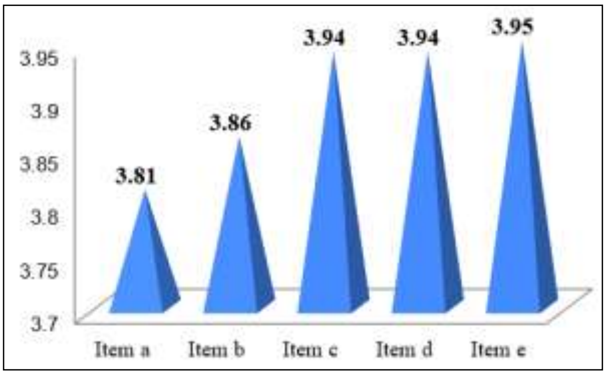

Fig. 10. The importance of theoretical preparation before traineeships
Source: Own contribution.

Analyzing the information presented in Figure 10, we observe that the majority of respondents consider knowing concepts related to organizational culture and corporate social responsibility to be important.

10. To what extent do you consider the following methods appropriate for evaluating the traineeship period?

a. ongoing evaluation by the practice supervisor designated by the company/institution.

b. final evaluation based on the supervisor's characterization.

c. combined evaluation, both ongoing and at the end of the traineeship, through the supervisor's characterization and grading of practical activities, projects, or other documentation completed in the company/institution.

d. conducting evaluations through an online platform.

The evaluation of traineeship periods is another variable that has been subjected to this study, built based on four items, through which respondents are asked for their opinions regarding the best method for assessing traineeships.

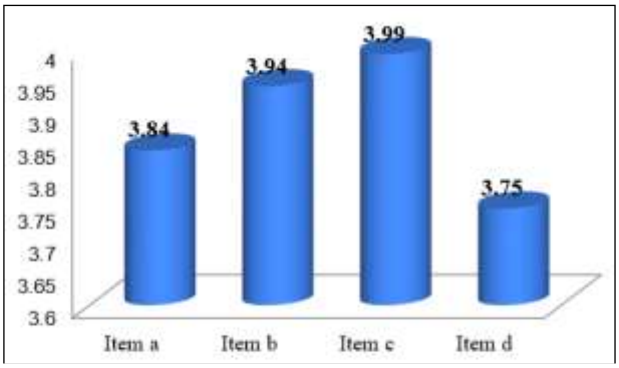

Fig. 11. Methods of evaluating traineeship periods
Source: Own contribution.

From Figure 11, we observe that the majority of respondents consider the combined evaluation method, both ongoing and at the end of the traineeship, through the supervisor's characterization and grading of practical activities, projects, or other documentation completed in the company/institution, to be the best.

11. Rate the effectiveness of the following forms of communication between the traineeship supervisor and students?

a. daily, through a student group coordinator

b. telephone communication with all students, at their initiative

c. daily participation in meetings held at the company's headquarters *d. constant communication through an online platform*

Communication between the teaching staff responsible for traineeships and students is an important variable that has been brought to the attention of the respondents. It has been constructed based on four items referring to the types and means of communication that can be used for the successful implementation of traineeships.

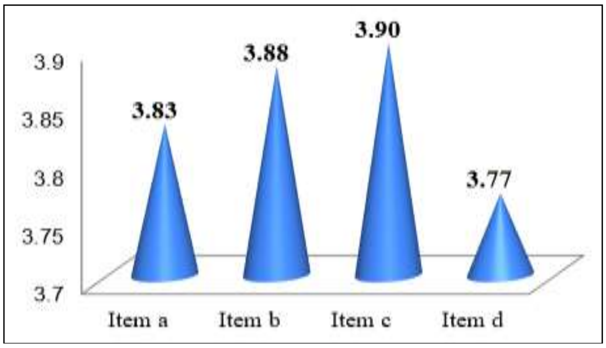

Fig. 12. Communication between the teaching staff responsible for traineeships and students
Source: Own contribution.

Analyzing Figure 12, we observe that the majority of respondents consider an optimal communication method between the teaching staff and students to be the daily participation in meetings held at the headquarters of the practice partner company.

12. To what extent do you consider the following activities of the practice coordinator to be important?

a. implementation of the ongoing and final evaluation process for students

b. continuous communication with students and mentors

c. ongoing monitoring of the traineeship to achieve its objectives

d. preparation of internal reports for the educational institution's leadership

The activity of the educational coordinator of traineeships is another variable analyzed through this questionnaire. It is based on four items referring to the involvement of the educational coordinator in the evaluation process, continuous communication with students and mentors, ongoing monitoring of traineeships, and the preparation of reports regarding their progress.

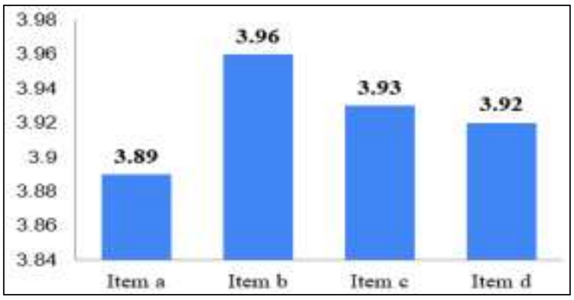

Fig. 13. Importance of the activity of the educational coordinator of the traineeships
Source: Own contribution.

According to Figure 13, the majority of respondents consider the activity of the educational coordinator important for maintaining ongoing collaboration with students and practice mentors.

13. The relevance of the traineeship for professional training:

a) the degree of alignment of the activities carried out with the recommended thematic

b) to what extent the objectives/work tasks were clearly outlined and their achievement was monitored

c)the degree of use of the knowledge acquired during theoretical training

d) to what extent are you satisfied with the practical skills gained.

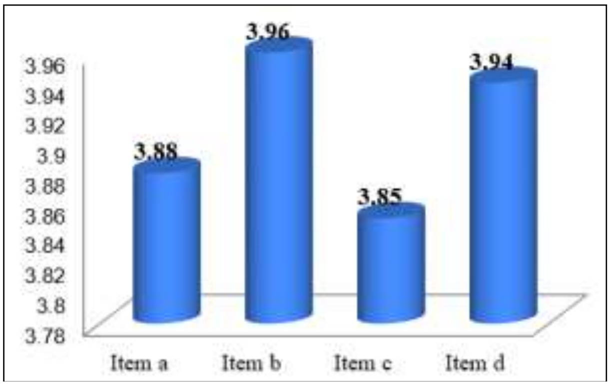

Fig. 14. The relevance of traineeships in the professional training of students
Source: Own contribution.

Another studied variable is the relevance of traineeships in the professional training of students. This was based on four items that draw the attention of respondents to the correlation of activities with those provided by the curriculum, the clarity of outlined tasks and their monitoring, the applicability of theoretical knowledge, and the practical skills acquired.

In Figure 14, we observe that the majority of respondents consider it important to what extent the objectives/work tasks were clearly outlined and their achievement was monitored.

14. What do you consider to be the main attributes that the students' traineeship should have?

a. Proper arrangement and equipping of spaces dedicated to traineeships.

b. Ensuring continuous monitoring and feedback throughout the traineeships.

c. Aligning the traineeship program content with the requirements of the job market.

d. Providing students, teachers, and traineeship partners with access to digital tools to facilitate planning, implementation, and monitoring of activities/traineeships, communication among all involved parties, and involvement in organizing activities.

Considering the utility of traineeships, respondents have expressed their opinions regarding the main attributes that such practice activities should have. To identify these attributes, four items were constructed based on the conditions of traineeship implementation, continuous monitoring and feedback, alignment of content with labour market requirements, and providing access to digital tools for all involved parties to optimize the training activities.

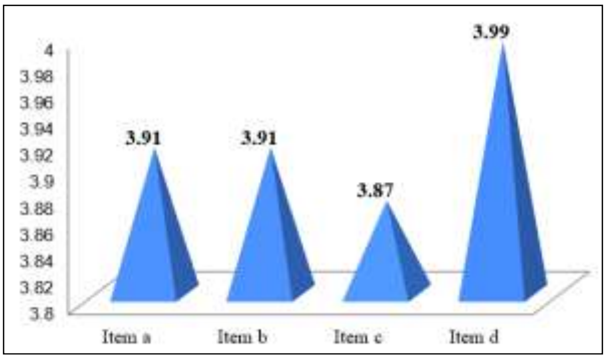

Fig. 15. Main attributes that traineeships should fulfill
Source: Own contribution.

In Figure 15, we observe that the majority of respondents find it opportune for all involved parties to have access to digital tools that help optimize traineeships by facilitating the planning, implementation, and monitoring of activities.

15. What do you consider to be the main benefits for students participating in traineeships carried out within economic operators?

a. the opportunity to become familiar with a work environment

b. acquiring specific knowledge in the field of training

c. developing practical skills specific to the field of activity

d. the opportunity to learn/acquire skills directly from mentors/specialized personnel working in the field

e. the opportunity to meet potential future employers

f. developing communication skills, teamwork, and flexibility.

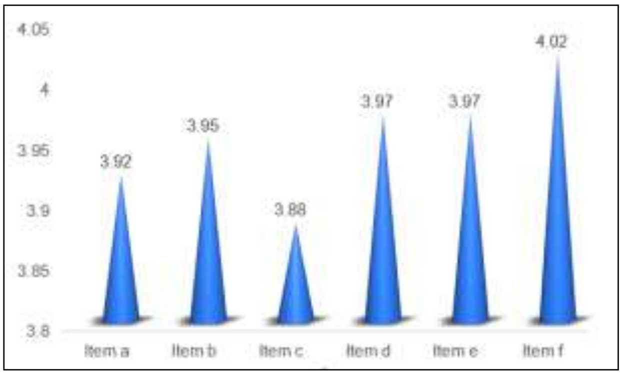

Fig. 16. Benefits that the traineeships offer to students
Source: Own contribution.

Regarding the benefits that traineeships offer to students, respondents have expressed their opinions on the six items related to becoming familiar with the work environment, acquiring specific knowledge, developing specific skills, the opportunity to learn from specialists, meeting potential employers, and developing communication, teamwork, and flexibility skills.

From Figure 16, we observe that the majority of respondents consider the main benefit obtained through completing a traineeship to be the development of communication skills, teamwork, and flexibility.

Section C. In the third section of the questionnaire, dichotomous and semi-open questions (from 16 to 19) were formulated regarding the number of hours of practical and theoretical training, the optimal size of the traineeship, the intention to be employed in the studied field, and the job offers received. Students responded by choosing from the provided options.

16. In your opinion, do you think there should be more hours of practical training or theory in the acquired specialization?

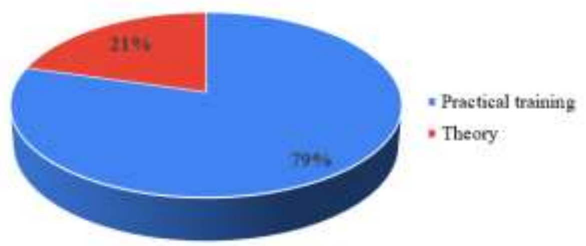

Fig. 17. Respondents' opinions on practical and theoretical training
Source: Own contribution

17. What period do you think is optimal for carrying out a traineeship?

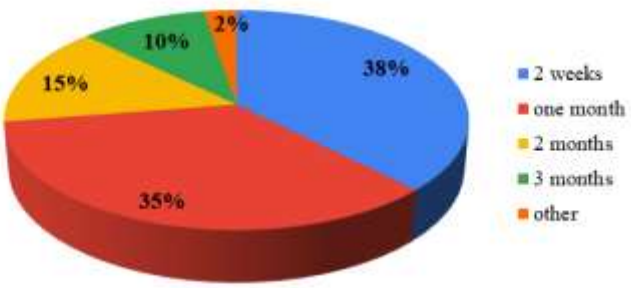

Fig. 18. Respondents' opinions regarding the duration of traineeships
Source: Own contribution.

18. After completing the study program, do you intend to work in the field you are studying?

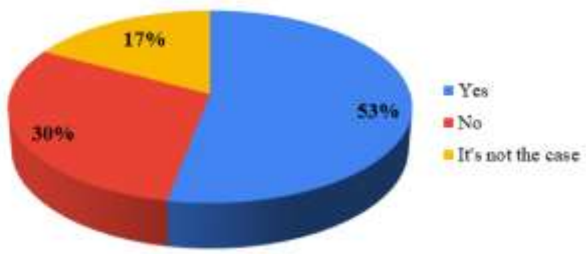

Fig. 19. Respondents' opinions regarding the intention to work in the field they are studying
Source: Own contribution.

19. Have you received job offers from the traineeship partners?

In the fourth section of the questionnaire, open-ended questions (from 20 to 23) were formulated, allowing students to respond using their own words. These questions are used in the exploratory stage of the survey, aiming to identify and describe a complete range of situations, behaviors, attitudes, etc., rather than determining their frequency (responses to these questions are either impossible or very difficult to code).

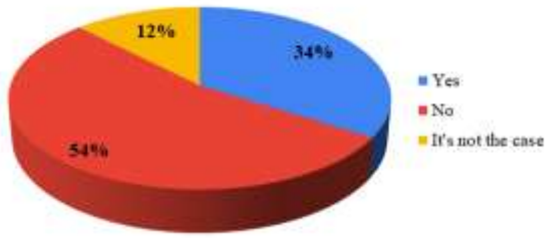

Fig. 20. Respondents' opinions regarding job offers
Source: Own contribution.

20. List 5 positive aspects of the traineeship, in descending order of importance

In response to this question, the predominant answers referred to: Teamwork development, acquiring new skills, adaptation in the workplace, implementation and enhancement of work skills, customer communication, developing the ability to work under pressure, preparation in the studied field, interacting with specialists in the field, and employment opportunities.

21. How do you think the traineeship process can be improved?

Regarding improving the traineeship process, respondents have suggested: improving the delivery of specific field-related knowledge, enhancing communication among students, instructors, and traineeship supervisors, and increasing or introducing new material incentives.

22. What content would you like to be introduced during the traineeships?

In the respondents' opinion, the majority of suggestions regarding desired content revolve around the development of ICT (Information and Communication Technology) skills by involving practising students in the administrative and economic activities of the traineeship partner and providing a more detailed involvement in the production workflow.

23. What other methods of evaluating the practical training (excluding the options mentioned in point 10) do you consider to be effective?

From the perspective of evaluating the practical training, the majority of respondents expressed satisfaction with the presented evaluation methods and advocated for the use of combined evaluation methods, both throughout and at the end of the traineeship. This involves the characterization by the supervisor and grading of practical activities, projects, or other documentation completed in the company/institution. This evaluation method is considered relevant because the instructor and traineeship supervisor assess the student by considering the entire activity conducted during the programme, rather than relying solely on a final exam, which may be influenced by various cognitive, interpersonal, biological, or social factors.

CONCLUSIONS

The questionnaire addressed to students in vocational and technical education served as a stage of summative evaluation and aimed to capture an initial situation at the level of Ilfov County. This initial situation is described by nine variables considered essential: the conditions of the activities, how organizational aspects were fulfilled, students' satisfaction with collaboration with businesses, contribution to the development of skills and working capacities, the importance of theoretical preparation before traineeships, evaluation of these programmes, communication between the teacher responsible for the traineeships and students, the activity of the coordinating teacher, the relevance of traineeships in the professional training of students. Each of these variables was operationalized through 3-7 items, statements for which the respondent was asked to agree on a Likert-type scale with five pre-established responses (totally unsatisfactory, unsatisfactory, neutral, good, very good), each receiving a numeric code. In total, there were 40 such items, along with four open-ended questions, four items about respondent data (age, qualification level, origin, and specialization), four items about the size of traineeships and the intention to work in the studied field, and 10 items regarding the main benefits and attributes that an traineeship should bring.

This initiative aimed to assess the extent to which respondents are satisfied with the traineeship programmes undertaken during the school year 2022-2023. From the responses recorded across the entire sample, several conclusions can be drawn, which can later be translated into measures to improve the quality of the traineeships:

✓ The majority of respondents believe that to be better prepared for the workforce, the time spent in host organizations should be increased. However, the duration of such training activities is one of the few variables/aspects that cannot be modified through this project, as the time allocated for traineeships is determined by the curriculum. Nevertheless, we can recommend decision-makers to consider increasing the minimum duration that students spend in professional traineeships during their studies. We believe that this change would better prepare students to find employment and fulfil their professional duties;

✓ To a large extent, students express satisfaction with the activities in which they participated and their involvement in them, as well as with the relationships established with their supervisor and the responsible teacher. Additionally, trainees appreciated how they were treated by the employees they came into contact with, how they were supervised or coordinated by their mentor during the traineeship, and the fact that through these traineeships, they gained a better understanding of the economic and production processes of the practice partners;

✓ Considering the competencies/skills that respondents wish to develop during the traineeship, we recommend mentors to focus on competencies/skills that tend to have a cross-cutting nature and to avoid or limit, as much as possible, those with a highly specific character. Additionally, mentors should emphasize activities and tasks that can ensure personal development and enhance employability;

- ✓ This study has also highlighted that the majority of students are not motivated to maintain connections with the businesses where they completed their traineeships, which can be considered problematic. The purpose of traineeships should be more complex than simply spending a predetermined period in host organizations; traineeships should establish a connection between students and organizations, a connection that can then be leveraged (directly or indirectly) for the integration of graduates into the labour market. For students, traineeships should be an opportunity to engage with the labour market, organizations, and professionals in the field, laying the foundation for informal networks that can be used to find employment after graduation.

The main measures that host businesses can take to improve traineeships include paying more attention to students, developing action plans for traineeship, better organizing/ planning activities, providing more detailed/ clear tasks, and offering a more diverse range of activities for trainees.

The primary suggestions that can be given to student trainees to enhance their practical preparation involve increasing their involvement and interest in activities during traineeships, taking responsibility for completing assigned tasks within set deadlines and gaining information about the specific nature of the business activities of the host company before starting the traineeship.

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THE LEADER PROGRAMME EVOLUTION IN THE EUROPEAN UNION AND ROMANIA

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Abstract

The LEADER programme provides new opportunities for rural development, identifies the local gaps/needs and implements the new solutions using a bottom-up approach. The publication follows the evolution of the programme both at European and national level, namely in Romania. The information was generated by the Ministry of Agriculture website and Rural Development and by the European Commission. They were processed by the Court of Accounts. In the European Union it was first introduced 32 years ago while in Romania only 16 years ago. The central mechanism and at the same time the beneficiary of this programme is the LAG (Local Action Group), meant to facilitate implementing the LEADER principles. The programme became compulsory to every member state between 2014–2020 and each state had to provide 5% of the rural development fund for the LEADER policy, excepting Croatia since it had just adhered to the EU, in 2013.In Romania, between 2011–2012, 163 LAGs were established while currently the number goes up to 259. However, parts of the Romanian territory are still not covered by any LAG, although they are eligible for the LEADER implementation. On the other hand, between 2014–2020 some LAGs' functioning authorizations were canceled. In Europe, a number of 143,487 LEADER projects were registered. Although the EU planned to provide funding of up to Euro 9.2 billion, the real amount was of 7 billion.

Keywords*: *LEADER, LAG, funding, development, rural

INTRODUCTION

In 1991, the European Union has developed the LEADER programme, having as a purpose the economic development of rural areas; it followed a bottom-up policy to address the existing problems [1, 2, 3].
With an extensive experience of over 30 years, LEADER is implemented by 2,800 LAGs (Local Action Groups), 61% of the European rural population. LEADER represents an approach that offers new rural development opportunities, in line with the needs of a certain area [12]. By identifying the local problems it helps building a development strategy, preserving the socio-cultural profile of the territory. The local people are encouraged to actively participate in creating a development pathway as they are the ones who best know the lacks of their area [4, 13]. The functioning mechanism of LEADER or the "beneficiary" of the policy is referred to as the Local Action Group (LAG). The formation of Local Action Groups (LAGs) is indeed a distinctive and integral aspect of the LEADER approach. LAGs play a crucial role in the implementation of the LEADER program, fostering a bottom-up approach to rural development. The two approaches mentioned - founding LAGs based on demand or building on existing partnerships - provide flexibility in tailoring the program to the unique characteristics of each region [4,11].
It is the core tool in implementing the programme and it involves partnerships between representatives of diverse socio-economic sectors in the area, aiming to build a development strategy that fits the local context.LEADER is part of the EU's Rural Development Policy implemented in every member state and it is financed by the European Agricultural Fund for Regional Development (EAFRD) [12].

PNDR is the tool our country uses to attract financial resources from the EU to improve the agricultural sector and to develop the rural areas. This tool is structured into different priority axes, each of them targeting a specific intervention area. LEADER represents Axis 4 in PNDR standing out through its specific approach [12].

The purpose of analyzing the evolution of the LEADER program in Europe and Romania using data from various sources, including the Ministry of Agriculture and Rural Development, the European Commission, the Court of Accounts, and LEADER surveys, is to gain comprehensive insights into the program's development, impact, challenges, and effectiveness. This multi-faceted approach allows for a nuanced understanding of how the LEADER initiative has evolved over time and its specific implications for rural development.

MATERIALS AND METHODS

As a method, this article followed a comparative analysis approach, the direct observation method, data received from the European Court of Auditors, and LEADER surveys regarding the number of LAGs [13, 14]. The bibliographic researchcovered a period of six months, starting in April 2023 and ending in October 2023. It was based on the analysis of data generated by the databases of the Ministry of Agriculture, the European Court of Auditors, the European Network for Rural Development as well as the National Network for Rural Development, accessed during the above mentioned period.

RESULTS AND DISCUSSIONS

The European Union registered the highest number of LAGs between 2007–2013 while the lowest amount was between 1991–1993 (LEADER I)as shown in Figure 1 [6].

Based on Romania's geographical location, we analysed the whole South-East European region, which includes countries that have implemented the LEADER programme: Bulgaria, Greece, Croatia and Cyprus. We studied the evolution of the number of LAGs in both programming periods, 2007-2013 and 2014-2020.

Map 1. Interactive map of the European Network for Rural Development ENRD [5].

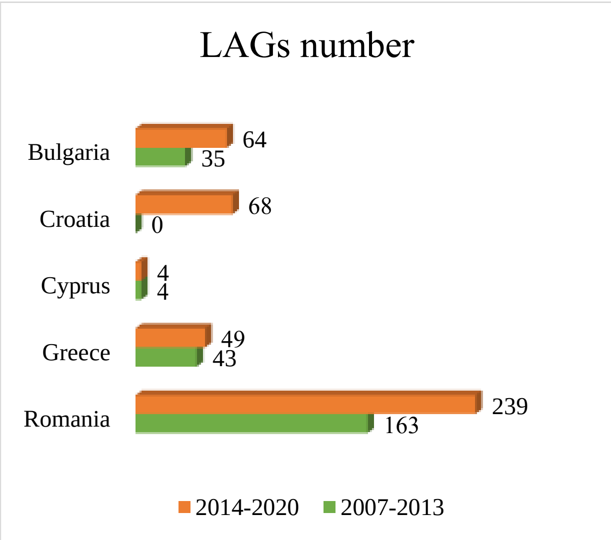


Fig. 2. Number of LAGs in South-East European, in the two programming periods.
Source: Own processing ENRD database [5].

In 2007-2013 Croatia did not register any LAGs, as it became a member of the European Union in 2013, and in the second programming period it registered a number of 68 LAGs. Romania is the country with the highest number of LAGs in the region, followed by Croatia. Cyprus is the country with the smallest number of LAGs because the surface area and population of the country are very small compared to the other countries in the region.

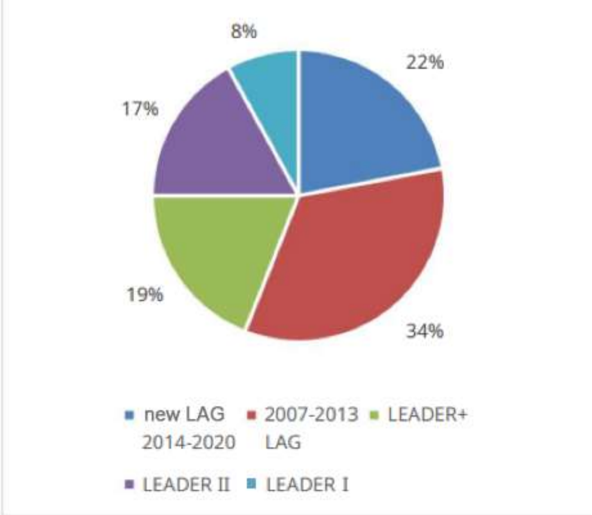
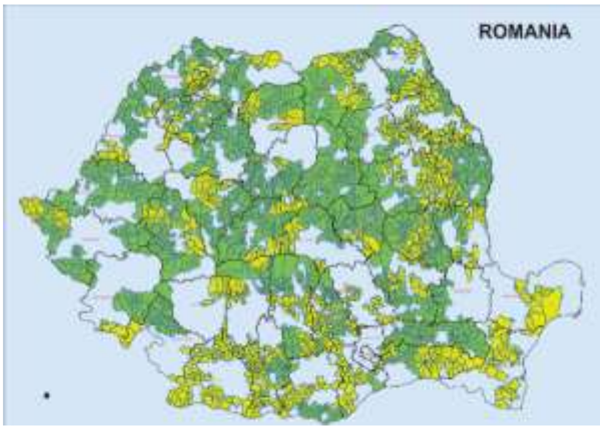


Fig. 2. Operational period LAGs in the EU
Source: LEADER LAG Survey 2017- Findings at the European Level [6].

In Romania the number of LAGs was established before 2007–2013 (Figure 3).
In Romania, the LEADER programme has significantly evolved between 2007–2013:the LAGs and LIGs numbers highly increased and the LEADER policy evolved and became well-known in the entire Europe.
However, a series of rural development actions were identified, such as LIGs (Local Initiative Groups) and other LEADER-like partnerships created and implemented by the local PNDR [9].



Map. 2. Territorial coverage with Local Action Groups in Romania 2012
Source: MARD, https://www.madr.ro/ [8].

Between 2011–2012 a number of 163 LAGs was established over the Romanian territory, covering approximately 142,000 km^2.

The dispersion of LAGS on Romania's surface is shown in Map 2.

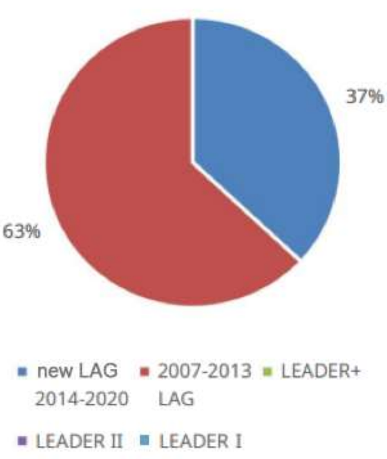


Fig. 3. Operational period LAGs in the Romania
Source: LEADER LAG Survey 2017- Findings at the European Level [6].

This number represented around 63% of the eligible territory and 58% of the eligible population for LEADER implementation [7].
On 30.09.2019, a number of 239 LAGs was registered [8]. Today, Romania has a number of 258 LAGs, being one of the countries with the highest number of LAGs.

Map 3. Territorial coverage with Local Action Groups in Romania 2020
Source: RNDR, https://www.rndr.ro/leader.html [9].

As it can be seen from Map 3, there are still white areas that are not represented by any LAG or it had a LAG whose functioning authorization was revoked between 2014–2020 [8].
The observation of an exponential growth in the number of Local Action Groups (LAGs) between 1991 and 1993, as indicated by data from the European Commission, underscores

the rapid adoption and expansion of the LEADER approach during that period. Establishing local development strategies was a crucial step of the LEADER approach. It had a positive outcome upon the local community, strengthening cooperation among partners such as the tourism sector and the agricultural landscape, preserving and promoting the local customs and traditions.

Table 1. The LEADER Programme - Dynamics of the number of LAGs and financial support

	Destination	No. of LAGs	Financial support Euro Million
LEADER I 1991-1993	Rural areas	217	0.44
LEADER II 1994-1999	Rural areas	906	1,76
LEADER + 2000-2006	Rural areas	1,153	2.11
LEADER IV 2007-2013	Rural areas Fisheries areas	2,714	6.32
LEADER CLLD 2014-2020	Rural areas Fisheries areas Urban areas	3,337	9.18
Absolute difference 2014-2020 Minus 1991-1993	-	+3,120	+8.74
2014-2020/ 1991-1993 %	-	1,537.78	2,086.36

Source: Own calculations based on the data from ECA and the European Commission [10].

Between 2014–2020, LEADER was included in all the Rural Development Programmes (Table 1).

All the members states, (except Croatia) had to implement the LEADER policy. Every state had to assign a minimum of 5% of the Rural Development Fund towards the LEADER programme.

Having just adhered to the European Union, in 2013, Croatia's percent was established at only 2.5%.

Over the 2014–2020 programme period, a number of 143,487 of LEADER projects was registered. The European Union provided financial resources up to Euro 9.2 billion to address the economic development of the rural areas. However, this objective was the community's responsibility (Table 2) [10].

Table 2**.** EU funding for the LEADER Programme 2014- 2020 (Euro million).

EU fund	Planned	Paid	Paid - Planned	Paid/ Planned %
European agricultural fund for rural development	7,010	3,026	-3,984	43.16
European maritime and fisheries fund	548	178	-370	32.48
European regional development fund	1,095	349	-746	31.87
European social fund	530	82	-448	15.47
T0TAL	9,183	3,635	-5,548	39.58

Source: Own calculations based on the data from ECA and the European Commission [10].

The rural development programmes were extended in order to cover 2021 and 2022 as well (the transition period). The National Programme of Rural Development budget, assigned for the transition period 2021–2022 was of up to 3.26 billion.

The EAFRD Fund 2021–2027 CFM (Multiannual Financial Framework): 2,569.10 billion; EURI Fund (Recovery and Resilience Facility): 692.09 billion.

In 2014, the member states agreed to spend 17% of the LEADER fund for administrative costs and for the functioning of the LAGs. However, at the end of 2020 the amount went to 24%. The same happened with the preparation costs: 1% of the fund was going to be spent, while in reality the double of this amount was needed.

For the cooperation activities and their additional costs, the paid amounts have been lower than initially agreed. At the end of 2020, the cost of the local projects was of approximately Euro 3 billion, almost 72% of the total LEADER fund [2]. For the cooperation actions, the LAGs have spent only half of the provided fund.

Table 3. The LEADER Programme 2014-2020

Cost type	Planned funding		Paid funds		Difference Paid - Planned funding	
	Value Euro Million	Share (%)	Value Euro Million	Share (%)	Value Euro Million	pp.
Preparatory costs	81.6	1	67.4	2	-14.2	+1
Administrative and running costs	1,673.6	17	1,038	24	-635.6	+7
Cooperation activities	380.9	4	98.6	2	-202.3	-2
Project costs	7,794.2	78	3,054.4	72	-4,739.8	-6
Total EU-27 + UK	9,930.2	100	4,258.4	100	-5,671	-

Source: Own calculations based on the data from ECA and the European Commission [10].

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CONCLUSIONS

Ever since 1991, the European Union identified the necessity of a local development method—LEADER.

While disseminating the LEADER principles, the newly formed LAGs and their financing also increased.

Although Romania registers a high number of LAGs, eligible areas that are not covered by any LAG are still observed.

Although the LEADER programme is present in Romania for only 16 years, the country is among the states with the highest number of LAGs.

The EU funding for the LEADER period of 2014–2020 was of up to Euro 9 billion; 5% of the Rural Development Fund had to be allocated to the implementation of the LEADER principles, excepting Croatia, a recent member, which received only 2.5%.

The LEADER expenditure consisted of preparation, clerical and functioning costs, to cooperation and projects-related expenses.

A valuable period was the transition period between 2021 and 2022, when the National Programme for Rural Development (NPRD) budget was of up to Euro 3.26 billion. The financing originated from EURI funds (Recovery and Resilience Facility) and from EAFRD (Multiannual Financial Framework 78%).

The LEADER policy enhances any rural context.

Using a bottom-up approach, it supports the local communities, encourages cooperation and innovation and facilitates development goals [8].

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NAVIGATING FISCAL WATERS AND STRATEGIC SHIFTS: ASSESSING THE RISK AND IMPACT OF ROMANIA'S 1% TURNOVER TAX ON COMMODITIES TRADERS, SUPPLY CHAIN IMPLICATIONS, ANDAGRICULTURAL SECTOR SUSTAINABILITY

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Abstract

The recent implementation of a 1% turnover tax on companies exceeding €50 million in annual turnover by the Romanian government aims to secure a minimum tax contribution from large corporations, a move that directly impacts those in the grain trade, where profit margins are well-known slimdue to the volatile nature of global market prices and fierce competition. The analysis conducted in this study highlights the financial dynamics of the last five years for the largest grain trading entities in Romania, such as Ameropa, Cargill, CHS, COFCO, and Viterra. The simulation of the 1% turnover tax reveals a dramatic increase in tax liabilities for these companies, with the projected tax payments under the new regime nearly equating to their combined gross profits of €196.96 million, a stark rise from the €32.32 million paid under the old profit tax system.This significant increase in tax burden underscores the potential risks and challenges facing the agricultural sector. For grain trading companies, the new tax could necessitate a re-evaluation of cost structures and operational efficiencies to maintain profitability. The study suggests that these companies may have to adjust their purchasing prices or seek other avenues to offset the increased fiscal demands, potentially affecting the entire supply chain, including Romanian farmers.Farmers, in turn, could see a reduction in their income and investment capacity due to lower purchase prices for their produce, complicating the financial sustainability of rural areas. Furthermore, the limited ability to pass on additional costs in the export market, given the competitiveness of global prices, could strain the sector's profitability.

Key words**:** *turnover tax, financial risks, profitability, agricultural commodities, fiscal challenges*

INTRODUCTION

Tax changes always represent pivotal moments for the economic dynamics of any sector. On January 1, 2024, Romanian government implemented a significant tax reform by introducing a minimum tax of 1% on the turnover for companies with an annual turnover exceeding 50 million euros. This measure aims to ensure a minimum tax contribution from large corporations, especially in situations where 16% of the gross profit would be less than 1% of the company's turnover [14]. This tax threshold could significantly impact large agricultural companies, particularly major grain trading companies.

These companies generally operate with slim profit margins due to the volatility of global market prices and intense competition [4]. The agricultural sector, and specifically the grain trade, is a sensitive domain, with profits that can be easily eroded by changes in raw material prices, currency exchange fluctuations, and variations in supply and demand on international markets. Furthermore, Romania, like other countries, faces pressures from domestic producers and the need to balance imports with exports [6].

By the nature of their activity, companies trading agricultural commodities not only face challenges in managing purchases and sales but also the necessity to navigate through fiscal complexities, now further accentuated by the new legislation. The introduction of this fixed tax on turnover, regardless of the profit made, may lead to a series of adjustments in corporate strategy. Companies might be forced to review their cost structure, seek increased operational efficiencies, or adjust purchase prices to maintain profitability and ensure long-term sustainability [22].

This new fiscal framework not only directly affects large commercial entities but also has the potential to disrupt the entire supply chain. Transferring the fiscal costs to Romanian farmers by lowering the purchase prices of grains could have negative consequences among the local agricultural community, affecting their incomes and investment capacity [13]. On the other hand, the possibility of transferring these additional costs to the export market is limited, given that prices are dictated by the dynamics and competition of global markets [19].

Analysing the impact of these tax changes requires a deep understanding of the business model of grain traders and their position in the global market, as well as a meticulous approach to financial data to anticipate and plan for the future. Next, we will take a detailed look at the impact of these tax changes on the financial data of major grain trading companies in Romania to better understand the challenges they face and possible adaptation strategies.

MATERIALS AND METHODS

This study aims to assess the impact and risks associated with fiscal changes introduced in Romania starting January 1, 2024, specifically the introduction of a minimum tax of 1% on turnover for companies exceeding a turnover of 50 million euros in the previous year when the standard tax rate of 16% on gross profit is less than 1% of their turnover. The analysis was conducted utilizing publicly available financial statements from the largest trading companies from Romania (Ameropa [2], COFCO [10], Cargill [5], Viterra [32], CHS [8]), focusing on the main indicators reported in the period 2018-2022: turnover, net profit, and gross profit. From these indicators, we calculated the proportion of profit taxes paid during the analysed period relative to turnover. Subsequently, we estimated what the tax would have been had the traders been required to pay the 1% tax on turnover, identifying the nominal difference and the percentage difference to facilitate a comparative analysis of the data resulting from this simulation.

It is evident that following the application of the new fiscal regulations, companies will adapt their business strategies to counteract the effects of the new tax rules [34]. The study's limitations are linked to the fact that results for the year 2023 could not be included at the time of this research, and the analysis only covers the top five trading companies by turnover.

This research was basedon an examination of the available financial data, ensuring a comprehensive understanding of the fiscal landscape and its implications for large agricultural trading companies. By focusing on the primary financial indicators and calculating the potential effects of the new tax regime, this study provides valuable insights into the adaptive measures companies may need to undertake.

The comparative analysis offers a detailed overview of how the fiscal changes could reshape the financial health of these companies. Although the study is limited to the top five companies by turnover, it offers a significant glimpse into the broader implications for the agricultural trading sector in Romania.

The adaptation strategies that companies might employ to mitigate the impact of the new taxation rules remain speculative at this stage [12]. However, this research lays the groundwork for future investigations into the actual responses and strategies implemented by these companies as more data becomes available, particularly including the fiscal year 2023 and beyond.

RESULTS AND DISCUSSIONS

Grain exports play a crucial role in the Romanian economy, serving as a significant source of revenue and a testament to the country's agricultural capacity [33]. As one of Europe's leading producers and exporters of grains, Romania capitalizes on its fertile lands and favourable agricultural conditions to supply a substantial portion of the global market's demand for cereals [7].

Romania's grain export data spanning from 2017 to the present period of 2023/2024 underscores the pivotal role of agricultural commodities trading within the national economy. The figures tell a story of the country's capacity to produce and trade key agricultural products on a scale that impacts not only domestic markets but also positions Romania as a substantial player on the international stage.

The data records an initial export volume of 6,601,671 tons in the 2017/2018 period, marking the beginning of a growth trend that reaches its apex in 2021/2022 with an impressive 12,960,208 tons of grain exported. This peak in exports, highlighted by a jump in common wheat exports from 3,975,447 tons to 6,738,084 tons, aligns Romania with some of the most prolific grain-exporting nations in Europe (Fig. 1).

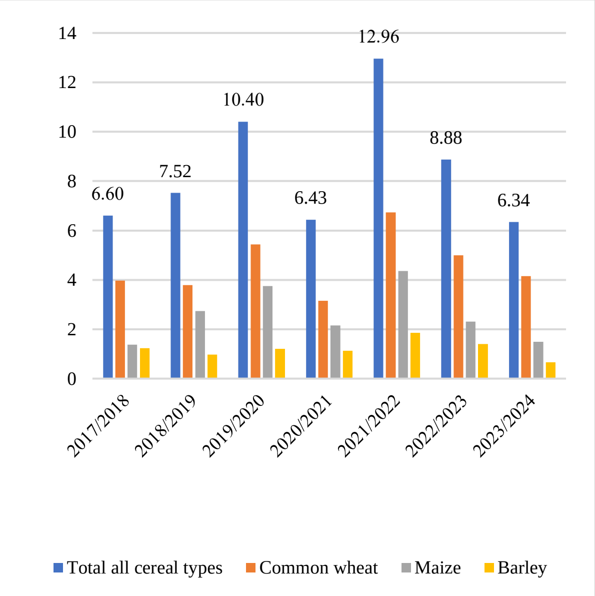

Fig. 1. Volumes of Romanian grains exports (million tons)
Source: agridata.ec.europa.eu [1].

The maize sector also mirrored this ascent, with the 2021/2022 period seeing a high of 4,362,564 tons exported, reinforcing the strategic importance of maize within Romania's portfolio of agricultural exports. Barley exports contribute to this narrative of diversity and growth, with a notable figure of 1,859,245 tons exported in the same period.

The flux represented in these export volumes is a clear signal of the intricacies and risks inherent in global commodities trading. The ebb and flow of Romania's grain exports reflect the sector's response to global demand, pricing, and competitive pressures. While the peak years have undoubtedly bolstered Romania's economic performance, the current period demands attention and possibly strategic adjustments to navigate the shifting landscape.

The interplay between these volumes and the economic health of Romania is profound. The grain trading sector is not just a reflection of the nation's ability to produce but also its capacity to engage with the global market effectively. The data serves as a strong indication of the sector's economic importance, highlighting how prosperous years contribute to economic growth and how difficult years necessitate strategic adjustments and assistance [20].

In a review of Romania's agricultural exports from 2017 to the ongoing year of 2023/2024, the, data presented in figure no. 2,outlines a narrative of the country's performance in the grain market.

As shown in Figure 2, starting from the fiscal year 2017/2018, total exports of all cereal types were recorded at 1.15 billion euros. This figure experienced year-on-year changes, reaching a peak of 3.33 billion euros in 2021/2022. In the current year of 2023/2024, the total stands at 1.45 billion euros thus far.

Within the cereal’s category, common wheat exports began at 666 million euros in 2017/2018 and saw a high of 1.77 billion euros in 2021/2022. Currently, in 2023/2024, common wheat exports amount to 970 million euros.

For maize, the export value was 289 million euros in 2017/2018, with an increase to 1.15 billion euros in 2021/2022. The current fiscal year's exports are at 332 million euros.

Barley exports were at 190 million euros in 2017/2018 and peaked at 407 million euros in 2021/2022. The figure for the ongoing year is 138 million euros.

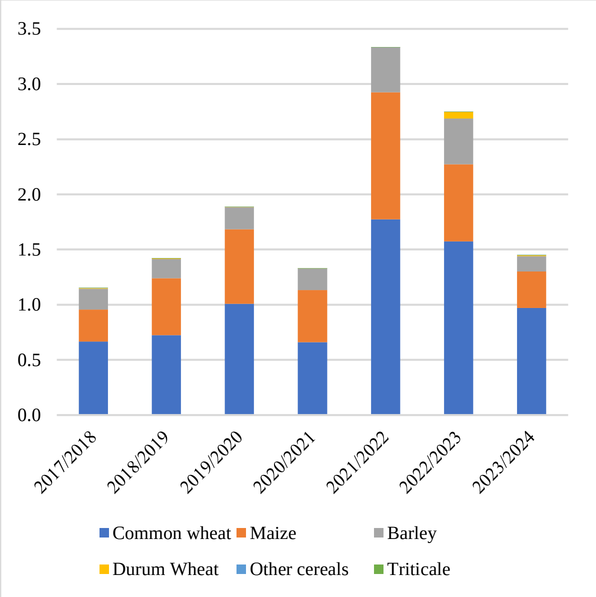

Fig. 2. Values of Romanian grains exports (billion euros)
Source: agridata.ec.europa.eu [1].

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Durum wheat showed more modest numbers, with 6 million euros in 2017/2018 and a slight increase to 9.7 million euros in the current year.

These values reflect the volumes of grain that Romania has contributed to the global market across these varied types of cereals.

In essence, the story woven by these figures is one of an economic sector that is both a contributor to and a reflector of Romania's economic fortunes. It is a narrative that underscores the necessity for continued innovation, strategic diversification, and proactive economic planning to ensure the longevity and success of Romania's grain trading within the competitive global marketplace.

In the period from 2018 to 2023, the major grain trading companies in Romania operated within a relatively stable tax landscape, where corporate income tax was set at a rate of 16% of the gross profit. During this time, the combined sums of net profits and paid profit taxes reflect financial operations within a well-defined fiscal framework. However, a significant shift is on the horizon with the introduction of new tax regulations imposing a 1% tax on turnover for companies with annual revenues exceeding the 50million euros threshold.

The Romanian agricultural landscape is marked by the presence of significant entities that drive the economic pulse of the sector. Among these, companies like Ameropa, Cargill, CHS, COFCO (former Nidera), and Viterra (former Glencore) stand out not only for their scale but also for their crucial role in both the export and import segments of the market.

These companies are pivotal in exporting the surplus of Romanian grain to international markets. Their operations are essential for balancing the country's agricultural trade and maximizing the economic potential of Romania's rich agricultural lands [27]. With their vast networks, sophisticated logistics, and market expertise, they help ensure that the produce of Romanian farmers reaches a global audience, contributing to the country's reputation as a reliable source of quality grains [26].

Simultaneously, these trading giants are among the primary importers of agricultural inputs essential for both crop and livestock farming. Their import activity includes soybean meal, a critical component in animal feed for livestock farms, and various chemical fertilizers, which are indispensable for enhancing the yield and quality of crops in plant farms [23, 31]. By supplying these vital inputs, they support the entire agricultural

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value chain, enabling farmers to boost productivity and maintain the sustainability of their farming practices.

The activities of these commodity trading companies are deeply intertwined with the health and growth of Romanian agriculture. Their ability to efficiently navigate the complexities of both the export and import markets makes them key players in ensuring the sector's resilience and adaptability to global market dynamics [28].

The analysis of the turnover figures presented in Figure 3 provides insight into the economic performance and growth trends of these companies within the Romanian market.

Ameropa has shown a consistent increase in turnover, starting from 0.78 billion in 2018 and growing to 1.73 billion by 2022. This upward trend indicates robust growth and an expanding market presence.

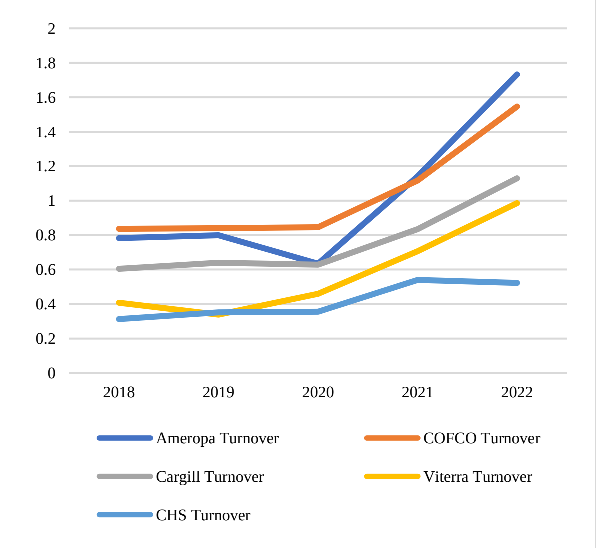

Fig. 3. Traders turnover (billion euro)
Source: Listă firme.ro [15].

COFCO exhibits a similar growth pattern, with an initial turnover of 0.84 billion in 2018, which slightly fluctuates in the subsequent years but shows a significant increase to 1.55 billion by 2022.

Cargill presents a steady increase over the five-year period, starting from 0.60 billion in 2018 and reaching 1.13 billion by 2022, nearly doubling its turnover, which may reflect successful expansion strategies or market gains.

Viterra has a more modest growth trajectory compared to the others, with turnover increasing from 0.41 billion in 2018 to 0.99 billion in 2022. While this is more than a twofold increase, it's at a slower rate than some of its counterparts.

CHS shows the smallest turnover among the five companies, with a starting figure of 0.31 billion in 2018 and an increment to 0.52 billion by 2022. This growth, while significant, suggests a more conservative expansion or possibly a focus on specific market segments.

Collectively, these figures highlight the expanding influence and business volume of these key players in Romania's agricultural sector. The consistent growth across all companies from 2018 to 2022 underlines the importance of commodity trading activities to the Romanian economy, suggesting a positive trend in the agricultural sector's performance and its contribution to the national economic landscape.

In a nutshell, Ameropa, Cargill, CHS, COFCO, and Viterra that is planned to merge with Bunge (another important commodity trader from Romanian and international market), are not merely participants but fundamental pillars in the Romanian agricultural economy. Their operations facilitate the flow of goods in and out of the country, affecting everything from the profitability of local farms to the stability of national food security. As such, their strategic decisions, market performance, and response to regulatory changes have far-reaching consequences for the Romanian economy and, by extension, for global agricultural commodity markets.

By simulating the 1% tax on turnover, we identified significant nominal and percentage differences between the old and new tax regimes. These differences starkly illustrate the financial risk that the new fiscal changes imply for large companies in the agricultural sector. While data for the year 2023 are not yet available, the trend indicated by our analysis suggests that companies need to brace themselves for a substantial shift in their tax planning.

The simulation applying a 1% tax rate on the turnover of commodity traders over the past five years serves as a hypothetical model to provide reference values for comparative analysis. It is important to stress that this exercise, while valuable for illustrative purposes, is a simplified representation of potential tax liabilities under the new fiscal regime.

The simulation doesn't account for the myriad of strategic adjustments companies might make in response to such a tax change. While it offers a baseline for understanding the impact of the new tax rule, it is clear that in reality, companies will actively seek ways to optimize their fiscal activities [18]. The nature of a turnover tax, which is levied on gross receipts rather than profits, indeed makes it more challenging to mitigate through traditional tax planning strategies that would typically target net income [12].

In practice, firms may consider a variety of operational changes to lessen the impact of such a tax. These could include restructuring supply chains, reassessing market strategies, diversifying product portfolios, or even re-evaluating investment plans. Companies might also explore cost-saving technologies and processes or negotiate more favourable terms with suppliers and partners to maintain profitability [29].

It should also be acknowledged that the real-world application of this tax could influence market behaviour. Companies may adjust pricing strategies, both for purchasing inputs and for selling goods, to reflect the new cost structures. Such price adjustments could have ripple effects throughout the supply chain, ultimately influencing market dynamics and sectoral profitability [3].

Furthermore, the simulation assumes static behaviour from the companies, not considering the dynamic nature of businesses that continually evolve and adapt to the changing fiscal and economic landscapes. In reality, the introduction of a new tax regime is often a catalyst for innovation and transformation within industries, as companies seek to maintain competitive edges.

Therefore, while the simulation provides a theoretical framework to gauge the potential impact of a 1% turnover tax, it is merely a starting point for a more complex and nuanced analysis that must consider the adaptive responses of businesses facing new financial and regulatory challenges.

Table 1. Impact assessment of the New 1% Turnover Tax on Trading Companies: afinancial simulation overview comparing nominal and percentage difference between previous Profit tax and new Profit tax (million euros)

Ameropa	Turnover(millions €)	Net Profit	Profit Tax (PT)	New PT 1%	Nominal difference Pew PT – Old PT	Percentage change *
2022	1,732.81	21.35	4.07	17.33	13.26	326%
2021	1,141.85	12.06	2.30	11.42	9.12	397%
2020	634.02	0.87	0.17	6.34	6.18	3,741%
2019	800.07	13.07	2.49	8.00	5.51	221%
2018	782.62	7.14	1.36	7.83	6.47	475%
Total	5,091.37	54.49	10.38	50.91	40.53	391%
COFCO	Turnover (millions €)	Net Profit	Profit Tax (PT)	New PT 1%	Nominal difference Pew PT – Old PT	Percentage change
2022	1,546.43	22.44	4.27	15.46	11.19	262%
2021	1,117.73	0.00	0.00	11.18	11.18	
2020	845.26	12.16	2.32	8.45	6.14	265%
2019	840.64	2.67	0.51	8.41	7.90	1,552%
2018	836.71	0.85	0.16	8.37	8.20	5040%
Total	5,186.77	38.13	7.26	51.87	44.60	614%

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Cargill	Turnover (millions €)	Net Profit	Profit Tax (PT)	New PT 1%	Nominal difference Pew PT – Old PT	Percentage change
2022	1,129.94	38.75	7.38	11.30	3.92	53%
2021	835.53	6.47	1.23	8.36	7.12	578%
2020	627.83	6.40	1.22	6.28	5.06	415%
2019	638.88	-0.18	0.00	6.39	6.39	
2018	604.71	-3.79	0.00	6.05	6.05	
Total	3,836.90	47.66	9.83	38.37	28.54	290%
Viterra	Turnover (millions €)	Net Profit	Profit Tax (PT)	New PT 1%	Nominal difference Pew PT – Old PT	Percentage change
2022	985.64	14.01	2.67	9.86	7.19	269%
2021	706.37	-1.07	0.00	7.06	7.06	
2020	459.45	0.12	0.02	4.59	4.57	19,208%
2019	338.78	2.64	0.50	3.39	2.88	573%
2018	407.64	1.21	0.23	4.08	3.85	1,662%
Total	2,897.88	16.92	3.43	28.98	25.55	746%
CHS	Turnover (millions €)	Net Profit	Profit Tax (PT)	New PT 1%	Nominal difference Pew PT – Old PT	Percentage change
2022	523.61	0.89	0.17	5.24	5.07	2,992%
2021	540.07	1.70	0.32	5.40	5.08	1,572%
2020	355.17	1.91	0.36	3.55	3.19	875%
2019	352.51	2.59	0.49	3.53	3.03	615%
2018	312.99	0.36	0.07	3.13	3.06	4524%
Total	2,084.35	7.44	1.42	20.84	19.43	1370%

*(New profit tax-Old profit tax)/Old profit tax x 100
Source: Own processing based on public data from [15].

An analysis of the public accounting data for companies such as Ameropa, Cargill, CHS, COFCO, and Viterra, summarizing the results over the last five years, provides a clear picture of the impact of this new tax. For instance, Ameropa, which accumulated a net profit of 54.49 million euros and paid 10.38 million euros in profit tax, now faces an increased tax burden estimated at 50.91 million euros under the new regime. Similarly, Cargill and the other analysed companies would experience substantial increases in due taxes, with CHS seeing an over tenfold increase in tax compared to the previous amount paid.

The Figure 4 and Table 1 reflect a cumulative analysis of the financial data for five major agricultural commodity trading companies in Romania over a recent five-year period, from 2018 to 2022.

The data captures the total gross profit reported by each company, the total amount of tax paid under the old profit tax system, and a simulated total tax amount if a 1% turnover tax had been applied during the same period.

Ameropa: With a total gross profit of €64.87 million over the five years, the old profit tax amounted to €10.38 million. If a 1% turnover tax had been applied instead, Ameropa would have faced a tax of €50.91 million, which is a significant increase and suggests a more substantial fiscal impact under the hypothetical turnover tax system.

Cargill: Cargill's total gross profit for the period was €57.49 million, with an old profit tax totalling €9.83 million. The simulated 1%

turnover tax for Cargill amounts to €38.37 million, nearly quadrupling the tax burden compared to the old system.

CHS: CHS reported a total gross profit of €8.86 million, with the old profit tax at €1.42 million. Under the 1% turnover tax scenario, the tax sum would escalate to €20.84 million, indicating a dramatic increase and potentially a more challenging fiscal environment for the company.

COFCO: Over the five years, COFCO earned a total gross profit of €45.39 million and paid a profit tax of €7.26 million. The simulation suggests that a 1% turnover tax would result in a tax liability of €51.87 million, significantly exceeding the profit-based tax paid under the previous system.

Viterra: Viterra's total gross profit was €20.35 million, with an old profit tax of €3.43 million. The hypothetical application of a 1% turnover tax would lead to a tax sum of €28.98 million, which also represents a considerable increase from the taxes paid on profits.

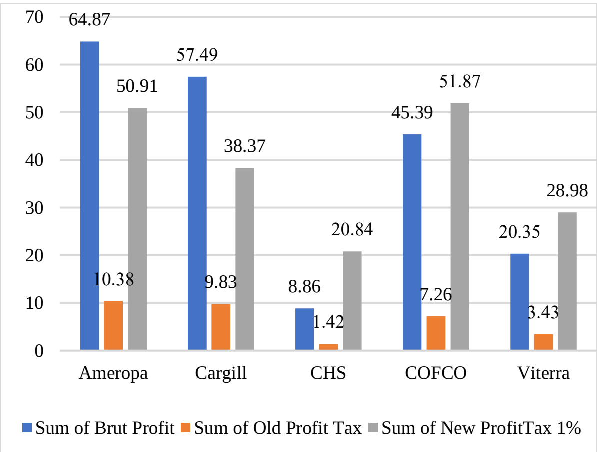

Fig. 4. Traders total turnover in period 2018-2022 (billion euro)
Source: own calculations.

The financial dynamics of the five-year period under review for the commodity traders CHS, COFCO, and Viterra reveal that their total gross profits reported during this time fall below the threshold of 1% of their total turnover. This suggests that under the new tax regulation that imposes a 1% tax on turnover, these companies would experience an increase in their tax liability, as their previously reported profits represent a smaller fraction of their business volume than the new tax rate demands.

For CHS, COFCO, and Viterra, the cumulative gross profit—being less than 1% of the turnover—indicates that the new tax rule would likely lead to a higher tax burden than what they incurred based on their profit levels. Essentially, their tax base would shift from a profit-centric model to a turnover-centric model, which does not account for the profitability of transactions but solely their volume.

On the other hand, for Cargill and Ameropa, the situation is slightly different. The total gross profit for these companies over the last five years marginally exceeds the value of 1% of their turnover. This indicates that while the new tax regime will still impact them, the difference between their historical profit-based tax and the new turnover-based tax will be less pronounced than for their counterparts. However, this narrow margin suggests that any fluctuations in their profit margins or turnover could easily result in a situation where the new tax rate exceeds their profit percentage, thereby increasing their tax obligation as well.

In essence, for CHS, COFCO, and Viterra, the new tax regime represents a more significant fiscal adjustment as it diverges more substantially from their historical tax payments relative to their profit margins. For Cargill and Ameropa, while still impactful, the change is less stark but presents a cautionary scenario where even minor downturns in business performance could lead to a disproportionate tax burden under the new regime. This underlines the delicate balance companies must maintain between turnover and profit margins in light of fiscal policy changes.

In summary, this retrospective simulation indicates that all five companies would have experienced a higher tax liability if a 1% turnover tax had been applied during the last five years, compared to the previous tax structure based on profits. This analysis provides a reference point for understanding the potential impact of such a tax change on the fiscal responsibilities of these key players in the Romanian agricultural sector. It is important to note that these simulated values serve as a historical comparative tool and do not necessarily predict how companies will respond to actual changes in tax policy. In reality, companies may seek various strategies to mitigate the impact of increased tax liabilities, such as optimizing operational efficiencies or reassessing their market strategies.

The risk associated with the new tax law, which imposes a 1% turnover tax, becomes evident when analysing the simulation of its potential impact over the last five years for the major agricultural commodity traders in Romania. The simulation reveals that the total tax payable under this new regime would be €190.97 million, which is nearly equivalent to the combined gross profit of €196.96 million reported by these companies during the 2018-2022 period. This situation poses several risks and challenges:

- Profitability Threat: If the 1% turnover tax were to consume almost the entire gross profit of the companies, it would leave them with little to no net profit after the tax payment. This could threaten the very viability of their operations, as businesses must maintain a certain level of profitability to be sustainable.
- Investment and Growth: With most of the gross profit being channelled to meet tax obligations, the companies would have significantly less capital available for reinvestment into their operations. This could stifle growth, innovation, and the ability to compete effectively, both domestically and internationally.
- Operational Adjustments: Companies may need to make drastic operational changes to cope with the increased tax burden. This could include cost-cutting measures that might reduce quality or output, or it could lead to increased prices for consumers, which could impact demand [11].
- Supply Chain Impact: The increase in operational costs due to the higher tax burden could lead to a ripple effect throughout the supply chain. Commodity traders might reduce the prices they are willing to pay suppliers, including farmers, which could have broader economic implications for the agricultural sector [24].
- Market Competitiveness: The new tax could impact the competitiveness of Romanian traders on the global market. If traders from other countries with more favourable tax systems can operate at lower costs, they could offer more competitive pricing, potentially eroding the market share of Romanian companies.
-Fiscal Planning Uncertainty: The unpredictability of turnover, which can be influenced by market volatility, weather conditions, and global economic shifts, makes fiscal planning under a turnover tax more challenging compared to a profit-based tax system.
- Cash Flow Concerns: Since turnover taxes are paid regardless of profitability, in a bad year where companies might have low or no profits, they would still owe a significant amount of tax, which could create cash flow issues.

The implementation of the 1% turnover tax poses a substantial risk to the financial health and competitiveness of Romania's key agricultural commodity traders. The simulation starkly illustrates the potential for such a tax to absorb the bulk of gross profits, necessitating careful consideration and planning by both the companies and policymakers to mitigate its impact.

These figures illustrate not just incremental increases but rather exponential ones, suggesting a fiscal landscape that could potentially reshape the way these companies operate. The figures starkly represent the magnitude of change, which will compel grain trading companies to reassess their cost structures and market strategies to navigate the heightened fiscal demands effectively [18]. Such an increase will undoubtedly necessitate a strategic pivot, potentially affecting the entire agricultural sector in Romania, from the large trading companies right down to the individual farmers.

The introduction of a 1% turnover tax on key sectors that support agriculture in Romania, particularly the oil, gas, and banking industries, could substantially raise farming costs. Energy providers may increase fuel prices to offset the tax, while banks may hike interest rates and service fees [35, 36]. Such increases could strain farmers' resources, potentially reducing agricultural productivity and efficiency [25].

Higher production costs passed along the supply chain may lead to elevated food prices for Romanian consumers, affecting all income levels and possibly altering consumer spending patterns. The impact may be especially acute in rural areas, where communities are more vulnerable due to their greater reliance on agriculture for livelihoods. Any additional financial burden on farmers can have a cascading effect on rural economies, jeopardizing the financial sustainability of these communities [22].

The potential increase in food prices due to the tax could contribute to inflationary trends, affecting the broader economy. Given the centrality of agriculture to rural development and the overall economy, the tax policy carries significant implications [30]. Ensuring the financial sustainability of farmers is not only critical for the agricultural sector's competitiveness but also for the vitality of rural areas [21]. It is crucial to approach such fiscal changes with comprehensive economic planning that considers the long-term development and stability of rural communities [17].

This fiscal policy emerges at a time when the agricultural commodities market is already navigating the turbulent waters stirred by the Russia-Ukraine conflict. This has significantly impacted global grain supply chains, adds another layer of complexity and uncertainty for trading companies [9]. As these entities grapple with the direct financial implications of the new tax—simulations indicating substantial increases in tax liabilities—the broader geopolitical landscape underscores the need for strategic agility. The conflict's effect on commodity prices and availability accentuates the challenges faced by these companies, pushing them to reassess operational strategies, supply chain resilience, and market positioning.

On top of these geopolitical and fiscal pressures, Romanian farmers are increasingly affected by climate change and drought, further complicating the situation. These environmental challenges exacerbate the difficulties in maintaining agricultural productivity and sustainability, adding another critical dimension to the sector's hurdles [16]. This scenario paints a picture of an industry at a crossroads, where fiscal policy changes interweave with geopolitical tensions and environmental concerns to shape the future of agricultural trading, highlighting the importance of adaptability and foresight in sustaining sector viability and growth amidst evolving challenges.

CONCLUSIONS

Grain traders in Romania operate in a sector characterized by price volatility and low profit margins. The introduction of a 1% turnover tax adds an extra fiscal burden that could further erode these slim margins. Frequent price fluctuations make profitability even more challenging, potentially leading to business strategy reevaluations with a heightened focus on efficiency and possible cost reductions, including cuts in technology or development investments.The simulation of the 1% turnover tax's effects reveals a potential for dramatically increased tax liabilities for these entities, with the total projected tax nearing their aggregate gross profits. This stark increase from the previously paid profit taxes underlines the substantial fiscal challenges and operational hurdles these companies may encounter, necessitating a thorough reevaluation of their business models, cost structures, and strategic approaches to maintain profitability and sustainability.

While fiscal regulations aim to increase budget revenues, the side effects on the agricultural sector could counterbalance the short-term benefits. Increased fiscal pressure might discourage investments in the agricultural sector, affecting productivity and innovation. In the long term, this could impact Romania's ability to remain competitive in the global grain and oilseed market.

This tax change is not just an accounting issue but a significant strategic challenge. Grain trading companies, operating in a domain with slim profit margins, will need to find innovative ways to counteract the impact of this new tax. Given the impossibility of raising export prices due to intense competition on global markets, it is likely that this fiscal burden will be transferred back along the supply chain. Romanian farmers, who supply the grains, might face lower purchasing prices, thus pressing their profit margins and potential for growth and investment.

Romania's new tax regulations represent an inflection point for grain trading companies, requiring a careful revision of financial strategies. The adjustments that companies will make in the coming months and years will be crucial for maintaining their viability in an ever-changing economic environment.

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DESIGN AND CREATION OF A COMMERCIAL WEBSITE – PRACTICAL SOLUTION FOR ELECTRONIC COMMERCE

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Abstract

Developing a solid online presence for a business in the commercial sector is vital to both its survival and growth. The culmination of all elements, strategies, tactics, and effort exerted by a company in selling products reaches its completion only at the moment of finalizing the sale of the product. An e-commerce business relies on a web-centered information system, built around the website that includes the online store. The purpose of this article is to present an IT solution for creating an e-commerce website as a working tool that incorporates the desire of businesses, consumers, and management to limit costs while simultaneously improving the quality of products and increasing the speed of service delivery. The e-commerce platform presented in this work constitutes a modern solution for implementing an online store, intending to sell agricultural products and equipment. For database management, a relational open-source software, MySQL, has been chosen, preferred for its numerous advantages and its ability to run on almost all software platforms. For fast processing and easy page loading, PHP has been used, which is one of the most popular open-source programs and has the advantage of running on almost all operating systems. The website features a modularized structure, consisting of administration, authentication, payment, and order launch/cancellation modules. All these components contribute to the optimal functioning of the e-commerce application.

Key words: *e-commerce, website, database*

INTRODUCTION

In today's world, a business that is not present on the web practically does not exist. It is much more convenient for the user to order with a click than to travel to the manufacturer's/provider's headquarters or a retail outlet. E-commerce is concerned with the presentation, sale, and marketing of goods and services through the technologies offered by the Internet.

The main advantages that e-commerce and, in general, automated information solutions bring to the activities of businesses are as follows [1]:

✓ facilitates the expansion of business by providing quick access to local and national markets, but more importantly, to international markets;

✓ reduces costs associated with the conduct of the company's activities, particularly those related to information creation, processing, distribution, storage, and retrieval;

✓ creates the possibility for easy customization of products and services according to the buyers' needs;

✓ adaptation to changes can be faster through the use of e-commerce technologies;

✓ generates new business models – customer databases and preferences can provide crucial information for subsequent decisions;

✓ communication and transportation costs are significantly reduced;

✓ product promotion is carried out more extensively and rapidly.

Among the multiple advantages for consumers, we can specify the following [3]:

✓ provides consumers the opportunity to buy or engage in transactions 24 hours a day, throughout the year, from almost any location;

✓ buyers can more easily choose the lowest price for a product or service;

✓ allows for the rapid delivery of products and/or services (in some cases);

✓ consumers can receive relevant information in a short time: within seconds,

not days or even weeks, as is the case in many traditional businesses;
✓ facilitates competition, leading to a decrease in the prices of products and services;
✓ enables consumers to interact with other buyers through electronic communities,
Additionally, e-commerce brings several advantages to society, including:
✓ providing the opportunity for more people to work and shop from home, which can lead, over time, to a reduction in traffic and pollution;
✓ marketing products at lower prices benefits those with lower incomes, contributing to social protection;
✓ e-commerce contributes to increased efficiency and/or improved quality of products and services.
The purpose of this work is to present an IT solution for creating an e-commerce website - an online store - dedicated to the sale of agricultural products and equipment.

MATERIALS AND METHODS

From a structural perspective, the implementation of an e-commerce platform requires the collaboration of four components (information subsystems) [11]:
→ ***Client*** **-** an equipment, typically a PC, directly connected (via an ISP) or indirectly (through a corporate network) to the Internet; the buyer uses this equipment to navigate and make purchases.
→ ***Merchant*** **-** an information system (hardware and software), usually located at the merchant's premises, which hosts and updates the electronic catalogue of products available for online ordering.
→ ***Transactional System*** **-** the information system that is responsible for processing orders, initiating payments, maintaining records, and other business aspects involved in the trading process.
→ ***Payment Gateway*** **-** an information system responsible for routing payment instructions within financial banking networks, verifying credit cards, and authorizing payments; this system serves as a gateway connecting the global Internet network with the financial banking subnetwork (subject to enhanced security requirements).
In the initial stage, designing electronic commerce systems involves determining the requirements necessary for website development [2],[10]:
✓ Hardware requirements: characteristics of the machines used as servers (memory, hard disk space, processor speed, etc.)
✓ Software requirements: operating system, web server,
✓ Firewall requirements,
✓ Optional program packages (tax calculation programs, etc.),
✓ Software packages for ensuring the security of the website and transactions;
✓ Communications (referring to bandwidth, network topologies, etc.).
The actual design can be divided into two parts:
→ ***Logical Design***, which includes:
- data flow diagram, describing the flow of information on the website, the processing functions to be performed, and the databases to be used;
- description of security elements and backup systems in case of emergencies, as well as the measures that will be taken.
→ ***Physical Design***, which translates the logical design into physical components.
The basic specifications of the website presented in this article were PHP and MySQL.
PHP is a programming language widely used in the development of web pages and applications. By using PHP, so-called dynamic pages can be created, incorporating elements of interactivity and allowing interaction with a database created on a server. To work with PHP, one must first have access to a server running PHP (this can be a separate server or a virtual server created on a personal computer, which can be installed using the free WAMP package) [9].
MySQL is a relational database management system, currently the most popular open-source RDBMS, and a key component of the LAMP stack (Linux, Apache, MySQL, PHP). The administration of the MySQL system is carried out using the ***PHPMyAdmin***

application, designed for managing databases through a web browser [5].

Through PHPMyAdmin, various operations can be carried out, such as creating, modifying, or deleting databases, tables, fields, or rows, as well as executing SQL commands (queries) [8].

Storage engines manage the way data is organized, stored, and accessed. For the e-commerce platform, the ***MyISAM*** storage engine was chosen, which is also the default in MySQL. It is responsible for executing SQL instructions and handling data from data files, ultimately determining the database's performance. The main features of MyISAM influenced the choice of database design and implementation: support for transactions, locking, indexing, and storage [6], [4].

For tables using the MyISAM storage engine, three types of files were defined: *.sdi* for table structure, *.myi* for index table, and *.myd* for data table. An important characteristic is its ability to scale memory (key_buffer_size) for storing both indexes and the processes of retrieval and sorting [7].

The MySQL server's database used for the website consists of interconnected tables, providing optimal transfer of information among clients, merchants, the transactional system, and the payment system.

RESULTS AND DISCUSSIONS

This article presents the stages of designing and implementing a platform for electronic commerce, serving as the foundation for an online store that will sell agricultural products and equipment. For this endeavour, it is necessary to build the database, construct the relevant tables, and populate them with values specific to the domain for which the application was created.

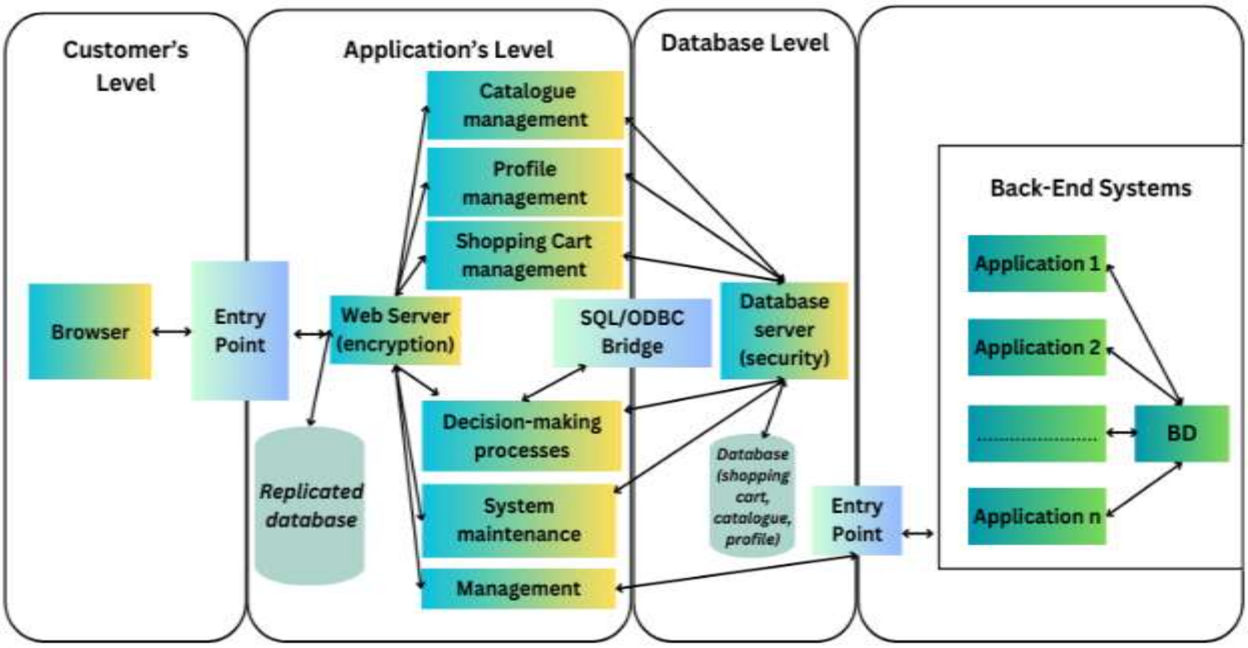


Fig. 1. The e-commerce application
Source: own contribution.

The e-commerce application consists of the following basic elements [2]:

✓ *Web Server* - ensures the functionality of the entire software package of the application.

✓ *Product Catalogue Management* - utilizes data from the product database to generate the catalogue with offerings. Users can browse the catalogue through the browser to search and compare products in the offering.

✓ *Virtual Shopping Cart* - represents the standard way of managing products selected by the customer and placing the order.

✓ *Product Database* - located on the respective server, with the note that the same data may be replicated in databases for users, making it more accessible to the application managing the online store.

The order processing application (purchase order) incorporates the business rules for conducting commercial transactions, with the following actions as premises:

✓ consulting and updating the product database,
✓ price calculation,
✓ selection of the delivery method,
✓ selection of the payment method.

Additionally, the application interfaces with the traditional business activity tracking system through the following actions:

✓ inventory management
✓ order tracking
✓ price calculation
✓ revenue tracking
✓ interactions with third parties, etc.

The Customer Relationship Management (CRM) component manages user profiles based on data transmitted by website visitors and/or data regarding site visitation behaviour, extracted from activity logs managed by the web server.

The Maintenance System component must provide authorized individuals with the capability to develop or reconfigure the system in a manner that is both accessible and secure, preferably through a browser.

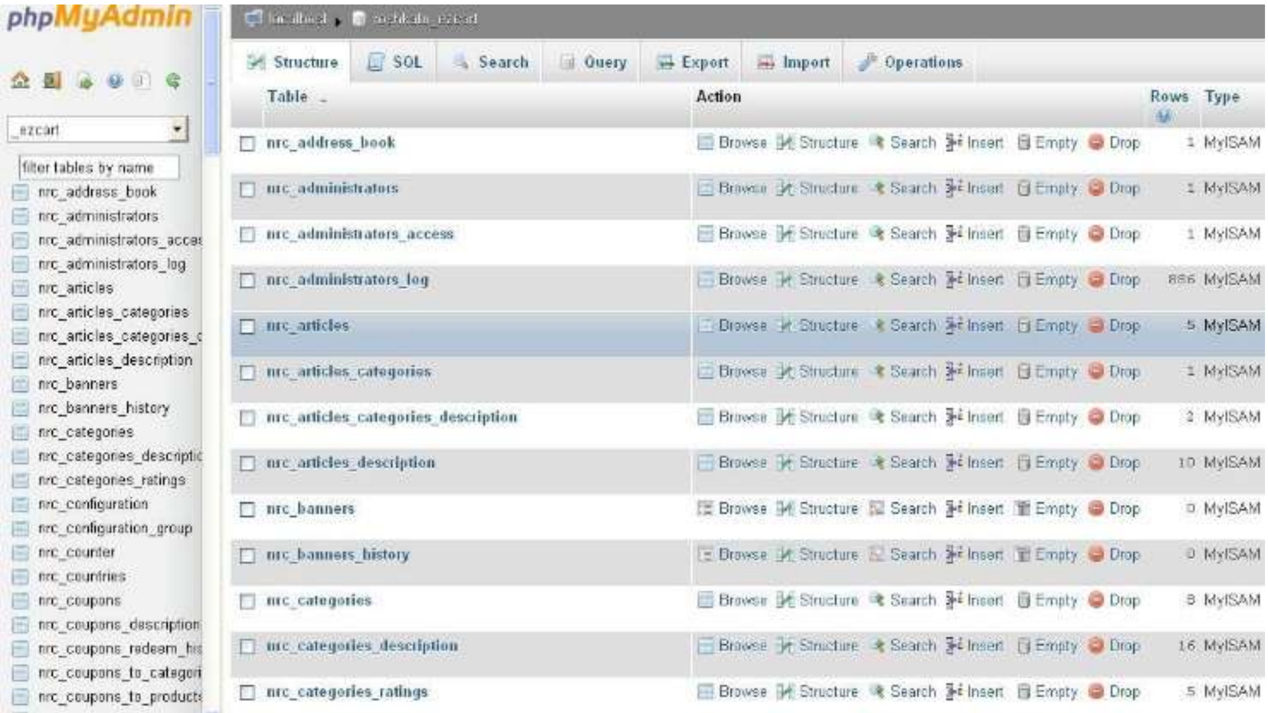


Table	Action	Rows	Type
nrc_address_book	Browse Structure Search Insert Empty Drop	1	MyISAM
nrc_administrators	Browse Structure Search Insert Empty Drop	1	MyISAM
nrc_administrators_access	Browse Structure Search Insert Empty Drop	1	MyISAM
nrc_administrators_log	Browse Structure Search Insert Empty Drop	886	MyISAM
nrc_articles	Browse Structure Search Insert Empty Drop	5	MyISAM
nrc_articles_categories	Browse Structure Search Insert Empty Drop	1	MyISAM
nrc_articles_categories_description	Browse Structure Search Insert Empty Drop	2	MyISAM
nrc_articles_description	Browse Structure Search Insert Empty Drop	10	MyISAM
nrc_banners	Browse Structure Search Insert Empty Drop	0	MyISAM
nrc_banners_history	Browse Structure Search Insert Empty Drop	0	MyISAM
nrc_categories	Browse Structure Search Insert Empty Drop	8	MyISAM
nrc_categories_description	Browse Structure Search Insert Empty Drop	16	MyISAM
nrc_categories_ratings	Browse Structure Search Insert Empty Drop	5	MyISAM

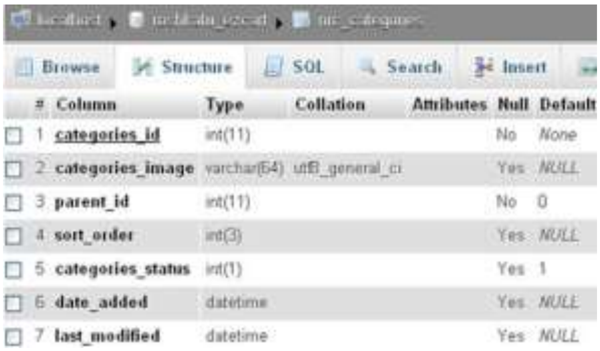
Fig. 2. Capture of the commercial website's database
Source: own contribution

#	Column	Type	Collation	Attributes	Null	Default	Extra	Action
1	id	int(11)			No	None	AUTO_INCREMENT	Change Drop More
2	user_name	varchar(32)	utf8_general_ci		Yes	NULL		Change Drop More
3	user_password	varchar(40)	utf8_general_ci		No	None		Change Drop More
4	user_settings	text	utf8_general_ci		Yes	NULL		Change Drop More
5	email_address	varchar(96)	utf8_general_ci		No	None		Change Drop More

Fig. 3. Fields and characteristics of the Admin table
Source: own contribution.

The database (Fig. 2) belongs to a MySQL server and structurally contains MyISAM tables with complex relationships, optimizing the organization of information.

The following presents the main tables of the database, whose functioning principle involves connecting through a network of the two main parts – the client and the server. In Fig. 3, the structure of the Admin table is presented, which includes the following fields: the ID (the primary key of the table, representing a unique identification number for each administrator account), the username, password, email address of the administrator, and the admin account settings.



#	Column	Type	Collation	Attributes	Null	Default
1	categories_id	int(11)			No	None
2	categories_image	varchar(64)	utf8_general_ci		Yes	NULL
3	parent_id	int(11)			No	0
4	sort_order	int(3)			Yes	NULL
5	categories_status	int(1)			Yes	1
6	date_added	datetime			Yes	NULL
7	last_modified	datetime			Yes	NULL

Fig. 4. Fields and characteristics of the Categories table
Source: own contribution.

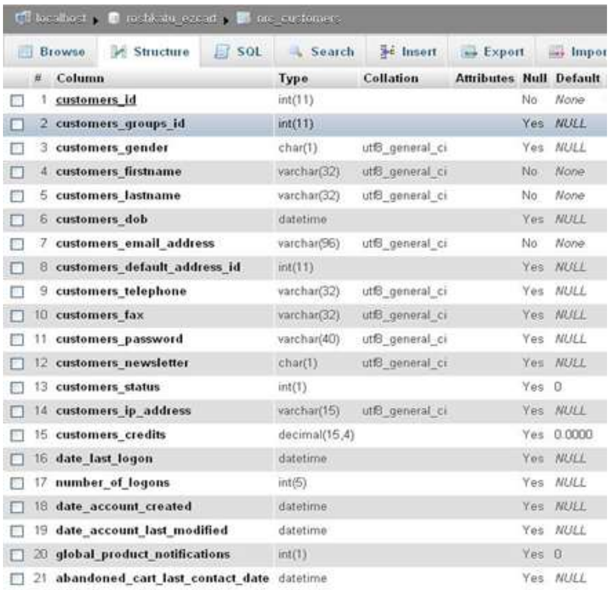
In Fig. 4, the structure of the Categories table is presented, which includes the following fields: category name, category image, category number, sort order, category status, date of addition, and last modification date.

#	Column	Type	Collation	Attributes	Null	Default	Extra
1	products_id	int(11)			No	None	AUTO_INCREMENT
2	products_type	int(4)			No	0	
3	products_quantity	int(4)			No	1	
4	products_moq	int(11)			No	1	
5	products_max_order_quantity	int(11)			No	-1	
6	products_price	decimal(15,4)			No	None	
7	products_sku	varchar(64)	utf8_general_ci		No	None	
8	products_model	varchar(64)	utf8_general_ci		No	None	
9	products_date_added	datetime			No	None	
10	products_last_modified	datetime			Yes	NULL	
11	products_date_available	datetime			Yes	NULL	
12	products_weight	decimal(5,2)			No	None	
13	products_weight_class	int(11)			No	None	
14	products_status	tinyint(1)			No	None	
15	products_tax_class_id	int(11)			No	None	
16	manufacturers_id	int(11)			Yes	NULL	
17	products_ordered	int(11)			No	0	
18	quantity_discount_groups_id	int(11)			Yes	NULL	
19	quantity_unit_class	int(11)			No	None	
20	order_increment	int(11)			No	1	

Fig. 5. Fields and characteristics of the Products table.
Source: own contribution.

In Fig. 5, the structure of the Products table is presented, containing fields related to product characteristics: product ID, type, weight, and quantity of the product, minimum order quantity, maximum order quantity, price, and model of the product, date of product addition, and date from which the product is available.

The Customers table (Fig. 6) contains fields associated with both customer identification elements and actions related to their activity on the site: customer ID, customer group number, gender, customer's first and last name, customer's email address, default address number, phone number, customer's fax, customer's password, newsletter subscription, customer status, customer's IP address, customer's credits, date of last activation, total visit count, account creation date, date of the last account modification, global notifications, date of the last shopping cart abandonment.



#	Column	Type	Collation	Attributes	Null	Default
1	customers_id	int(11)			No	None
2	customers_groups_id	int(11)			Yes	NULL
3	customers_gender	char(1)	utf8_general_ci		Yes	NULL
4	customers_firstname	varchar(32)	utf8_general_ci		No	None
5	customers_lastname	varchar(32)	utf8_general_ci		No	None
6	customers_dob	datetime			Yes	NULL
7	customers_email_address	varchar(96)	utf8_general_ci		No	None
8	customers_default_address_id	int(11)			Yes	NULL
9	customers_telephone	varchar(32)	utf8_general_ci		Yes	NULL
10	customers_fax	varchar(32)	utf8_general_ci		Yes	NULL
11	customers_password	varchar(40)	utf8_general_ci		Yes	NULL
12	customers_newsletter	char(1)	utf8_general_ci		Yes	NULL
13	customers_status	int(1)			Yes	0
14	customers_ip_address	varchar(15)	utf8_general_ci		Yes	NULL
15	customers_credits	decimal(15,4)			Yes	0.0000
16	date_last_logon	datetime			Yes	NULL
17	number_of_logons	int(5)			Yes	NULL
18	date_account_created	datetime			Yes	NULL
19	date_account_last_modified	datetime			Yes	NULL
20	global_product_notifications	int(1)			Yes	0
21	abandoned_cart_last_contact_date	datetime			Yes	NULL

Fig. 6. Fields and characteristics of the Customers table
Source: own contribution.

The Orders table (Fig. 7) contains fields related to the customer's order, as follows: order number (ID), invoice number, customer number, customer name, company name of the customer (for legal entities), street name, sector, postal code of the customer/company address, city, country, phone number, email address, customer's address format, customer's IP address, delivery name, delivery company name, delivery address.

The Wishlists table contains three fields that are keys for relationships within the database:

✓ wishlists_id (it is the primary key of the table, representing a unique identification number for each record);

✓ customers_id (it is a foreign key to the Customers table, representing a unique identification number of the user);

✓ wishlists_token (it is a foreign key to the Products table, representing a unique identification number of the product).

#	Column	Type	Collation	Attributes	Null	Default
1	orders_id	int(11)			No	None
2	invoice_number	varchar(10)	utf8_general_ci		Yes	NULL
3	customers_id	int(11)			No	None
4	customers_name	varchar(64)	utf8_general_ci		No	None
5	customers_company	varchar(32)	utf8_general_ci		Yes	NULL
6	customers_street_address	varchar(64)	utf8_general_ci		No	None
7	customers_suburb	varchar(32)	utf8_general_ci		Yes	NULL
8	customers_city	varchar(32)	utf8_general_ci		No	None
9	customers_postcode	varchar(10)	utf8_general_ci		No	None
10	customers_state	varchar(32)	utf8_general_ci		Yes	NULL
11	customers_state_code	varchar(32)	utf8_general_ci		Yes	NULL
12	customers_country	varchar(64)	utf8_general_ci		No	None
13	customers_country_iso2	char(2)	utf8_general_ci		No	None
14	customers_country_iso3	char(3)	utf8_general_ci		No	None
15	customers_telephone	varchar(32)	utf8_general_ci		No	None
16	customers_email_address	varchar(96)	utf8_general_ci		No	None
17	customers_address_format	varchar(255)	utf8_general_ci		No	None
18	customers_ip_address	varchar(15)	utf8_general_ci		Yes	NULL
19	delivery_name	varchar(64)	utf8_general_ci		No	None
20	delivery_company	varchar(32)	utf8_general_ci		Yes	NULL
21	delivery_street_address	varchar(64)	utf8_general_ci		No	None

Fig. 7. The fields and characteristics of the Orders table
Source: own contribution.

#	Column	Type	Collation	Attributes	Null	Default	Extra	Action
1	wishlists_id	int(11)			No	None	AUTO_INCREMENT	Change Drop More
2	customers_id	int(11)			Yes	NULL		Change Drop More
3	wishlists_token	varchar(32)	utf8_general_ci		No	None		Change Drop More

Fig. 8. *Wishlist* table
Source: own contribution.

The store is structured into 3 sections and is available to any user:
a. Presentation area;
b. Client area;
c. Administration area.

a. *The presentation area* is represented by the website's homepage and is designed for the ordinary, unregistered user. This user can gather information about the store and the displayed products, access the store's catalogue at any time, and navigate to pages such as New Products, Contact, My Account, etc., from the main page. To have full access and be able to order products from the site, visitors need to create a customer account by going through the classic process, providing a username, email, password, etc.

The e-commerce website features several functions that allow the following:
- products can be viewed by component category;
- listing of products can be done by manufacturer;
- advanced search for products can be performed;
- the shopping cart can be viewed;
- modifying the quantity of products is possible;
- adding comments for a specific product is possible;
- any product can be added to the favourites list;
- registration details can be modified;
- the 'wishlist' of products can be viewed.

In Figure 9, the homepage of the website is presented, containing a list of main menus (equipment, pesticides, tools, and accessories), a list that can be updated by the administrator at any time.

Fig. 9. Online Store Interface
Source: own contribution.

In Figure 10, a screenshot of the page displaying the products on promotion with the new reduced prices can be found.

Fig. 10. Promotional Products Page
Source: own contribution.

b. *The customer section* is available to registered users. In addition to the usual features offered to a store visitor, registered users can order desired products. Figure 11 presents a screenshot of the shopping cart, displaying the content of the cart, and the cost of selected products, and from here, the order can be placed for processing.

Fig. 11. Shopping Cart Page
Source: own contribution.

Fig. 12. Order Form Page
Source: own contribution.

Fig. 13. Order Placement and Confirmation Page
Source: own contribution.

On this same page, the customer has two options through two buttons: to continue shopping or to go to checkout. Throughout the navigation, products can be added or removed from the shopping cart. At the end of the shopping session, the customer can submit the order with a single click on the "Go to Checkout" button and will be directed to the page containing the order form (Fig. 12), where the customer needs to fill in the details, and then to the order placement and confirmation page (Fig. 13).

Figure 14 presents the page where users can quickly get in touch with the administrator of the online store through a form.

Fig. 14. Contact Page
Source: own contribution.

c. The administration section is accessible to the administrator of the online store, who may be an employee with access to the store's products, not necessarily the store's programmer. An administrator has access to all pages of the store. Additionally, they can add or modify products, view user orders and contact forms, modify user data and access levels, respond to or delete messages, and process or delete orders when they are not finalized or confirmed.

Fig. 15. Edit Category Page
Source: own contribution.

Security standards for the customer are also met, ensuring that an administrator does not have access to a user's password and cannot log in as a client using their username and password. It is a standard procedure in e-commerce to store all passwords encrypted in the database securely. However, an administrator has access to the entire database and is practically responsible for its management.

The administrator manages the product categories table, and operations such as deleting/editing/adding a newly created category can be performed from the Edit Category page (Fig. 15).

The administrator has the right to edit/add/modify products, and this can be done from the Edit Product page (Fig. 16).

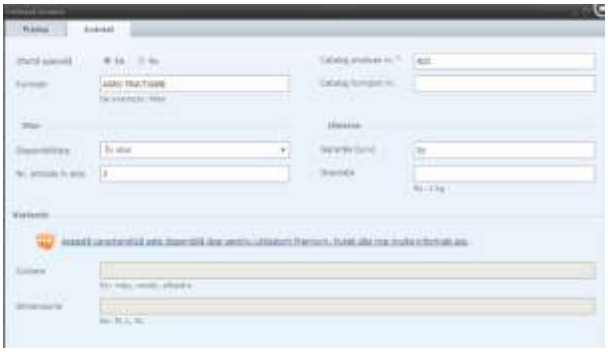


Fig. 16. Edit Product Page
Source: own contribution.

The administrator can add a new product (Fig. 17),

by filling in all the fields on this page: name, price, price without VAT, VAT, initial price (if a discount is applied), product category, description, information, and can subsequently edit and modify them.

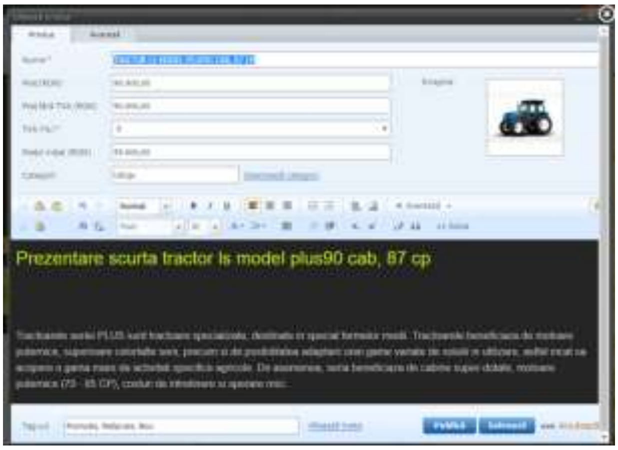


Fig. 17. Add Product Page
Source: own contribution.

Next are the pages where the administrator finds information about customers and can retrieve both the list of customers (Fig. 18) and the list of orders (Fig. 19).

Fig. 18. Customers Page
Source: own contribution.

Fig. 19. Orders Page
Source: own contribution.

The main page in the administration section contains the list of customers along with the following information: name, surname, order placement date, email address, customer group, IP address, visit count, date of the last visit, as well as the order status and payments made.

In the end, the administrator retrieves the order and sends it for processing, and all information about the order is displayed on the final page, as shown in Figure 20.

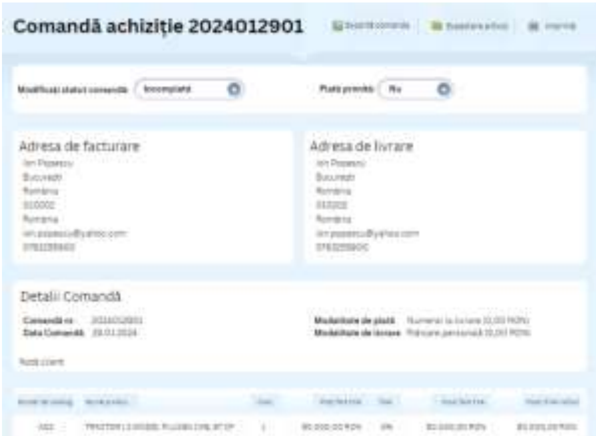


Fig. 20. Order Information Page
Source: own contribution.

CONCLUSIONS

The e-commerce platform developed in this work represents a modern solution for implementing a virtual store aimed at selling agricultural products such as machinery, tools, pesticides, etc. The product list can be easily updated or edited by the website administrator. The MySQL database contains a complex structure and relationships, ensuring that the organization of information is done correctly both logically and physically, while PHP scripts collaborate to ensure the optimal functioning of the web application.

Having a website can be compared to having a business card, and through it, any company can create a positive image, gaining a real advantage over businesses that are not present in the virtual environment. The website is a convenient tool for the online store, and the advantages for a company that owns its website are evident for both the customer and the seller.

Since the 21st century is the era of technology, most companies strive to develop their businesses as much as possible and turn to the most efficient and modern methods of promotion and sales, specifically online methods, which favour communication on the Internet and, consequently, sales, contacts, and the reputation of a company.

The increasing number of e-commerce applications has led to the growth of businesses developing their operations online, attracting a larger number of customers. New technologies have resulted in a decrease in the implementation and development duration of web platforms, making market entry much faster. With all these characteristics, e-commerce applications have a very high reliability and are increasingly used by users worldwide.

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RESEARCH ONTO THE IMPLEMENTATION OF THE ECOLOGICAL LABEL IN AGROTOURISM

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Abstract

The European Ecolabel for tourism accommodation services was created to reward accommodation and environmentally friendly tourists. It is a way of marking good environmental performance and providing quality assurance for tourists choosing a particular structure. The assignment criteria of the ecological label for the tourist housing services are governed by the European Commission Decision no. 287/2003/CE. The work we are proposing is the result of a study by university professors and master students from the management and agro-tourism specialty at the University of Agronomic Sciences and Veterinary Medicine of Bucharest. The study was carried out during 2017-2023 period, the target group consisting of 150 agro-tourist hostels, from the most representative agritourism areas in Romania: Alba, Argeș, Brașov, Bucovina, Buzău, Danube Delta, Harghita, Maramureș, Neamț, Oltenia, Sibiu, members of National Association of Ecological and Cultural Rural Tourism. The study looked at the possibility of implementing the ecolabel for accommodation services in the agro-tourism hostels. Although in 2017 the implementation rate was low – 58%, the results of the year 2023 – 81% are encouraging to implement the Ecolabel in agro-tourism.

Key words**:** *agro-tourism, ecological label, implementing, tourism management.*

INTRODUCTION

Agro-tourism is defined by moving people to an unpolluted rural location, set in a scenic area, completed by a stay of at least 24 hours and by the consumption of specific food and non-food, supplemented by cohabitation and integration in a rural society in all its complexity [4] [3].

This form of tourism comprises two major components: the actual tourist activity, materialized in accommodation, food related services, recreation (travel, fishing, equitation), other current services and, on the other hand, the economic activity (agricultural) the owner of the agro-farm (boarding house), which is involved in the primary production and processing of agro-food products in the household and their direct marketing to tourists or other commercial networks [1] [17].

Agrotourism undoubtedly plays an important role in the overall metamorphosis of rural area, especially villages and small towns with a high degree of rurality and a valuable tourist potential [2] [18]. Settlements with a long historical past, with architectural buildings typical of the region, with their habits, traditions and a way of life, attract tourists who want to know these aspects [7] [19].

Despite agritourism is not a new phenomenon, specific regulation for this tourism segment does not exist thus far in Europe [10] [20].

The development of this sector has been promoted by two EU regulations [8] [13]. EU regulations intended as methods for diversification of farm households in the rural economy and thus contributing to the rural area development [6] [15]. These EU directives are not able to carefully take into account the wide [11] [3] [22].

In this context, the paper aimed to the study looked at the possibility of implementing the ecolabel for accommodation services in the agro-tourism hostels.

MATERIALS AND METHODS

The work we are proposing is the result of a study by the university teachers and master students from the management and agro-tourism specialty at the University of Agronomic Sciences and Veterinary Medicine of Bucharest [21].

The study was carried out during 2017-2023 period, the target group consisting of 150 agrotourist hostels, from the most representative agritourism areas in Romania: Alba, Argeș, Brașov, Bucovina, Buzău, Danube Delta, Harghita, Maramureș, Neamț, Oltenia, Sibiu, members of National Association of Ecological and Cultural Rural Tourism [12] [27] [28].

The study looked at the possibility of implementing the ecolabel for accommodation services in the agro-tourism hostels [16][24].

Fig. 1. Physical map of Romania
Source: [5].

RESULTS AND DISCUSSIONS

The research conducted in this field aimed to compare the criteria for awarding the ecological label for tourist accommodation services with the actual existing conditions. Additionally, it sought to highlight the agritourist sites where the ecological label can be effectively implemented [9] [22].

These criteria can be divided into two groups: compulsory and optional criteria [23] [25].

Compulsory criteria. All such criteria in the group must be fulfilled.

Table 1. The Energy Criteria

1	Electric energy coming from regenerating resources – At least 22% of the electric energy has to come from regenerating resources.
2	Windows insulation.
3	Coal and hard oil fuel – The coal and the resources of hard oil fuel having a sulphur concentration higher than 0.2%.
4	Using electric energy for heating.
5	Air conditioning units.
6	Low energy consumption bulbs.
7	Working capacity of hot water boilers.
8	Lighting switch off.
9	Heat and air conditioning stop.
10	Sauna timing out.

Source: [38].

Table 2. The Water Criteria

1	The housing unit has to announce the authority responsible for the water supply.
2	Water flow at taps and showers.
3	Saving bathroom and toilet water.
4	Garbage baskets in toilets.
5	Changing towels and bed sheets.
6	Watering plants and gardens.
7	Water flow for wee units.
8	Leakages – The personnel has to be trained.
9	Used waters treatment.
10	Administration of used waters.

Source: [38].

Other services:

Public transportation – Tourists and personnel have to be able to get easy access to information regarding the way they can reach the housing unit and other local places by means of the public transportation [24] [26].

Non smoking areas in the common places – In the common places, there have to be a non-smoking area [36] [37].

Table 3. General management system

1	Personnel training.
2	Data regarding the energy and water consumption.
3	Maintenance and repairs of hot water boilers.
4	Maintenance and general repairs
5	Establishing policy and action plan.
6	Tourist information.
7	Other data gathering.
8	The information shown on the ecologic service: Paragraph 2 on the ecologic label has to comprise the following text: (a)measures taken to save energy and water (b)measures taken to reduce waste (c)general measures for a better environment

Source: [38].

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Optional criteria

Criteria regarding the scoring

Based on the information comprised in the title of each criteria in this section, a scoring has been established for all optional criteria. The number of complied criteria has to amount to a total of 16.5 points [29] [14].

The total scoring will be increased with one point for each of the following three supplementary facilities offered which are administrated or constitute the property of the tourist housing unit: food services, sports activities and green areas [30] [32]. The food services include breakfast [34] [35]. The sports activities include a sauna, swimming pools and other facilities located on the ground of the housing unit. Green areas include parks and gardens open for tourists [31] [33].

Table 4. The Optional Criteria

1	**Energy** Photovoltaic and wind generation of electric energy (2 points) – The housing unit has to have a photovoltaic and wind electricity generating system that supplies or will supply 20% of the total annual consumption of electric energy. Energy for heating deriving from regenerating energy resources (1.5 points) – The requirement for renewable energy: At least 50% of the total energy used for heating rooms or hot water must be sourced from renewable energy resources.Energy efficiency of hot water boiler: The housing unit must possess a hot water boiler with a '****' energy efficiency rating. NO(x) emissions of the hot water boiler: The hot water boiler must be classified under class 5 as per the Romanian standard SR EN 297/A3:201, governing NO(x) emissions, and it must release less than 70 mg NO(x)/kWh.-Urban central heating.-Combined heating and electric energy production.-Heating pumps.-Heat recuperation: The housing unit must be equipped with a heat recuperation system, earning one or two points based on the system's capacity.-Heating adjustment: The temperature in each room must be individually adjustable.-Insulation of the existing premises: The building must be insulated according to the national minimum criteria to significantly decrease energy consumption.-Air conditioning: The air conditioning system must be of class A. Automatic switch off of the air conditioning (1 point) Bioclimatic architecture (2 points) – The housing unit has to be built in full respect of the bioclimatic architectural principles. Freezers (1 point), dishwashing machines (1 point), laundry washing machines (1 point), and office equipment (1 point) that are efficient from an energetic point of view, class A. Location of freezers (1 point) Automatic lighting switch off in the tourist rooms (1 point) Automatic outdoor lighting switch off (1 point)
2	**Water** Using rainwater (1.5 points) and re-circulated water (1.5 points) – The water flow at taps and showers (1.5 points). The toilet water flow (1.5 points. The dishwashing machine's water consumption (1 point) The laundry washing machine water consumption (1 point) The temperature and water flow of the tap water (1 point) Shower timers (1 point)
3	**Dangerous chemical substances** Detergents (maximum 4 points) – 80% should have an ecologic label. Dyestuff and indoor varnish (1 point) – 50% ecologic label Swimming pool disinfectant dosage – (1 point) Mechanical cleaning (1 point) Ecologic gardens (1 point)
4	**Wastes** Tin packing (2 points) Single-use doses for drinks (2 points) Breakfast packing (2 points) Fat/oil discharge (2 points) Old textile materials and furniture (2 points)
5	**Other services** Communication and education regarding environmental protection (1.5 points) Rooms for non-smokers (1 point) Bicycles (1 point) Recyclable bottles (2 points) Paper products (up to 2 points) Long-lasting goods (up to 3 points) Ecologic food (1 point) Local food products (1 point)
6	**General management** EMAS registration (3 points) or ISO certification (1.5 points) of the housing unit EMAS registration (1.5 points) or ISO certification (1 point) of the suppliers Questionnaire regarding environment protection (1 point) Electricity and water meters (1 point) Extra measures for environmental protection (maximum 3 points)

Source: [38].

Between 2017 and 2023, a study was conducted targeting 150 agritourism hostels located in the most representative agritourism areas of Romania, namely Alba, Argeș, Brașov, Bucovina, Buzău, Danube Delta, Harghita, Maramureș, Neamț, Oltenia, and Sibiu. These hostels are members of the National Association of Ecological and Cultural Rural Tourism. The study aimed to assess the feasibility of implementing an eco-label for accommodation services in agro-tourism hostels. The initial findings in 2017 indicated a low potential for implementation, standing at 58%. In 2023, the implementation rate was 81%, by 23 pp. higher.

Table 5. Obtained results

AREA	RESULTS 2017	RESULTS 2023
ALBA	57%	80%
ARGEȘ	60%	82%
BRAȘOV	73%	95%
BUCOVINA	70%	92%
BUZĂU	50%	73%
DANUBE DELTA	42%	64%
HARGHITA	66%	88%
MARAMUREȘ	60%	82%
NEAMȚ	50%	72%
OLTENIA	55%	77%
SIBIU	72%	94%
TOTAL:	**58%**	**81%**

Source: Our calculation.

Interpretation of results based on compulsory and optional criteria

The increase in the degree of implementation in 2023 compared to 2017 is explained by the following:

- Many guesthouses obtain electricity and hot water from renewable resources, through the use of photovoltaic panels, acidified from their own resources or from government funds;
- Many hostels have implemented modern air and lighting systems, based on motion sensors and led systems;
- Accommodation units installed sensor-based water use systems in the bathroom and shower;
- Most of the residual water is recycled and used for watering own plants and gardens;
- Application of legislation regarding the prohibition of smoking in public places;
- All electrical appliances (supplied air, TV, refrigerator, freezer, boiler are energy class A, which save electricity);
- Development of the selective waste collection system;
- Banning or limiting the use of plastic bags, plastic cutlery, plastic containers in the bathroom;
- Widespread use of organic detergents;
- Bath towels are washed only if necessary;
- The buildings were, for the most part, insulated externally and internally, avoiding heat loss;
- Increased consumption of organic food, some obtained in the respective area;
- ISO management systems were implemented;
- The staff was trained to apply the new rules;
- Tourists were informed through leaflets and posters, located at the reception or in the rooms;
- Investments made by municipalities to modernize water and sewage systems.

Interpretation of the results by area:

Agritourism areas with a high percentage:

- They have a more developed water and canal infrastructure;
- They are economically more developed areas.
- Pensions have a higher degree of occupancy, therefore higher incomes;
- They have implemented selective waste collection systems;
- Administrators or owners of guesthouses are more trained;
- They have implemented ISO management systems;
- In the respective areas there are more guesthouses of 4 and 5 daisies, therefore more modern and developed;
- Tourists who come to these areas are mostly foreigners, more attentive to eco norms.

Agritourism areas with a lower percentage:

- They have not developed the water and canal infrastructure, in some cases (Danube Delta) it does not exist;
- They have not implemented ISO management systems;

- In the respective areas there are more guesthouses of 1, 2 and 3 daisies, therefore less developed;
- They are the least developed area from an economic point of view;
- Pensions have a lower degree of occupancy, therefore lower incomes;
- They have not implemented selective waste collection systems;
- Hostel managers or owners are less trained.

CONCLUSIONS

The results suggest a substantial need for a significant allocation of funds, which should be sourced from both local and central authorities to improve infrastructure. Furthermore, a substantial effort from individuals crossing borders is crucial. It's worth noting that these funds cannot be fully met by the profits generated from the eco-label's implementation. One potential solution could involve accessing finances from European sources or securing low-interest loans from financial institutions.

The favorable outcomes observed in 2023 offer encouragement for introducing the eco-label in agritourism, with an impressive rate of 81%.

We must mention the fact that, at the present time, there is no guesthouse in Romania that holds the ecological label.

The explanations would be the bureaucracy at the Ministry of the Environment, the rather high costs for authorization and the fact that this certification is voluntary, being more of a marketing tool.

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COST AND PROFITABILITY ANALYSIS IN CARNATION PRODUCTION: THE CASE OF ISPARTA PROVINCE, TÜRKİYE

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Abstract

In this study, it was aimed to analyze the cost and profitability of carnation production in Isparta province, Türkiye. The main material of the study was the data obtained by survey method from producers growing carnations in Isparta province. Data were collected by face-to-face interviews with producers. 25 producers were interviewed according to the complete count method. Farms were examined by dividing them into two groups according to their size. According to the research results, total land assets, carnation production area and number of parcels per farms II it was found to be higher in the group. Carnation area accounted for 85.70% of all land assets. It was found that the farms under investigation grew the Standard and Spray carnation kinds. Production costs per decare were lower in Group I. Production costs per branch were lower in the farms in Group II due to higher productivity. Average gross and net profit per decare IIt was found to be higher in group farms. Profit margin per branch and the ratio of profit margin to sales price are similarly shown in the group II were higher in group farms. As a result, it can be said that large farms are more advantageous in terms of economic criteria. Therefore, it is important to support farmers in growing their carnation-producing regions.

Key words: *Carnation, ornamental plants, economic analysis, Türkiye*

INTRODUCTION

The industry for decorative plants, which contributes significantly to the production of plants, has an important place in the world thanks to its high added value and high export potential. Ornamental plants are preferred as a decorative element that brings happiness on special occasions and social events. Ornamental plants are divided into four groups: cut flowers, indoor ornamental plants, outdoor ornamental plants and natural flower bulbs [7].

The cut floriculture sector, which has a significant foreign trade value worldwide, is a rapidly developing investment area. In the early 20th century, this sector started to gain importance and today it is known to be cultivated in about fifty countries. The largest share in terms of production areas in the world belongs to Asian countries. The Asian continent is followed by the American continent and the European continent [10].

Türkiye has a lot going for it when it comes to growing beautiful plants because of its ideal climate and geographic location, ease of access to other market nations, and inexpensive labor. 95% of high added value is produced in the ornamental plant industry [8].

Türkiye's advantageous geographic location, close proximity to market nations, and inexpensive labor force make it a perfect place to cultivate ornamental plants [8].

According to 2022 data, ornamental plants are produced on a total area of 5,687 ha in Türkiye. Outdoor plants and cut flowers constitute 70% and 26% of the production areas, respectively [12].

In Turkey, ornamental plant exports have been produced for around thirty-five years. In 2022, exports of ornamental plants and products came to a total of $137.2 million. Roughly 36% of the export value of ornamental plants is made up of cut flowers. In 2022, Türkiye exported ornamental plants to 70 countries. The top three ornamental plant export destinations are the Netherlands, Germany and Uzbekistan. Other important export markets are Azerbaijan, England, Georgia, Turkmenistan, Iraq, Russia and Italy [8].

Commercial production of cut flowers in Türkiye started in and around Istanbul in the 1940s and Yalova province has become an important production center. Yalova was followed by Antalya in the Mediterranean region and Izmir in the Aegean region [4].

Türkiye's cooperation with international organizations played an important role in the development of cut flower production. In the 1970s and 1980s, FAO (Food and Agriculture Organization of the United Nations) and the World Bank funded several research initiatives in the 1970s and 1980s to help Turkey's cut flower industry grow. [1].

Carnation ranks first in cut flower production in Türkiye. Rose and chrysanthemum follow carnation in second and third place. In 2022, a total of 986,298,552 carnations were produced in 14,665 da area in Türkiye. In carnation cultivation in Türkiye, Isparta province has a share of 28.05% in terms of production area and 24.64% in terms of production amount. According to these data, Isparta ranks second in Türkiye after Antalya [12].

The goal of this study was to examine the expenses and financial performance of producing carnations in the province of Isparta, which has a significant potential for producing carnations in Türkiye. Calculations were made for the study's general producer characteristics based on farm groups, land availability, kinds of carnations grown, production costs, and profitability indicators. It is believed that producers, prospective investors, and policy officials will find value in the data gathered from the study.

MATERIALS AND METHODS

The primary source of data for this research was the initial questionnaire-based data collected from carnation farms in the province of Isparta. Furthermore, comparable research, reports, and data on the topic produced by other people and organizations were also incorporated. The survey data pertains to the 2022 production period.

In line with the information obtained from the records of Isparta Provincial Directorate of Agriculture and Forestry, the central district where carnation production is intensively carried out was selected as the research area. The total number of farms producing carnations in the central district is 28 and 25 farms were interviewed face to face. Since the land sizes of the farms differed from each other, it was decided that the farms should be divided into two groups in order to homogenize the population. Accordingly, the farms were classified as group I (1-24 decares; 12 farms) and group II (>24 decares; 13 farms). The data collected from the determined farms by questionnaire method were transferred to the computer environment, calculations were made in Microsoft Excel and SPSS programs and interpreted by creating charts. Independent sample t test was used to determine the significance levels of the variables between the farms groups. Significance levels of $p<0.01$, $p<0.05$ and $p<0.10$ were selected.

The research region's foreign labor wages served as the foundation for calculating the family labor wage equivalent. The computation of general administration expenses involved deducting 3% from the overall variable costs. The variable costs multiplied by half of the interest rate (4.25%) that the Turkish Agricultural Bank applied to loans for crop production were used to compute interest on the revolving fund. Based on the producers' declarations in the research region, the rental cost of bare land was computed.

In the calculation of the annual depreciation of greenhouse capital, the straight line method was used, and the average economic life of the construction in plastic greenhouses was taken as 20 years [9]. Interest on plant capital was obtained by applying 5% interest to the half value of total plant costs [6]. The amount of product obtained as a consequence of the carnation manufacturing activity was multiplied by the sales price to get the gross production value. Gross profit was calculated by subtracting the difference of changing costs from the gross production value, and net profit was obtained by subtracting production expenses from that value. The ratio of gross production value to production expenses yielded relative profit [11].

RESULTS AND DISCUSSIONS

Some characteristics of carnation producers are given in Table 1. It was found that the producers in Group II had more experience and a longer educational background than the producers in Group I. In the same way, the proportion of producers who received training on carnation cultivation, who were members of cooperatives, who met with extension staff and who used credit was higher in Group II. There was no significant difference between the groups in terms of the average age of the producers. In Group I, the number of family members was found to be larger. It was discovered that there was a statistically significant difference between the groups with regard to the length of the producers' education, the frequency of training in carnation cultivation, and the frequency of meetings with extension personnel.

Table 1. Producers' characteristics

Properties	Farm groups (da)		Mean	P-value
	I	II		
Age (year)	47.83	48.38	48.12	0.767
Education (year)	11.08	14.15	12.68	0.000*
Experience (year)	13.92	18.23	16.16	0.039
Population (person/family)	4.08	3.54	3.80	0.246
Receiving training on carnation cultivation (%)	16.67	61.54	44.00	0.070***
Membership of cooperative (%)	41.67	66.67	52.00	0.340
Meeting with publishing staff (%)	66.67	100.00	84.00	0.022**
Using credit (%)	83.33	92.31	88.00	0.510

*: p<0.01, **: p<0.05, ***:p<0.10
Source: Own calculation.

The land assets of the farm are given in Table 2. Total land per farm, land held for rent, carnation production area and number of parcels per farm were found to be higher in Group II. It was discovered that there was a statistically significant difference between the farm group averages. In accordance with the average of all farms, each farm had 6.36 plots and 37.49 da of land. Carnation area accounted for 85.70% of all land assets. When the ownership status of the lands is analyzed, it is seen that the share of the land operated by tenancy is high. The rented rate was calculated as 80.26%.

Table 2. Land availability in farms

	Farm groups (da)		Mean	P-value
	I	II		
Total land size (da/farm)	16.35	57.00	37.49	0.000*
Carnation land size (da/farm)	11.02	51.62	32.12	0.000*
Property land size (da/farm)	7.50	7.31	7.40	0.963
Rent land size (da/farm)	8.85	49.69	30.09	0.000*
Number of parcels (numbers/da)	3.58	8.92	6.36	0.000*

*: p<0.01, **: p<0.05
Source: Own calculation.

Table 3 shows the carnation kinds grown by the producers along with the percentage of farmers who grow these varieties. The two carnation kinds that were grown on the farms under investigation were found to be Standard and Spray. Based on the average of all farms, it was discovered that 20% of farms were growing only the Standard type, 24% were growing only the Spray kind, and 56% were growing both varieties simultaneously. The percentage of farms cultivating both carnation kinds together was higher in Group I and Group II farms, according to an analysis of farming groups. According to a survey by Ozdemir [10] in the region of Antalya, a larger percentage of farms (49%) grew both Standard and Spray types simultaneously.

Table 3. Carnation varieties produced in farms

	Farm groups (da)				Mean	(%)
	I (n)	(%)	II (n)	(%)		
Standard	4.00	33.33	1.00	7.69	5.00	20.00
Spray	2.00	16.67	4.00	30.77	6.00	24.00
Standard and Spray	6.00	50.00	8.00	61.54	14.00	56.00
Total	12.00	100.00	13.00	100.0	25.00	100.00

Source: Own calculation.

The cost elements of carnation production activity are classified as fixed and variable costs. A cost that changes according to the amount of output is called a changing cost. Conversely, fixed costs are expenses that are independent of production volume; that is, they are incurred whether or not production is undertaken [5]. Table 4 lists the cost components and production shares of carnations for each farm. According to farm groups, the average cost of producing one decare of carnations was determined to be 107,093.24 TL, Group II's cost was 111,083.26 TL, and Group I's cost was 101,524.87 TL. As a result, Group I had lower manufacturing costs per decare than Group II. The group average differences were determined to be statistically significant ($p<0.01$).

The mean value of all farms indicates that 64.49% of total production costs are attributable to variable expenses, while 35.51% are attributable to fixed costs. Upon analyzing the cost components, seedlings ranked first (at 22.99%), followed by permanent labor (18.99%), fertilizer (13.39%), plastic sheeting (11.10%), and chemical pesticides (10.27%) in terms of input expenses overall. These five inputs account for 76.74% of total production expenses. In a research by Ozdemir [10] in the province of Antalya, the proportion of fixed costs to total production costs in the carnation industry was 47.67% and the proportion of variable costs was 52.33%.

Table 4. Production costs in farms (TL/da)

Cost items	Farm groups (da)				Average	(%)	P-value
	I	(%)	II	(%)			
Seedling	24,375.00	24.01	24,850.00	22.37	24,622.00	22.99	0.5523
Tool-machine rental	1,200.00	1.18	1,223.08	1.10	1,212.00	1.13	0.1125
Plastic sheeting	12,527.78	12.34	11,288.46	10.16	11,883.33	11.10	0.2214
Chemical pesticides	11,333.33	11.16	10,692.31	9.63	11,000.00	10.27	0.6074
Fertilizer	15,916.67	15.68	12,892.31	11.61	14,344.00	13.39	0.1481
Electricity and water	1,544.19	1.52	1,274.97	1.15	1,404.20	1.31	0.2211
Rope	1,466.67	1.44	1,619.23	1.46	1,546.00	1.44	0.2050
Product insurance	-	0.00	461.54	0.42	240.00	0.22	-
Revolving fund interest	2,905.45	2.86	2,732.83	2.46	2,815.69	2.63	0.2550
Variable cost (A)	71,269.09	70.20	67,034.72	60.35	69,067.22	64.49	0.2550
Administrative costs (A*0.03)	2,138.07	2.11	2,011.042	1.81	2,072.02	1.93	0.2550
Permanent labor	17,583.33	17.32	21,734.62	19.57	20,340.00	18.99	0.0203**
Depreciations	4,018.75	3.96	10,680.77	9.62	7,483.00	6.99	0.0000*
Interest	2,565.62	2.53	5,745.19	5.17	4,219.00	3.94	0.0000*
Land rent	3,950.00	3.89	3,876.92	3.49	3,912.00	3.65	0.6680
Total fixed costs (B)	30,255.78	29.80	44,048.54	39.65	38,026.02	35.51	0.0000*
Total production cost (A+B)	101,524.87	100.00	111,083.26	100.00	107,093.24	100.00	0.0000*

*: $p<0.01$, **: $p<0.05$

Source: Own calculation.

When evaluating the competitiveness of production activities, gross profit is a key performance indicator [3].

Gross, net and relative profits per decare in carnation production are given in Table 5. The table shows that Group II farms had larger gross, net, and relative profits for each decare than Group I farms. By averaging I., II., and all farms, gross profit per decare was computed as 63,697.92, 94,787.77, and 79,769.18 TL. There was determined to be a statistically significant difference ($p<0.01$) between the groups. In Group I, the net profit per decare was 33,442.14 TL; in Group II, it was 50,739.23 TL; and in the average of all farms, it was 41,743.16 TL. A significantly significant difference ($p<0.05$) in net profit per decare was seen between the farm groups. Relative profit is another metric used to assess the performance of production branches. Group II farms had a relative profit of 1.46, while Group I farms had a relative profit of 1.33. It was determined that there was a statistically significant difference ($p<0.10$). 1.39 was found to be the relative profit based on the average of all farms. These findings suggest that large farms outperform small farms in terms of profitability. A study by

Barlas et al. [2] in İzmir province found that carnation production was more profitable than other cut flower species, and a study by Ozdemir [10] in Antalya province found that gross and net profit per decare increased in tandem with the size of the farm.

Table 5. Profitability indicators of farms

Indicators	**Farm groups (da)**		**Average**	**P-value**
	I	II		
Yield (branch /da)	112,083.33	132,307.69	122,600.00	0.020**
Price (TL/branch)	1.20	1.22	1.21	0.168
Gross product value (TL/da)	134,967.01	161,822.49	148,836.40	0.007*
Variable costs (TL/da)	71,269.09	67,034.72	69,067.22	0.255
Production costs (TL/da)	101,524.87	111,083.26	107,093.24	0.000*
Gros profit (TL/da)	63,697.92	94,787.77	79,769.18	0.004*
Net profit (TL/da)	33,442.14	50,739.23	41,743.16	0.043**
Relative return	1.33	1.46	1.39	0.085***

*: p<0.01, **: p<0.05, ***:p<0.10
Source: Own calculation.

Table 6 provides the profit margin and the profit margin to sales price ratio for a single carnation. One carnation's sales price was subtracted from the production costs to determine the profit margin. It was discovered that Group II farms had a larger profit margin than Group I farmers. There was a statistically significant difference (p<0.05) between the groups. For each branch carnation, the profit margin was calculated as follows: 0.30 TL for farms in Group I, 0.38 TL for farms in Group II, and 0.34 TL for the average of all farms.

Table 6. Profit margin of 1 branch of carnation in farms

Indicators	**Farm groups (da)**		**Average**	**P-value**
	I	II		
Production costs (TL/da)	101,524.87	111,083.26	107,093.24	0.000*
Yield (branch/da)	112,083.33	132,307.69	122,600.00	0.020**
Production cost per branch (TL/branch)	0.91	0.84	0.87	0.116
Price per branch (TL/branch)	1.20	1.22	1.21	0.168
Profit margin (TL/branch)	0.30	0.38	0.34	0.050**
The ratio of profit margin to sales price (%)	24.78	31.35	28.05	0.064***

*: p<0.01, **: p<0.05, ***: p<0.10
Source: Own calculation.

The amount that is profit and how much is expense in the carnation sales price was computed using the profit margin to sales price ratio (profit margin/sales price*100) criterion.

According to the average of all farms, this ratio was determined as 28.05%. According to these results, while the farms in Group II made a profit of 31.38% for every 1 carnation they sold, the farms in Group I made a profit of 24.78%. The difference between the groups was statistically significant (p<0.10).

CONCLUSIONS

As a result, The average area used for carnation cultivation was found to be 32.12 da, and the producers' favorite cultivars were

Standard and Spray. Production expenses per decare and per branch were computed to be 107 093.24 TL and 0.87 TL, respectively, based on the average of all farms. In terms of total production expenses per decare, the top five items were seedlings (22.99%), permanent labor (18.99%), fertilizer (13.39%), plastic cover (11.10%), and chemical pesticides (10.27%). The net profit per decare was determined as 33,442.14 TL in Group I farms and 50,739.23 TL in Group II farms. The profit margin of 1 branch of carnation was determined as 0.30 TL in Group I farms and 0.38 TL in Group II farms. The ratio of profit margin to sales price was determined as 24.78% and 31.35% in Group I and II farms. These findings led to the conclusion that large farms had more advantages in terms of profitability metrics. Therefore, incentive measures should be taken to increase the capacity of the farms in the research region.

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OPPORTUNITIES AND CHALLENGES ASSOCIATED WITH AI-BASED DIGITAL TECHNOLOGIES USAGE FOR AGRICULTURAL EXTENSION SERVICES IN NIGERIA

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Abstract

Digitalization of agriculture has been identified as panacea to the problem of food security to teeming population, although its uses for agricultural extension services is still evolving and challenging among extension professionals. This study examined the opportunities and challenges of using AI-based digital tools for agricultural extension services in Nigeria; the study described the socioeconomic characteristics of extension professionals and identified the effects of its usage on extension service delivery. An online questionnaire was used to gather primary data from 131 agricultural extension professionals drawn across the states in Nigeria. Frequency counts, percentages and means were used to analyse and summarize the data collected. The result reveals that majority (75.6%) were male with a mean age of 48.1±15.8 years. The respondents mostly identified provision for real-time insights into the farms and landscape (97.7%) and provision of reliable farm data (75.6%) as the major opportunities for AI-based Digital tools for agricultural extension service, while lengthy technology adoption Process (94.7%) and higher technical skills (70.2%) were the major challenges identified with the use of AI-based digital tools for agricultural extension services by the respondents. The study also reveals that respondents mostly indicated timely enhancement of communication (88.5%) and provision of an update on best practices globally (64.1%) as the key effects of AI-based digital for agricultural extension services. The study recommends that capacity building of extension professionals and farmers; involvement of farmers and other agriculture value chain stakeholders in the development of digital technologies; as well as provision of digital infrastructures and enablers which are germane for digitalization and utilisation of AI-based digital tools for agricultural extension service delivery in Nigeria.

Key words: *agricultural extension delivery, extension professional, digital tools, information dissemination, utilisation*

INTRODUCTION

Dissemination of agricultural information is a crucial task performed by agricultural extension to link agricultural stakeholders with the most recent technology required for optimal performance that would lead to the growth of the community at large [1]. According to [21], the availability of quality information and its frequent flow to the farming community has a direct relationship with better farm production and the prosperous life of the clientele. Agricultural extension and advisory services (EAS) make it easier for farmers to access the information, knowledge, tools, resources, and financial services needed to increase their productivity and subsequently, their farm and non-farm earnings especially in challenging and emergencies as witnessed during emergence of Covid-19 pandemic which negatively impacted on every sector of the society all over the world [4]. But many rural regions of the world still have serious issues with access to agricultural extension services. The lockdown and its attendant restrictions from nations' government prevent close contact between people, as evident in agricultural extension services which largely requires face-to-face interaction with smallholder farmers for farm visits, training, demonstrations, exhibitions, and field days. This automatically led to a reduction in farmers' access to appropriate extension services. This necessitates the adoption of alternative ways of transferring innovations and improved technologies to smallholder farmers. Apart from this, Covid-19 has indeed presented an opportunity for extension professionals to be creative and think of alternative ways of reaching out to farmers in the era of Information Communication Technology and globalized community [10]. AI-based technologies on digital platforms have become an alternative response for agricultural extension and advisory services to farmers in post-Covid -19 era [4].

Artificial intelligence (AI) is becoming more prevalent worldwide in recent times. It is a creative tool that mimics how human intelligence and technology work, particularly computer systems, robots, and digital devices [3]. [8] defines AI as the emulation of human intelligence (thus, artificial) into machines for tasks that would typically need humans. Complex algorithms and mechanical processes are used to create this intelligence. They are used in smartphones, cars, social media fields, surveillance, and many more. Artificial intelligence is playing a vital role in modernizing agricultural extension activities. Artificial intelligence systems for extension work will require the constant provision of new information and increasing the amount of information in the back-end database used to perform tasks with greater accuracy.

[23] observed that AI is advancing rapidly and is widely accepted. According to their studies, AI technologies inevitably have the potential to empower people and communities, resulting in more significant social change and better quality of life. [9] reported that several AI-based digital technologies have been deployed and used for agricultural extension and advisory services by smallholder farmers in many African countries. These digital technologies include Esoko, Agrohub, M-Farm, Kilimo Salama, M-Shamba, iCow, MyAgro, Senekela, WeFarm, Farmdrive, mAgri and among others. The benefits of AI-based digital agricultural extension and advisory services are inestimable, especially in the context of the global emergent information economy.

[7] observed that AI-based tools have the potentials of digitalizing agriculture systems and taking it to a higher level in data gathering, dissemination, and advisory services, as well as production and consumption. [20] discovered that AI-based technologies have brought about tremendous increase in productivity in all industries and agricultural sector. In the area of agriculture, AI-based tools have provided solutions the problems of crop yield, irrigation, soil content sensing, crop monitoring, weeding, pest and disease control, crop management, harvesting, processing value addition and marketing.

According to [19], digital technologies could assist in many ways to better tailor various agricultural advisory services to farmers' needs. For instance, location-specific agricultural advice such as weather forecasts, soil conditions, market prices, and other aspects can be developed and delivered to individual farmers through predictive analytics and machine learning algorithms. From the foregoing, the potential of AI-based digital agricultural extension and its attendant challenges is yet to be adequately documented. Identifying challenges seems to be crucial, if those working on a system are not aware of its potential problems, those problems can become threats; with more knowledge, however, they can become opportunities. Unfortunately, insufficient empirical evidence on the opportunities and challenges of AI-based digital agricultural extension and advisory services in Nigeria. Hence this study examined the opportunities and challenges associated with the use of AI-based digital technologies for agricultural extension services in Nigeria. The study profiled the socio-economic characteristics of the respondents in the study area; highlighted opportunities of using AI-based digital technologies for agricultural extension services; highlighted challenges of using AI-based digital tools; and identified the effects of using AI-based digital technologies for agricultural extension service delivery.

Theoretical Framework

This theoretical background for this study is based on the “Use and Gratification” theory of communication propounded by Jay Blumler and Elihu Katz in 1974 which examined media consumption and what benefits it creates for the consumer [5]. The theory explains why people choose and use certain media forms and emphasizes that media have a limit or limited effect on their audience because the audience is able to exercise control over their media. The fundamental idea is that audiences turn to media because they expect media to gratify specific needs. Use and Gratification theory was posited to investigate how media is consumed, and the possible effects the media has on society at large. The emergence of AI digital agricultural extension services has a lot of benefits that will necessitate extension professionals and farmers to adopt these technologies to boost agricultural production and overcome the problems of face-to-face traditional extension approaches

In this context, the aim of the study is to identify the opportunities and challenges of using AI-based digital tools for agricultural extension services in Nigeria.

MATERIALS AND METHODS

Sampling techniques

The study was carried out in Nigeria. The population for the study were extension professionals who were members of various extension professional associations such as RuSAN, AESON and CYIAP. Questionnaire was prepared and validated among experts from the Agricultural Extension and Computer Science departments using an online Google form to obtain a standardized questionnaire. An online validated questionnaire with open and closed questions was administered to 282 extension professionals through their individual e-mail addresses obtained from their professional associations. While a total of ninety-two non-registered extension professionals including contact farmers (farmer-led extension workers) and lecturers in the department of agricultural extension in various institutions in Nigeria were individually contacted. After six weeks, a total of 131 online questionnaires were completed and submitted by these extension professionals. Data collected were processed through Excel sheet and IBM SPSS version 23 and data were analysed through the use of appropriate descriptive statistical tools to summarise the data.

Measurement of variables

Perceived opportunities were measured by asking the respondents to respond to each of the listed conventional opportunities associated with the use of AI-based digital tools for agricultural extension. Yes, was scored one point while no was scored zero. to each listed conventional extension activity. The Maximum score was nine while the minimum was 0. Challenges to the use of digital tools was determined by requesting the respondents to respond to the listed challenges. Positive response was scored one point while no was scored zero. The Maximum score was nine while the minimum was 0. The effects of using AI-based digital technologies for agricultural extension and advisory services was achieved by requesting the respondents to the listed effects of AI-based digital tools for extension service delivery. Their responses were scored as one point for positive response while zero point as negative response.

RESULTS AND DISCUSSIONS

Socio-economic characteristics

Table 1 shows that the mean age of extension professionals was 47.6 ±15.8 years. This suggests that majority of the extension professionals are in their active age, this could have positive implication on the utilization of AI-based technologies because younger people are more adventurous, willing to explore Hi-Tech decives. Also, majority (75.6%) of the respondents were males. this reveals male dominance in extension profession composition in Nigeria. This finding corroborates with the submissions of [2], [17] and [18] that reported male’s domination in extension service in South-Western Nigeria. This signifies that the females are less represented in the agricultural extension and advisory system in Nigeria, which may negatively influence female farmers' access to information and technologies. Majority (89.3%) of the respondents had at least B.Sc. degree. This means that the respondents in the study area were highly educated and had necessary academic qualification which might be needed to adopt AI-based digital technologies for effective extension service delivery. Also, 30.5% and 29.8% were lecturers and researchers in agricultural extension profession. The result shows that every stratum of extension professionals were included to give their opinions on the use of these emerging technologies in agricultural extension services.

Table 1. Respondents' socio-economic characteristics

Variables	Frequency	Percentage	Mean ± St. Dev.
Age			
> 30	12	9.2	
31-45	35	26.7	48.1±15.8
46-60	67	51.1	
≤ 61	17	13.0	
Sex			
Male	99	75.6	
Female	32	24.4	
Level of Education			
ND	3	2.3	
HND	11	8.4	
B.Sc.	39	29.8	
M.Sc.	51	38.9	
Ph.D.	27	20.6	
Categories of extension professional			
Extension Lecturers	40	30.5	
Extension Researchers	39	29.8	
Public Extension Agents	32	24.4	
Private Extension Agents	11	8.4	
Farmer-led extension workers	9	6.9	

Source: Online survey, 2021.

Opportunities for AI-based digital technologies for agricultural extension services

Table 2 reveals that the majority (97.7%) of the extension professionals indicated that AI-based technologies used for extension services offer an opportunity of providing real-time insights. This is because these technologies have the ability to create awareness, assist during sessions of emergency operations, disseminate accurate and real-time information to rural farmers, and teach them to utilize good agronomic practices [11]. The majority (75.6%) of the respondents indicates that the provision of reliable farm data was an opportunity for using AI-based Digital technologies for Agricultural Extension and Advisory Services in Nigeria.

About 67.2% perceived that AI-based digital technologies also help in the proper identification and treatment of farm diseases.

This is due to the simplicity with which farmers can obtain information on how to identify and diagnose pests and diseases, as well as how to differentiate diseases with similar symptoms, how to use biological pest and disease control methods, and the appropriate stage at which to control pests and diseases.

This agrees with the results of [12] who submitted that smallholder farmers in Uganda and Kenya acquired information on the identification and treatment of diseases from digital extension and advisory services. It is also consistent with the submissions of [22] and [16] that management of crop and animal diseases can be done through the use of digital technologies.

About 57% of extension professionals also indicated that AI-based digital technologies are effective in farm management.

This is because it is very easy to get information on weather forecasting, market information, good agronomic practices, credit facilities, quality seeds, fertilizer use, and water management which are essential ingredients of effective farm management.

Besides, half (53.3%) of the respondents perceived AI-based digital technologies for agricultural extension and advisory service offers the opportunity of providing effective communication and advisory services even during times of emergency.

This is because AI-based digital technologies is an interactive platform that has the capacity of providing effective interaction between extension agents and farmer beyond the traditional face-to-face approach, through which information on improved agricultural technologies can be disseminated to the farmers without any delay.

Table 2. Opportunities of using AI-based digital technologies for agricultural extension Services

**Opportunities	Frequency	%
Provision of real-time insights	128	97.7
Reliable farm data	99	75.6
Reliable problem identification and treatment	88	67.2
Effective farm management	75	57.3
Effective communication and advisory services	70	53.4
Improved trust between farmers and extension agents	56	42.7
Increased production	38	29.0
Improved farmers and household livelihood	31	24.0
Reduced vulnerability	22	17.6

**Multiple responses.
Source: Online survey, 2021.

Challenges associated with the used of AI-based digital technologies

The evidence in Table 3 show that the majority (94.7%) of the respondents indicated a lengthy technology adoption process as the prime challenge of using AI-based digital technologies for agricultural extension and advisory services. This supports the submission of [10] who identified the lengthy technology adoption process as one of the constraints of using AI digital tools in extension services. This is because [6] described AI-based digital technologies as a more advanced version of basic technologies for processing, acquiring, and monitoring field data. This requires a proper technological infrastructure and internet connectivity, which are not readily available at present in rural communities as reported by [24]. As a result of this, it will take a longer time for extension professionals and farmers to tap this opportunity in using these tools for agricultural extension and advisory services. The majority (70.2%) of the respondents reveal that lack of higher technical skills was also a challenge to the use of AI-based digital technologies for agricultural extension and advisory services in Nigeria. The prerequisites for using and accessing various digital resources and services are digital literacy and skills which many of the extension personnel and farmers do not possess for the utilization of this AI-based digital technology. This buttress the finding of [15] that most farmers lacked digital skills in using mobile digital applications to access agricultural information.

The majority (65.5%) of the extension professionals also identified privacy and security threat as one of the perceived threats to the use of AI-based technologies. Owning to no clear-cut policies and regulations regarding the use of AI in cyberspace and particularly in agriculture in Nigeria, Extension professionals and farmers may likely face major challenges of privacy and security threats like cyber-attacks and data leaks which could give access to some unwanted people or entities to hack their data [14].

Inadequate involvement of farmers, and other stakeholders' capacity building in the technology development (60.3%) was also identified by the extension professionals as one of the challenges of using AI-based digital technologies for agricultural extension and advisory services. Inadequate involvement of farmers, extension professionals, and other stakeholders in the development of AI-based digital tools for agricultural extension and advisory services could pose a great challenge for them in using these AI-based digital tools effectively for agricultural extension and advisory services. This is because a clear understanding of the audience and their technological aptitude is critical to the positive experience of the users. This supports the position of [9] who submitted that success of AI-based technologies in agricultural extension services is a fundamental thorough understanding of the needs, dynamics, and challenges of the users.

Table 3. Challenges to the use of AI-based Digital technologies

**Challenges	Frequency	%
Lengthy technology adoption process	124	94.7
Requires higher technical skills	92	70.2
Privacy and security threats	86	65.6
Inadequate involvement of farmers and other stakeholders in capacity building and technology development	79	60.3
High-cost implication	64	48.9
Big data management for informed decision –making	28	21.4
Management of internet of Things	22	16.8
Inadequate interdisciplinary AI research and communication	16	12.2

**Multiple Responses.
Source: Online survey, 2021.

Effects of using AI-based digital technologies for agricultural extension services

The results in Table 4 reveals that extension professionals mostly identified timely enhancement of communication (88.5%), providing an update on best practices globally (64.1%), and improved the quality of extension services (51.1%) as the perceived effects of AI-based digital technologies for agricultural extension and advisory service delivery in Nigeria. This is because AI-based technology allows for flexible communication with people regardless of their locations or time of the day and provides capacity for data acquisition and storage. AI-based digital technologies for agricultural extension and advisory services also provide timely and accurate farm data on agricultural information to clientele and extension professionals in all aspects of agriculture which can improve agricultural production. It is evident in these results that extension experts' perception about the use of AI-based digital technologies for agricultural extension and advisory services was similar to that of [13] that stated that extension experts perceived that AI-based technologies for agricultural extension and advisory services had positive effects on the quality of the content and services they delivered. As a result of this, AI-based digital tools for agricultural extension and advisory services could enhance the provision of need-based services to the farmers and other agriculture value chain actors in the agricultural production system

Table 4. Effect of the AI-based Agricultural Extension and Advisory Services

**Effects	Frequency	%
Enhance timely communication	116	88.5
Update on best practices globally	84	64.1
Improves quality services	67	51.1
Help professionals to compete favourably at global platform	57	43.5
Loss of job for extension professionals	56	42.7
Enhance interdisciplinary and holistic expertise	56	42.7
Enhance adequate knowledge and skills	54	41.
Results in effective capacity building	51	38.9
Improves job satisfaction	37	28.2

**Multiple Responses.
Source: Online survey, 2021.

CONCLUSIONS

AI-based digital technologies offer great potentials of transforming agricultural extension services in Nigeria by providing an interactive platform for extension agents and farmers' interaction beyond the traditional face-to-face approach. However, some of the challenges identified can limit these opportunities if they are not addressed. Capacity building of farmers, extension professionals and other agriculture value chain actors should be enhanced through regular trainings, seminars and workshops. There is need for the involvement of all relevant stakeholders in the development of digital technologies meant for their use in order to take into consideration their socio-economic characteristics, digital skills, and language before developing such AI tools. There should be a review of the national curriculum for higher institutions to integrate AI technology concepts and practices into extension education. Finally, affordable smartphones, digital infrastructure, good internet facilities, and affordable cost of internet data should be provided by relevant stakeholders and the government to encourage AI-based digital tool usage for agricultural extension services to enhance effective extension service delivery for sustainable agricultural production in in Nigeria.

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ECONOMIC ANALYSIS OF RAINBOW TROUT CAGE FARMS DIFFERING IN SIZES

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Abstract

This study aims to conduct an economic analysis of the farms breeding rainbow trout in cages in Türkiye. The study was carried out at Karacaören-I Dam Lake in the Western Mediterranean Region of Türkiye. The primary material of the study was the data gathered using the survey approach from all 21 farms. The farms were divided into three groups according to their capacities. According to the results, it was determined that as the size of the farm increased, the production costs per tonne decreased, and the gross and net profits, as well as the relative return, increased. In Groups I, II, and III, production costs per tonne were determined as $1,975.57, $1,703.01, and $1,384.23, respectively, and net profit was $514.21, $724.60, and $1,388.31. It was found that the profit margin of 1 kg of trout and the ratio of profit margin to sales price increased as the farm groups grew. Accordingly, farms in Group III made a profit of 48.90% from each kg of trout they sold, while farms in Group I earned 18.33% and in Group II made a profit of 28.23%. With these results, it was established that large farms were more advantageous from an economic standpoint.

Key words: c*age farms, rainbow trout, cost, profitability, Türkiye*

INTRODUCTION

Fisheries, one of the largest animal protein sources in the world, are an important sector that provides continuous input to the economies of all countries today. The world's population is increasing day by day, and this increase causes both a decrease in food resources and a decrease in the rate of access to healthy food. According to the data from the United Nations Food and Agriculture Organization (FAO), it is stated that the world population is increasing by 78 million annually and will reach the level of 12–13 billion in the 2050s. This will also increase the demand for aquatic products. The aquaculture sector is expressed by FAO as the fastest growing and most constantly developing sector among all food sectors [8].

Day by day, people pay more attention to their nutrition and take care to choose foods suitable for their health. Fish in these foods, with their rich protein content and polyunsaturated fatty acids in their structure, meet the body's basic nutritional needs and are among the most important nutrients in maintaining a healthy life with their positive effects on human physiology and metabolic functions [15].

Türkiye has significant potential in terms of the sea, inland waters, lakes, ponds, and aquaculture resources. She is surrounded by the sea on three sides and has 8,333 km of coastline, 177,714 km of rivers and 342,377 hectares of dammed lakes. The surface area of the sea and inland waters is 25 million hectares. It is important to protect and effectively use the fishing resources of Türkiye [3].

Fishery production is carried out in two ways: hunting (sea and inland water) and aquaculture (sea and inland water). According to the data for 2020, fishery production in Türkiye is 785,811 tonnes, of which 53.63% is obtained from aquaculture and 46.37% from hunting [24]. In recent years, significant progress has been made in Turkish aquaculture systems, and the transportation of

fish farms in the sea to open and deep waters has demanded the application of new techniques appropriate for these conditions. As a result, advances in cage sizes and constructions, net systems, and feeding systems have been developed by employing technology that exceeds global standards [6].
The amount of seafood produced in Türkiye by the aquaculture method is 421,411 tonnes, of which 69.57% was produced in the seas and 30.43% in inland waters. The fish species that are grown intensively within the scope of aquaculture in Türkiye are trout (Rainbow trout and Black Sea trout), sea bream and sea bass. According to 2020 data, the amount of trout produced in inland waters in Türkiye is 127,905 tonnes [24].
The amount of fishery products produced by the fishing method in Türkiye is 364,400 tonnes, 90.91% of which is obtained from the seas and 9.09% from inland waters. Marine fish constitute 71% of the seafood production obtained from the seas. Anchovy is the most important species caught from the sea [24].
The Karacaören-I Dam Lake, where this study was conducted, is located in Türkiye's Western Mediterranean region at the intersection of the provinces of Burdur, Isparta, and Antalya. 2/3 of the lake is located in Burdur, and 1/3 is within the borders of Isparta Province [13]. In Karacaören-I Dam Lake, rainbow trout are raised in cages. This study aims to make an economic analysis of the farms that raise rainbow trout in cages in Karacaören-I Dam Lake. In the study, the general characteristics, production costs, gross production values, gross profit, net profit, and relative return values of the farms producing rainbow trout according to different size groups and the profit margin of one kg of trout were determined, and comparisons were made between the groups, and it was specified which farm group was more advantageous. Studies have been carried out on the technical aspects of trout farming in Türkiye. The number of studies on the economic aspect of trout farming has remained limited. It is expected that the results obtained from this study will be beneficial to policymakers, trout producers, farmers who want to invest in this field, researchers, and other relevant institutions.

MATERIALS AND METHODS

The main material of the study was the data obtained via the survey method from the farms breeding rainbow trout in cages in Karacaören-I Dam Lake. Data was collected through face-to-face interviews with the farmers. In addition to this data, similar studies, reports, and statistics on the subject were also used. The survey data covers the production period of 2021.
A list of farms that raise rainbow trout in cages in Karacaören-I Dam Lake was obtained from the Burdur and Isparta Provincial Directorates of Agriculture and Forestry. According to the records, it was determined that there were a total of 26 farms in the research area. However, since five producers stopped production in 2021, data was collected by interviewing 21 producers. Since the cage capacities of the farms were very different, the trout farms were examined by dividing them into groups to make the population homogeneous. The farms were divided into three groups depending on their frequency of distribution, taking into account their cage capacities. According to this, farms with a capacity of 1–50 tonnes (6 farms) are in Group I, farms with a capacity of 51–100 tonnes (6 farms) are in Group II, and farms with a capacity of 101+ tonnes (9 farms) are classified as Group III. The data collected by the survey method from the chosen farms was transferred to the computer environment, where calculations were made in Microsoft Excel and SPSS programs, and tables were created and interpreted. The General Linear Model (GLM) approach of the SPSS program (SPSS 2017) was used to determine the significance levels of the dependent variables. $P<0.05$ was considered statistically significant in terms of the significance level.
A depreciation expense for tool-machine and building capital was calculated: 12.5% for boats, vaults, chains, anchors, and buoys; 20% for grading machines, nets, and rope; 25% for the pickup truck; 15% for the generator; and

10% for the ice machine; 6.66% for feed storage and containers [2].

The following formulas were used in the calculation of interest on equipment, machinery, and building capital [16].

Interest = (Machinery or building worth) / 2 * Interest rate ……………………………(1)

The real interest rate was used since the year-end values of equipment, machinery, and building capital were taken into account [12]:

$i = (1+r) / (1+f) - 1$ …………………….(2)

where:
i: the real interest rate
r: the net nominal interest rate
f: the inflation rate (WPI- Wholesale Price Index)

At the time of the survey, the annual nominal interest rate was 18.42% and the inflation rate was 14.55%. Thus, the real interest rate was calculated as 3.38%.

General administrative expenses were computed by taking 3% of the variable costs [16]. During the period from the beginning to the end of the aquaculture, the interest in the expenditures made for the aquaculture inputs should also be calculated. This interest, called the revolving fund interest, represents the opportunity cost of the capital invested in the production activity. The revolving fund interest was calculated by using half of the interest rate (2.67%) applied by Ziraat Bank to government-supported aquaculture loans to variable costs [23].

The gross production value was calculated by multiplying the amount of trout obtained as a result of the production activity and the sales price. Gross profit was calculated by subtracting the variable costs from the gross production value, and net profit was calculated by subtracting the production costs. The relative return was also found by the ratio of the gross production value to the production costs [22].

RESULTS AND DISCUSSIONS

General information about the farmers is given in Table 1. It was determined that the average age of the producers varied from 33.33 to 41.56 years, and their education levels varied between 8.67 and 12.17 years. Also, the experience period of trout farming was between 9.17 and 14.78 years, according to the farm groups. All of the producers were found to be members of the aquaculture producers' association. It was discovered that the family population varied between 3.06 and 4.22 people depending on the group, with an average of 3.71 people across all farms. Furthermore, the producers in the large farm group were older, more experienced, and had a larger population. The difference between Groups I and III in terms of the number of individuals in the family was statistically significant ($P < 0.05$).

Table 1. Descriptive statistics about producers by farm groups

	Farm Groups			
	Group I	Group II	Group III	**Mean**
Age (years)	33.33	40.17	41.56	38.81
Education level (years)	12.17	8.67	11.22	10.76
Trout farming experience (years)	9.17	14.50	14.78	13.10
Membership in the aquaculture producers' association (%)	100.00	100.00	100.00	100.00
Number of people in the family (persons)	3.00^{a}	3.67^{ab}	4.22^{b}	3.71

Note: $^{a, b}$ Means with a different superscript in the same row differ ($P < 0.05$).

Table 2 provides descriptive statistics about trout farming. The amount of fish produced per farm increased in direct proportion to farm size. In Groups I, II, and III, the amount of fish produced was 33.86, 63.33, and 518.72 tonnes/farm, respectively. The average amount of fish produced by all farms was 250.07 tonnes/farm. There was a statistically significant difference between Group III and Groups I and II. All of the fish produced were rainbow trout, and the majority of them were exported. Similarly, the number of cages and average cage capacity increased in parallel with the size of the farm. The average cage capacity ranged between 5.35 and 24.83 tonnes, and the number of cages per farm ranged between 6.33 and 20.89. The number of cages per farm and the average cage capacity were higher in Group III than in other groups ($P < 0.05$). According to the overall average, the number of cages per farm was 13.86, with a cage capacity of 18.05 tonnes. The feed conversion ratio (FCR) is an important parameter for measuring fish development performance because it is the ratio at which feed is transformed into flesh. It is calculated by dividing the amount of feed consumed by body weight growth [17]. The feed conversion ratio varied between 1.05 and 1.11 according to the farm groups, and the average of all farms was 1.09. Accordingly, 1.09 kg of feed was consumed for 1 kg of live weight gain. In terms of feed costs, this ratio was significant because feed costs (55.10%) accounted for the majority of total production costs. In their study, Diken et al. [7] determined the feed conversion ratio for rainbow trout to be 1.02, 1.0, and 0.97 for the 2016–2017, 2017–2018, and 2018–2019 production periods, respectively. In another study, Bilguven and Baris [5] discovered that the feed conversion ratio for rainbow trout was 1.24 and 1.35 for Groups I and II, respectively. The weight of fingerlings raised on the examined farms ranged between 20.00 and 26.44 gram depending on the farm group, with an average of 22.76 gram calculated for all groups. The average weight of the caught fish varied between 325.00 and 472.22 gram, and the average of all farms was 389.29 gram. Fingerlings and harvest weight in Group III were higher than in Groups I and II ($P < 0.05$). The mortality rate ranged from 2.00% to 5.22% depending on farm group, with an overall average of 3.45%. Group III had greater mortality rates than Groups I and II ($P < 0.05$). The distance of the cages to the shore varied between 133.33 and 491.67 metres, and it was 249.52 metres, according to the average of all farms. It was observed that the examined farms produced once a year in the period of November-June and that all of the producers received aquaculture support from the Republic of Türkiye Ministry of Agriculture and Forestry.

Table 2. Descriptive statistics about trout farming by farm groups

	Farm Groups			**Mean**
	Group I	Group II	Group III	
Amount of production (tonne/farm)	33.86^{a}	63.33^{a}	518.72^{b}	250.07
Number of cages (unit/farm)	6.33^{a}	10.83^{ab}	20.89^{b}	13.86
Cage capacity (tonne/cage)	5.35^{a}	5.85^{a}	24.83^{b}	18.05
Feed conversion ratio (FCR)	1.05	1.11	1.10	1.09
Fingerling weight (gram)	20.00^{a}	20.00^{a}	26.44^{b}	22.76
Weight of caught fish (gram)	329.17^{a}	325.00^{a}	472.22^{b}	389.29
Mortality rate (%)	2.00^{a}	2.25^{a}	5.22^{b}	3.45
The distance of the cages to the shore (metres)	491.67^{a}	133.33^{b}	165.56^{b}	249.52
The proportion of farms receiving aquaculture support (%)	100.00	100.00	100.00	100.00
The number of annual harvests (pieces)	1.00	1.00	1.00	1.00
Production period	November-June			

Note: $^{a,\,b}$ Means with a different superscript in the same row differ ($P < 0.05$).

Cost calculations are significant for many farm functions, such as farm analysis, preparation of farm budget plans, and profitability analysis. Furthermore, cost calculations aid in the formulation and implementation of macro-level price policies and other agricultural policies (subsidies of agricultural inputs, etc.) [9]. The cost items for trout production were classified as fixed and variable costs. Variable costs are costs that rise or fall depending on the volume of production. These costs are incurred during production and vary according to the amount of production. Fixed costs, on the other hand, are costs that do not vary with production volume or whether production is carried out or not [11]. Production costs consist of the sum of fixed and variable costs. Trout production costs according to farm groups are given in Table 3. It was discovered that as the size of the farm increased, so did the production costs per farm. Production costs per farm were calculated as $66,892.75, $107,851.79, and $718,028.48 for Groups I, II, and III, respectively. The difference between Group III and the other groups was found to be statistically significant (P < 0.05).

Table 3. Production costs by farm groups ($/farm)

Cost items	Farm Groups						Mean	
	Group I		Group II		Group III			
	$	%	$	%	$	%	$	%
Feed	34,647.68^{a}	51.80	57,442.20^{a}	53.26	398,115.85^{b}	55.45	196,932.47	55.10
Fingerling	14,195.67^{a}	21.22	21,738.44^{a}	20.16	176,294.65^{b}	24.55	85,821.74	24.01
Veterinary-medicine-disinfectant	741.56^{a}	1.11	1,716.19^{ab}	1.59	4,915.51^{b}	0.68	2,808.87	0.79
Tool-machine oil-fuel	578.84^{a}	0.87	1,546.69^{a}	1.43	10,664.41^{b}	1.49	5,177.76	1.45
Electric	165.26	0.25	222.47	0.21	2,648.45	0.37	1,245.83	0.35
Tool-machine and cage repair maintenance	1,695.01	2.53	2,235.29	2.07	4,449.39	0.62	3,029.82	0.85
Other	868.69	1.30	635.63	0.59	3,298.20	0.46	1,625.39	0.45
Revolving fund interest	1,412.24^{a}	2.11	2,283.84^{a}	2.12	16,030.32^{b}	2.23	7,926.16	2.22
(A) Variable costs	54,304.95^{a}	81.18	87,820.74^{a}	81.43	616,416.77^{b}	85.85	304,568.03	85.21
General administrative expenses (3%)	1,629.15^{a}	2.44	2,634.62^{a}	2.44	18,492.50^{b}	2.58	9,137.04	2.56
Rent	335.82^{a}	0.50	213.99^{a}	0.20	1,437.93^{b}	0.20	773.35	0.22
Permanent labour	2,235.29^{a}	3.34	4,322.26^{a}	4.01	13,863.73^{b}	1.93	7,815.18	2.19
Tool-machine depreciation	7,222.20^{a}	10.80	11,453.20^{a}	10.62	61,483.18^{b}	8.56	31,685.76	8.86
Tool-machine capital interest	690.94^{a}	1.03	1,038.72^{a}	0.96	5,714.13^{b}	0.80	2,943.10	0.82
Building depreciation	381.29	0.57	296.63	0.28	498.50	0.07	407.33	0.11
Building capital interest	93.10	0.14	71.61	0.07	121.74	0.02	99.24	0.03
(B) Fixed costs	12,587.79^{a}	18.82	20,031.04^{a}	18.57	101,611.71^{b}	14.15	52,861.01	14.79
(A+B) Production costs	66,892.75^{a}	100.00	107,851.79^{a}	100.00	718,028.48^{b}	100.00	357,429.03	100.00

Note: $^{a, b}$ Means with a different superscript in the same row differ (P < 0.05).

The production costs per farm were determined to be $357,429.03 based on the average of all farms. The share of variable costs in total production costs was found to range between 81.18% and 85.85%, depending on the farm group, and was 85.21% for the average of all farms. The share of fixed costs varied between 14.15% and 18.57% and was calculated as 14.79% for the average of all farms. Afero et al. [1] found the share of variable costs was 75.3% and the share of fixed costs was 24.7% of total production costs. The most important variable costs were the purchases of feed and fingerlings. Feed costs ranged from 51.80% to 55.45% of total production costs, depending on the farm group, and the cost of procuring fingerlings ranged from 20.16% to 24.55%. For the average of all farms, the proportions of feed and fingerling purchase costs in total production costs were 55.10% and 24.01%, respectively. Other research has yielded similar results. In Erman and Kucuk's [10] study, feed expenses accounted for 58.8% of total production costs and 53.67% in Karabulut et al.'s [14] study. Pangemanan et al. [21] emphasized that feed costs have become an important problem in fish farming due to high feed prices. Barbosa et al. [4] found that the main cost factor in family trout farming was feed, and the share of feed cost in total costs was 60.61% for small-scale farms and 62.80% for medium-sized farms. The most important fixed cost elements are tool-machine depreciation, general administrative expenses, and permanent labour costs. These three cost elements accounted for 13.61% of production costs on the total farm average.

Gross production values according to farm size groups are given in Table 4. In the trout farming activity branch, the gross production value consists of fish sales and government support. According to the average of all groups, the gross production value per farm was \$684,373.44, and it was determined that it increased in parallel with the size of the farm. In Groups I, II, and III, the gross production value was calculated to be \$84,303.73, \$153,740.55, and \$1,438,175.17, respectively. The difference between Group III and Groups I and II was statistically significant ($P < 0.05$). Fish sales accounted for a large portion of the gross production value. The share of fish sales in the total gross production value ranged from 96.83% to 98.10% according to the farm groups, and it was determined as 97.98% on average. Support for trout farming is given to producers by the Republic of Türkiye Ministry of Agriculture and Forestry. The share of the subsidies in the gross production value varied between 1.90% and 3.17% according to the farm groups, with an average of 2.02% for all farms.

Table 4. Gross production values by farm groups (\$/farm)

Income items	Farm Groups						Mean	
	Group I		Group II		Group III			
	\$	%	\$	%	\$	%	\$	%
Fish sale	81,627.68[a]	96.83	149,068.69[a]	96.96	1,410,896.18[b]	98.10	670,583.04	97.98
Supports	2,676.05[a]	3.17	4,671.86[a]	3.04	27278.99[b]	1.90	13,790.40	2.02
Gross product value	84,303.73[a]	100.00	153,740.55[a]	100.00	1,438,175.17[b]	100.00	684,373.44	100.00

Note: [a, b] Means with a different superscript in the same row differ ($P < 0.05$).

Table 5 shows the farm group's profitability indicators per farm and tonne. Calculations of the gross profit, net profit, and relative return were made to determine the profitability of farms. In terms of the use of scarce production factors, gross profit is a significant indicator of success for assessing the competitiveness of farm production operations. In a nutshell, gross profit is an important measure for determining a farm organisation's performance [9]. According to the average of all farms, the gross profit per farm was \$379,805.41, which increased in direct proportion to the size of the farm. The average gross profit in Groups I, II, and III was \$29,998.78, \$65,919.80, and \$821,758.40, respectively. Group III's difference from Groups I and II was statistically significant ($P < 0.05$). Net profit was calculated by deducting production costs from gross production value. The average net profit per farm was calculated as \$17,410.98 in farms in Group I, \$45,888.76 in Group II farms, \$720,146.69 in Group III, and \$326,944.40 for the all farm average. Accordingly, as the farm groups grew, it was seen that the average net profit per farm also increased. Group III differed from Groups I and II by a statistically significant margin ($P < 0.05$). Relative return is another indicator of farm success. A relative return shows the income obtained for a unit cost in a production line. Similar to the gross profit, the relative return increased in tandem with the size of the farm for the average of all farms, and it was 1.91. In Groups I, II, and III, the average relative return was 1.26, 1.43, and 2.00, respectively. The difference between Group III and the other groups was statistically significant (P < 0.05). According to the average of all farms, revenue of $1.91 was obtained in exchange for a cost of $1 in trout farming. Concerning these findings, it can be stated that as farm size groups increase, the farms become more profitable for trout farming.

Table 5. Profitability indicators by farm groups

Profitability indicators	Farm Groups			Mean
	Group I	Group II	Group III	
Gross product value ($/farm)	84,303.73[a]	153,740.55[a]	1,438,175.17[b]	684,373.44
Variable costs ($/farm)	54,304.95[a]	87,820.74[a]	616,416.77[b]	304,568.03
Production costs ($/farm)	66,892.75[a]	107,851.79[a]	718,028.48[b]	357,429.03
Gross profit ($/farm)	29,998.78[a]	65,919.80[a]	821,758.40[b]	379,805.41
Net profit ($/farm)	17,410.98[a]	45,888.76[a]	720,146.69[b]	326,944.40
Relative return	1.26[a]	1.43[a]	2.00[b]	1.91
Gross production value ($/tonne)	2,489.77[a]	2,427.61[a]	2,772.55[b]	2,736.73
Variable costs ($/tonne)	1,603.81[a]	1,386.72[a]	1,188.34[b]	1,217.93
Production costs ($/tonne)	1,975.57[a]	1,703.01[a]	1,384.23[b]	1,429.32
Gross profit ($/tonne)	885.97[a]	1,040.89[a]	1,584.20[b]	1,518.80
Net profit ($/tonne)	514.21[a]	724.60[a]	1,388.31[b]	1,307.41
Relative return	1.26[a]	1.43[a]	2.00[b]	1.91

Note: [a, b] Means with a different superscript in the same row differ (P < 0.05).

In the research region, the amounts per tonne of cost and profitability indicators were calculated, as well as the amounts per farm. It was discovered that the production costs per tonne decreased in direct proportion to farm size in the farms studied. Production costs per tonne were determined as $1,975.57, $1,703.01, and $1,384.23 in Groups I, II, and III, respectively. It was discovered that as the farm's size increased, so did the gross and net profits, and the relative return per tonne. Gross profit per tonne was determined as $885.97, $1,040.89, and $1,584.20, respectively, and net profit was $514.21, $724.60, and $1,388.31, respectively, for Groups I, II, and III. The difference between Group III and Groups I and II in terms of production cost per tonne, gross profit, net profit, and relative return was found to be statistically significant (P < 0.05). Other studies on the subject had similar results. According to Musaa et al. [19] and Erman and Kucuk [10], large-scale cage farms were more profitable for fish farming. According to Miao et al. [18], the scale of production in cage culture and cobia breeding was cost-effective, and cobia production would be more profitable due to positive economies of scale.

Table 6. The profit margin of 1 kg of trout by farm groups

	Farm Groups			Mean
	Group I	Group II	Group III	
Production costs ($/kg)	1.98[a]	1.70[ab]	1.38[b]	1.43
Sales price ($/kg)	2.42[a]	2.37[a]	2.71[b]	2.53
Profit margin ($/kg)	0.44[a]	0.67[a]	1.32[b]	1.10
The ratio of profit margin to the sales price (%)	18.33[a]	28.23[a]	48.90[b]	43.51

Note: [a, b] Means with a different superscript in the same row differ (P < 0.05).

The profit margin per kg of trout and the ratio of profit margin to sales price by farm group are given in Table 6. The profit margin was calculated by subtracting the production cost of one kg of trout from the selling price of one kg of trout. It was determined that the profit margin of one kg of trout increased as the farm groups grew in size. The profit margin for one kg of trout was $1.10 on average across all farm groups, and it was $0.44, $0.67, and $1.32 in I, II, and III Group farms, respectively. The ratio of profit margin to selling price (profit margin/sales price*100) criterion was calculated to determine proportionally how much of the sale price of trout was cost and how much was profit. It was discovered that the ratio of profit margin to sales price increased as the farm groups expanded. When compared to the average of all farms, the profit margin to sales price ratio was 43.51%, and it was calculated as 18.33%, 28.23%, and 48.90% in Groups I, II, and III, respectively. According to these results, farms in Group III profited 48.90% on each kg of trout they sold, while farms in Group I made a profit of 18.33% and farms in Group II profited 28.23%. In terms of profit margin and the ratio of profit margin to the sales price, the difference between Group III and Groups I and II was found to be statistically significant ($P < 0.05$). In their study, Navy and Bun [20] determined the profit margin rate in fish production as 56.03%, emphasizing that the fishing activity was profitable and the producers should continue production.

CONCLUSIONS

As a result, the fish produced were all rainbow trout in the research region, and the majority of them were exported. It was determined that each farm produced an average of 250.07 tonnes of trout. The feed conversion ratio varied between 1.05 and 1.11 depending on the farm group, and the average of all farms was 1.09. The farmers produced once a year between November and June, and all producers received aquaculture support from the Republic of Türkiye Ministry of Agriculture and Forestry. It was determined that as the farm's size increased, so did the production costs per tonne. The most significant cost items among the total production costs were the purchase costs of feed and fingerling. The share of feed costs in total production costs varied between 51.80% and 55.45%, and the cost of purchasing fingerlings varied between 20.16% and 24.55%, depending on the farm group. It was discovered that as the size of the farm expanded, so did the gross and net profits, as well as the relative return. In Groups I, II, and III, the average net profit per tonne was $514.21, $724.60, and $1,388.31, respectively. Similarly, when the farm's size increased, it was determined that the profit margin of one kg of trout and the ratio of profit margin to sales price increased. The profit margin of one kg of trout was $0.44, $0.67, and $1.32 in Groups I, II, and III, respectively. Also, the ratio of profit margin to sales price was 18.33%, 28.23%, and 48.90%. According to the profit margin to sales price ratio, farms in Group III profit 48.90% from each kg of trout sold, while farms in Group I make a profit of 18.33% and those in Group II make a profit of 28.23%. According to these findings, large farms are more beneficial in terms of profitability and cost criteria. Therefore, policy measures should be developed to increase the capacity of farms in the research region. Furthermore, incentives and support for lowering feed costs in trout farming should be increased.

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FOREIGN EXPERIENCE IN DEVELOPING SCIENTIFIC AND INTELLECTUAL POTENTIAL OF THE AGRIFOOD COMPLEX

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Abstract

The formation of the scientific and intellectual potential of the agri-food complex contributes to the achievement of sustainable socio-economic growth. The article proposes models for the development of the scientific and intellectual potential of the Russian agri-food complex. An analysis of the activities of existing institutes for the development of agricultural scientific research was carried out. The assessment of the state of scientific and intellectual potential was carried out on the basis of cross-country comparisons of indicators of the number of researchers and expenditures on research and development. Empirically, imbalances were identified between the number of researchers and internal R&D costs. The positive experience of forming the scientific and intellectual potential of countries with developed market economies has been systematized, priority directions and stimulation of innovation and investment development have been identified. The practical significance of the research results lies in increasing the efficiency of agricultural production based on the development of scientific and intellectual potential.

Key words: *scientific and intellectual potential, agri-food complex, world experience, innovative agricultural systems, internal costs for research and development*

INTRODUCTION

In modern conditions of structural transformation and transition to a neo-industrial economy, the relevance of information and knowledge and the introduction of advanced knowledge-intensive and digital technologies are increasing. One of the main factors determining the competitiveness of a national economy on the world stage is the level of development of its scientific and intellectual potential.

A country's global competitiveness is largely determined by the efficiency of its research sector. Sustainable socio-economic development of the agri-food complex is predetermined by the possibilities of creating, introducing and disseminating innovations and knowledge-intensive solutions. To develop the main directions for the balanced development of scientific and intellectual potential at the federal, regional and industry levels, it is necessary to use the concept of national and regional innovative agricultural systems. According to the World Bank, agricultural research development institutions include the National Agricultural Research Systems (NARS), the Agricultural Innovation System (AIS), and the Agricultural Knowledge and Information System (AKIS).

These structures have their own goals, factors, results, organizational principles of construction, the role of the policies pursued, as well as a mechanism for implementing innovations [6, 17, 23].

The scientific works of foreign scientists examine trends in the development of the world economy, which must be taken into account when forming the innovative potential of the agro-industrial complex and developing mechanisms for its effective use [2].

Many scientists agree on the importance of innovative factors for increasing the efficiency of agricultural production Dasgupta S., Mamingi N. [4], Oliver, Y., Robertson, M., Wong, M. [12].

Fundamentally new production technologies, the implementation of which requires additional financial resources, make a great contribution to the formation of a high-tech agricultural sector [8]

Bush L., Bain C. identified the main areas of network interaction and transfer of knowledge and technology as the main factors in increasing scientific and intellectual potential [3].

A critical analysis of the scientific works of foreign and domestic economic scientists has identified the key areas of research into the innovative development of the agro-industrial complex. In particular, foreign researchers widely use the strategy of technological leadership and the proven practice of forming cluster structures that contribute to the scientific and technological development of large companies, including transnational corporations.Thereisquiteademandforamodelofknowledgeflowinclusters, whichinitiatesknowledgeasoneofthemainfactorsofcompetitiveadvantagewiththedistinctivefeatureofself-generation [10].

The formation of new knowledge and its free movement within the cluster represent the necessary conditions for the transition of the cluster to an innovative development model.

For the effective organization of innovation management in agriculture, no small importance is given to substantiating the directions of its balanced development and developing appropriate strategies at the federal and regional levels. In this regard, it is urgently necessary to use the basic provisions of the concept of national and regional agroinnovation systems (AIS)[5,24].

It should be noted that the AIS concept has not yet been finalized; certain provisions are the subject of discussion and adjustment. As some researchers note, there are discrepancies in the categorical apparatus, methods used and assessment and forecast tools [13, 19].

In the process of forming an AIS, disagreements between subjects and divergence of their interests are inevitable [11,18].

There are frequent cases of rotation of actors due to changed interaction relations [21,22].

The functioning mechanisms of AIS include, along with traditional activities (support for research, dissemination and education, development of communications between research, extension services and farmers), additional activities (building professional skills, stimulating the development of partnerships and business, improving knowledge flows; creating conditions for the introduction of innovations).

According to Chris Steiert, effective relationships between company employees largely depend on the startup models used [20]. The experience of operating knowledge-intensive startups in Ankara (Turkey) has shown that stakeholder relationships begin to develop already at the stage of creating a company. The development of mutually beneficial relationships between the startup’s stakeholders allows for the successful implementation of the company’s development goals [9].Research on the structure of the population, its characteristics, labor productivity and its impact on gross value added is widely presented in the works of Popescu A. [14, 15, 16].

The dissemination of knowledge and high technology occurs through their large-scale transfer. Moreover, the dissemination of innovations and knowledge at the level of one agricultural enterprise can lead to spillover and transfer of knowledge to other farms in the region. These processes are the result of diffusion and transfer of technology and innovation, as well as cross-flow of personnel between science and agribusiness. In the geographical aspect, conglomerates of knowledge and innovation are concentrated in large agrarian-oriented regions, and in the regions themselves in agricultural holdings. Issues of improving agricultural production in regions unfavorable for farming are also repeatedly discussed and calculated from the perspective of resource costs and expected results of agricultural production.

It should be noted that the mechanisms for managing the scientific and intellectual potential of developed countries can be used in countries and regions with similar natural and climatic conditions for agricultural production.

The purpose of the article is to study foreign experience in developing the scientific and intellectual potential of the agri-food complex and develop strategic directions for its use at the federal and regional levels.

MATERIALS AND METHODS

The methodological basis of the study was state legislative acts, regulatory documents, and works of foreign and Russian authors on the topic of innovative development of the agri-food complex. During the research process, monographic, abstract-logical, analytical, economic-statistical, and expert research methods were used. As an information base for the study, regulatory and legislative acts, information from OECD, INSEAD, Global Innovation Index, Rosstat, Higher School of Economics, Deloitte Research Center and other sources were used.

RESULTS AND DISCUSSIONS

The work analyzes and estimates the number of personnel engaged in research and development in various countries.

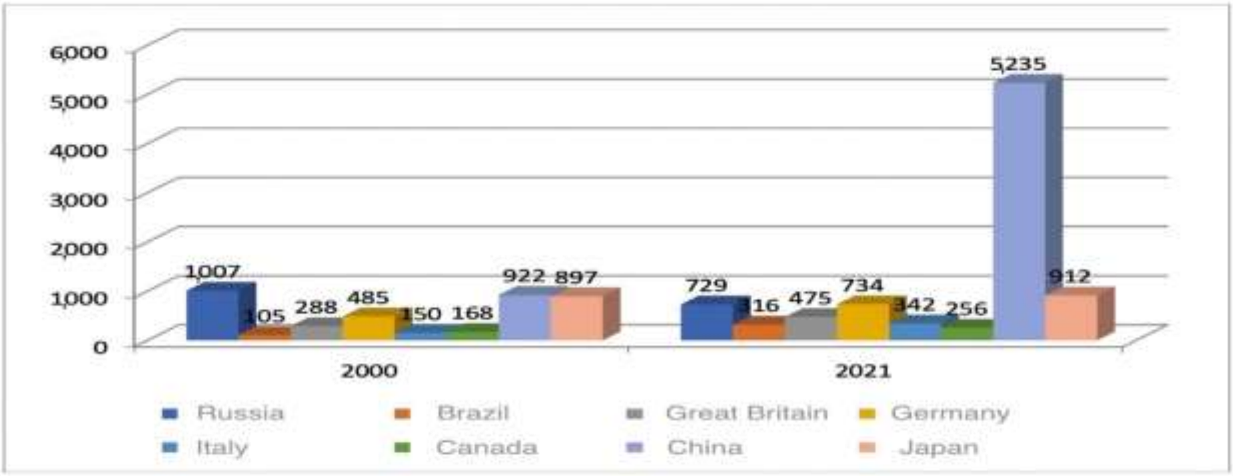

Fig. 1. Cross-country comparisons of the indicator «Personnel engaged in research and development», thousand person-years; full time equivalent
Source: Own calculations based on data [7].

The figure shows that the largest number of researchers is characteristic of China, which may be due to both the demographic situation and the level of scientific and technological development of the country.

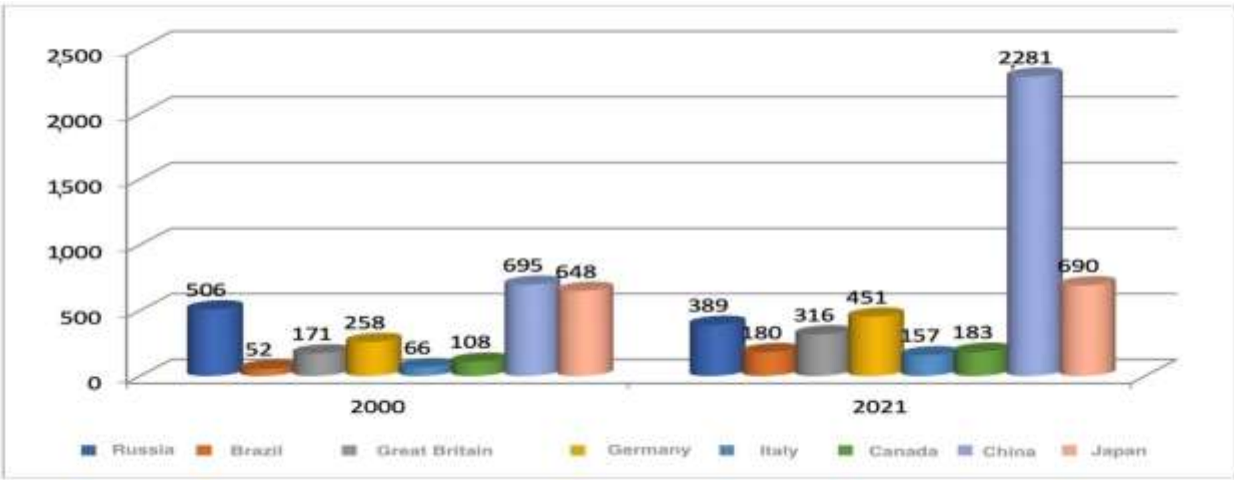

Fig. 2. Cross-country comparisons of the indicator "Number of researchers by country, thousand person-years; full time equivalent
Source: Own calculations based on data [7].

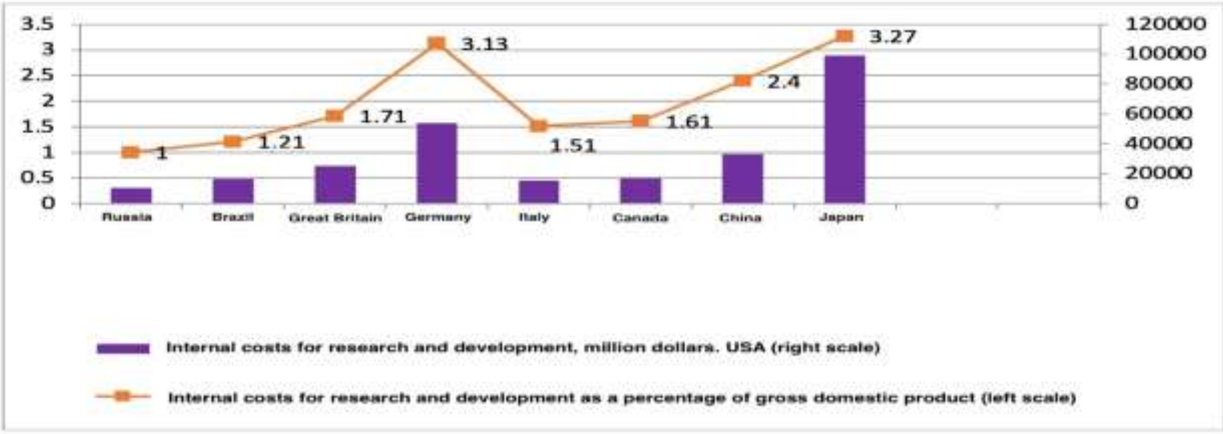

Fig. 3. Cross-country comparisons of domestic R&D expenditure indicators (2021).
Source: Own calculations based on data [7].

The largest number of researchers is in China, Japan, Germany, Russia and Italy. In some countries, there are disproportions between scientific and intellectual potential and internal costs for scientific research, which indicates insufficient economic and technological efficiency (Figs. 2 and 3).

Table 1. Strategies for the development of scientific and intellectual potential and innovative activity of foreign countries

Strategies	Main Components	Countries
Creation of national innovative agricultural systems	Development of innovative entrepreneurship in small and medium-sized businesses	Czech Republic and Slovakia, Romania, Chile, Baltic countries
	Integration of the functions of scientific and educational institutions	Czech Republic, Latvia
	Improving the structure of R&D organization in the public sector	Poland, Bulgaria, Lithuania
Creation of an optimal structure of an innovative agricultural system	Expanding forms of financing innovative activities in agriculture	Sweden, Norway, UK, USA, France, Denmark
	Stimulatingbasicresearch	UK, Sweden
	Planning of investments for the tasks of innovative development	Israel, Finland
Creation of investment relationships in agricultural sectors	Creating investment relationships to improve the efficiency of agricultural production	USA, Norway, Ireland
Increasing the effectiveness of the science-agribusiness relationship	Attracting funding and regional budgets	Germany, France, Finland
	Stimulation public and private investments within the country in scientific developments	Israel, Finland
Creation of state programs to finance innovative enterprises engaged in R&D for government organizations	Expanding government R&D funding programs	USA, China, UK, Japan
Payment of subsidies compensating 50% of costs when creating innovative products and technologies	Subsidiary support for innovatively active enterprises	Belgium, Brazil, Canada, USA, Austria, Germany, France, Sweden, Japan
Belgium, Brazil, Canada, USA, Austria, Germany, France, Sweden, Japan	Insurance of risks of agricultural production	USA, Japan

Source: Own determination.

The development of scientific and intellectual potential in the agri-food complex of advanced countries is based on investment activity that ensures the intensification of agricultural production in terms of economic, technological, and social efficiency [1].

In addition to government support, private investors, corporations, and firms are also involved in scientific research in agriculture. According to statistics, the introduction of technologies into production requires a threefold investment of financial resources compared to the cost of scientific research.

Table 1 presents a systematization of foreign experience in strategic directions for the development of scientific and intellectual potential.

A comparative analysis of the strategic directions for the development of the scientific and intellectual potential of economically developed countries has revealed their diversity. Recommended models and development vectors can be used in the process of preparing state programs for the development of scientific and intellectual potential and stimulating innovative activity in the agricultural sector of the economy.

CONCLUSIONS

The article examines positive foreign experience in the formation and development of the scientific and intellectual potential of the agri-food complex. The assessment of the development of scientific and intellectual potential was carried out on the basis of cross-country comparisons of indicators of the number of researchers and internal expenditures on scientific research and development. Empirically, disproportions have been identified between the number of researchers and internal costs of scientific research, which indicates an insufficient level of economic and technological efficiency. The experience of developing the scientific and intellectual potential of the agri-food complex of economically developed countries is systematized, strategic directions and mechanisms for stimulating the innovative and investment development of scientific and intellectual potential are proposed.

The practical significance of the research results lies in increasing the efficiency of agricultural production based on the development of scientific and intellectual potential.

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ASSESSMENT OF THE DEGREE OF IMPLEMENTATION OF THE RESULTS OF SCIENTIFIC RESEARCH AND INVENTIONS IN THE AGRICULTURAL SECTOR OF THE ECONOMY

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Abstract

In ensuring the country's food security, the dominant role belongs to scientific activity and the development of advanced production technologies. Moreover, the process of implementation of innovations and further stimulation of demand for the results obtained are of greatest relevance. The purpose of the study is to develop theoretical and methodological approaches to assessing the implementation of scientific developments and new technical solutions in agriculture in the context of innovative transformation of the economy. The article reveals significant interregional and intercountry differentiation of patent activity, and notes the gap between the total number of patents and the inventions being introduced into Russian agriclture. Based on a scientometric analysis of patents with text mining, trends and patterns in the formation of promising patent developments in agriculture have been identified and a bibliometric map has been generated in the direction of the relationship between areas of patent activity in Russian agriculture. The predominant clusters have been identified - agricultural engineering; soil treatment, harvest, pest control, production of herbicides and their components. The results obtained determine the need to develop effective mechanisms for supporting patent activity in agriculture and stimulating the introduction of scientific developments and new technical solutions into the production process in order to determine the most promising areas of research in agricultural science. The practical implementation of the research results is associated with the justification of the necessary incentive measures and government support for scientific developments in the context of fundamental technological changes and innovative structural shifts.

Key words: *agro-industrial complex, innovative development, scientific research, scientometric analysis, bibliometric map, implementation of the results of intellectual activity, differentiated approach*

INTRODUCTION

Ensuring Russia's national security largely depends on the level of development of the country's scientific and innovative potential and the wider use of fundamentally new production technologies [4].
Research confirms that economic growth in countries with developed market economies is determined by more than 80% of the materialized results of scientific and technical activities [23].
The implementation of scientific developments and new technical solutions in agriculture and other industries will improve the efficiency of using the financial, human, land, and technological resources used. [25, 26].
Russian researchers are working on the problems of breeding high-yielding plant varieties and creating a breeding base of highly productive animal breeds, developing advanced technologies and high-tech products, machinery and equipment, which will increase the competitiveness of agri-food products on the world market [6,33].
In the near future, the area of research on breeding and seed production will significantly expand.
The degree of significance of scientific research and development is determined on the basis of scientometric analysis [23].

Scientometric analysis systems provide the ability to process data sets, classify and systematize publications in various areas, and also calculate certain bibliometric indicators.

Scientometric systems differ depending on the content of information, built-in search functions, and areas of research [14].

The most common characteristics are research activity and citation, supported by such scientometric citation indicators as the Hirsch index, the maximum citation index (f-index).

To assess the effectiveness of scientific research and identify trends in the development of Russian science, the Russian Science Citation Index (RSCI) system with various versions of the Hirsch index (h-index without self-citations, h-index according to the RSCI core) is used [19].

One of the common methods for identifying trends in the formation of knowledge interests is mapping science, called the scientific landscape [11].

Currently, international information and analytical databases such as Web of Science, Scopus, Google Patents, PatSearch, ExactusPatent, The Lens, Dimensions are mainly used to build scientific and patent landscapes.

Building a scientific landscape aims to highlight priority areas of research based on topic modeling [31].

Research using scientometric analysis of patents is reflected in the scientific works of J. Thavorn. V. Muangsin, C. Gowanit, N. Muangsin. Their research was based on theoretical aspects of the concept of technological intelligence associated with the search for the necessary information on innovative activities at the micro and macro levels. The identified five technology sectors of the Chinese economy reflected different levels of patent activity [29].

Many publications demonstrate a new methodological approach to reflecting the information array about the state and main directions of agricultural science based on the construction of a scientific landscape. Its visualization is most often represented by road and bibliometric maps, forecast scenarios, and windows of opportunity. For example, the scientific landscape on the development of innovative processes in agriculture is built using information from bibliometric and patent analysis about the innovative technologies used, the state of the market for high-tech products, patent and scientific activity and development trends based on innovation, and the search for materials for monitoring the market for high-tech products.

For information processing, a technology for automatic text analysis with the ability to build clusters and model promising areas of research is intended [8].

For example, a content analysis of research into the scientific and technological development of the crop growing industry with the construction of a scientific landscape revealed that the predominant part of research in agricultural science is related to the development of resource-saving technologies, the study of problematic issues of rational land use, as well as the reduction of greenhouse gas emissions [15].

In the previous studies of the authors, a bibliometric map was formed on the basis of publications of Russian scientists in foreign journals on the problems of introducing innovations and technological transformations in agriculture; the predominant clusters are identified - biotechnology and processing of raw materials, livestock farming, crop production, economic and organizational support [7].

Ensuring sustainable economic growth is largely determined by the effective interaction of science, education and business in order to implementation the results of intellectual activity [1,22].

The study of the peculiarities of the processes of innovative development in agriculture, taking into account the positive and negative external effects of the flow of knowledge, is of particular importance in the context of accelerating the international exchange of scientific and scientific-technical information. [5].

The technology gap theory considers the presence of knowledge absorption potential as the most important condition for the commercialization of acquired or acquired knowledge based on cross-country exchange. Practice shows that companies for which it is developed, have stable connections with external suppliers of knowledge and technology. This provision is more relevant for developing countries [12,34].

Paul Romer's endogenous growth theory identifies the keyfactors of economic growth: knowledge, innovation and investment in human capital. In long-term development, priority is given to the acquisition of knowledge and its use in the production process [27].

Studies of the dynamics of R&D and innovation in US agriculture have revealed a higher innovative susceptibility of farmer-entrepreneurs included in value chains and actively interacting with food industry enterprises. The authors developed a dynamic model that allows us to identify the relationship between technological innovations in agriculture and scientific research on agricultural topics [13].

In the scientific works of domestic and foreign scientists, various methods of knowledge transfer are highlighted. These include education, scientific communications, scientific and technical databases, and joint scientific activities [3,16,18].

Scientists have proven that knowledge flows have a more significant impact on economic development compared to international trade or foreign direct investment [2, 21]. Accordingly, the country's innovative potential increases [9]. One of the common forms of knowledge transfer is the patenting of scientific developments. Patenting in agriculture helps stimulate innovation and scientific and technological progress, which results in improved product quality and food safety.

It should be noted the work of foreign scientists on the transfer and use of the results of scientific developments in agriculture through patents. For example, H. Fujii, K. Yoshida, K. Sugimura identified the highest priority factors for the growth of patent applications based on the results of the development of biotechnologies and their implementationin various sectors of the economy, including agriculture and food production.

Based on the research conducted, a conclusion was made about the relationship between the number of patents and an increase in the volume of research funding [17].

One of the main trends in patenting in Russian agriculture is the protection of developments related to the use of genetic resources and biotechnologies. The selection of new varieties of plants and animals, genome modification to increase crop yields or improve product quality have become widespread. In addition, the number of patent applications for digital technologies, monitoring and control systems is increasing, which contributes to significant savings in production costs.

Russian scientists are actively patenting their innovative achievements in the field of crop production on the topic of combating pests and plant diseases, as well as the development of advanced resource-saving technologies aimed at achieving stable growth and sustainable development of agriculture [20].

The purpose of the study is to develop theoretical and methodological approaches to assessing the implementation of scientific developments and new technical solutions in agriculture in the context of innovative transformation of the economy.

MATERIALS AND METHODS

The methodological basis of the study was regulatory documents, state legislative acts, regulations, research by domestic and foreign economists on the topics of scientific activity and patent activity. During the research process, monographic, abstract-logical, analytical, economic and statistical research methods were used. As an information base for the study, information from the scientometric system The Lens, as well as information from the ISSEK Foresight Center of the National Research University Higher School of Economics and Rosstat were used.

RESULTS AND DISCUSSIONS

A country's innovative potential is largely determined by the level of inventive activity, which is measured using various indicators.

Patent information allows you to assess the uniqueness of the technology being developed, determine the conditions and opportunities for innovation, and search for the most popular patent applications. Cross-country comparisons of patent activity indicators showed China's dominance in the total number of patent applications, which is largely determined by the presence of effective mechanisms for stimulating scientific research and supporting patenting. One of the support measures is multi-level stimulation of patent development, including the implementation stage [10].

Unlike most countries, the majority of China's patent applications are aimed at commercializing research results within the country [29].

Japan, Germany, France, and the UK also submitted a significant number of patent applications in 2021.

According to the Institute of Statistical Research and Economics of Knowledge of the National Research University Higher School of Economics, in 2021, the share of Russia in the global number of patent applications for inventions decreased by 8 thousand units. compared to 2015 and amounted to 25.5 thousand units (Fig. 1-2).

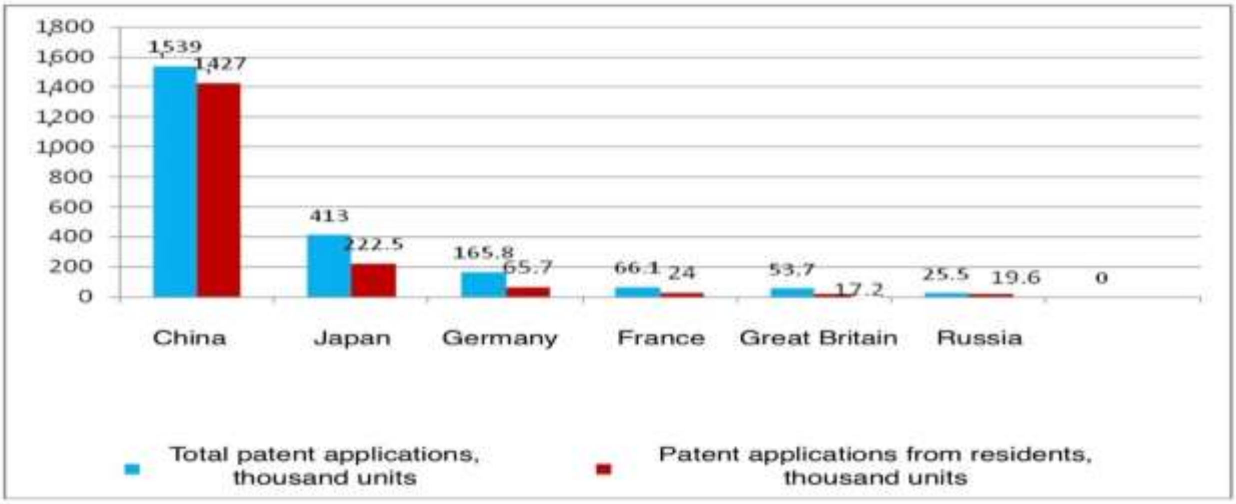

Fig. 1. Cross-country comparisons of patent applications for inventions by country of applicant and place of filing, 2021
Source: Own calculations based on data [35].

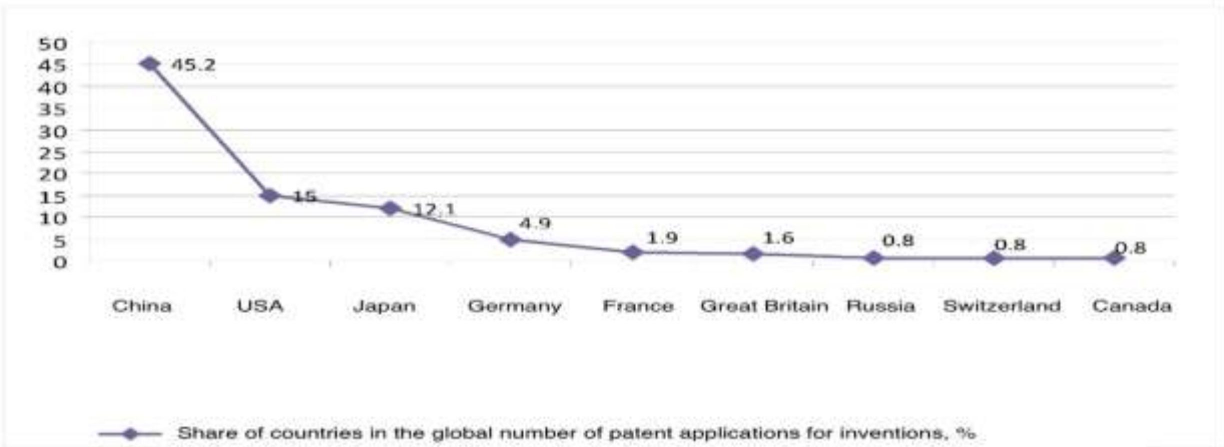

Fig. 2. Cross-country comparisons of relative indicators of patent activity, %, 2021.
Source: Own calculations based on data [28].

However, it should be noted that there is a tendency for increase in the coefficient of technological independence, calculated as the ratio of the number of domestic applications to their total number (Fig. 3).

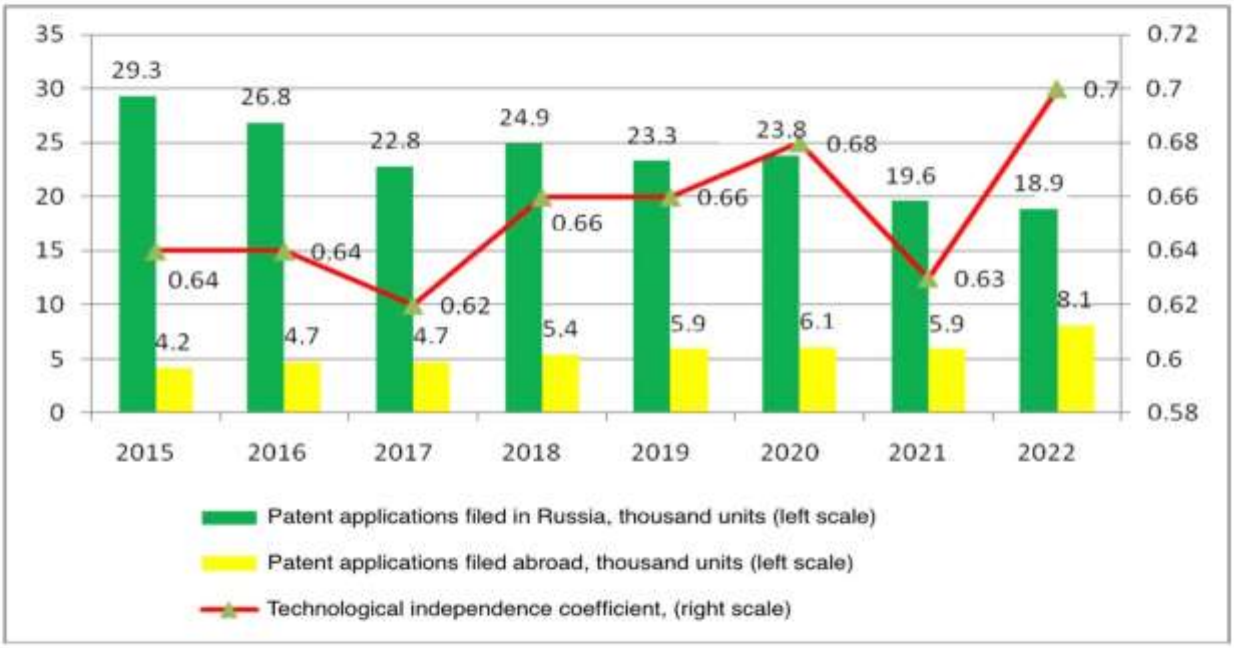

Fig. 3. Indicators of patent activity in Russia, 2015-2022.
Source: Own calculations based on data [28].

The calculated coefficients of technological independence for the countries leading patent activity showed that in 2021 the highest indicator was achieved in China (0.92). In the UK, Germany, USA, France and Japan, the figures were 0.32, respectively; 0.4; 0.51; 0.36 and 0.54. The above indicates the strengthening of the innovative vector of the Russian economy.

There is a certain relationship between the indicator of inventive activity per 10 thousand people. population and the country's innovation rating.

For example, in 2021, Korea ranked first in the world in both the Inventive Activity Ratio and the Bloomerg Innovation Index; China ranked fourth and sixteenth, respectively [10].

One of the possible reasons for the insufficient degree of implementation of knowledge and developments is the incomplete correspondence between filed patent applications and the use of these scientific results in production. As Russia's own technological base develops, an increase in patent activity is predicted in various sectors of the economy, including in the agricultural sector[24].

In 2022, agricultural organizations introduced into production 3 inventions, 2 utility models, 12 computer programs, 2 databases and 117 breeding achievements [30].

It should be noted that there is significant interregional differentiation of patent activity, which is determined by such factors as the level of specialization, natural and economic conditions, the presence of agricultural scientific potential, and the presence of vertically integrated holding-type structures. In regions with a low level of development of agricultural production, patents are almost never registered. According to research by Russian scientists, the largest number of patents was registered in Moscow, St. Petersburg, as well as the regions of the North Caucasus and the Volga region. A certain relationship has been identified between the level of innovative development and patent activity. In particular, regions with registered in 2010-2019. patents in the field of “Agriculture” in the amount of 400 and above are called “innovation centers”, and regions with indicators of less than 20 are characterized as innovation periphery. The innovation periphery includes regions with unfavorable natural and economic production conditions and a low level of agricultural scientific potential [24].

The diffusion of implementation of inventions is heterogeneous in terms of space and industry. In agriculture, large investors and agricultural holdings play a significant role in the implementation of progressive technological solutions using nanomaterials, nanotechnologies, and soil cultivation technologies.

Strengthening interregional and international exchange of results of scientific and intellectual activity predetermines the need to study the dissemination of knowledge based on the analysis of patent and scientific publishing activity.

The article provides a scientometric analysis of patents based on text mining.

To compile a bibliometric map of patent activity in Russian agriculture, we used the Lens open database, which contains information about publications and patents. The advantage of the chosen service is associated with the availability of more extensive information on publications and patents compared to other scientific databases, which predetermined the use of the above-mentioned database for research.

The search parameters were limited to the search query “Agricultural”, and the term “patents” was used as filters. The search was aimed at obtaining the necessary information for Russian agriculture, taking into account the patents of only Russian scientists. The search process involved downloading 16,872 patents issued between January 1, 2001 and January 1, 2024, in Research Information Systems (RIS) format. Subsequent processing of information for clustering and graphical construction of a bibliometric map was carried out using the scientometric tool VOSviewer, which allows removing inaccuracies and typos. To cluster keywords according to the degree of their mention, the “co-occurrence” method was used, on the basis of which thematic clusters with visual differences were formed.

The results of clustering the patent activity of domestic inventors are presented in Figure 4. The resulting clusters are marked in color, and the size of the bubble of an individual keyword is directly related to the overall data matrix. According to generally accepted methodological approaches to the analysis of bibliometric maps, the number of lines and their line thickness are determined by the close connection with the general data array [32].

Recognition of the obtained bibliometric map data as one of the forms of visualization of the results of processing an array of information revealed the corresponding vector of innovative development of agriculture. Patent activity reflects the most common topics of domestic inventions.

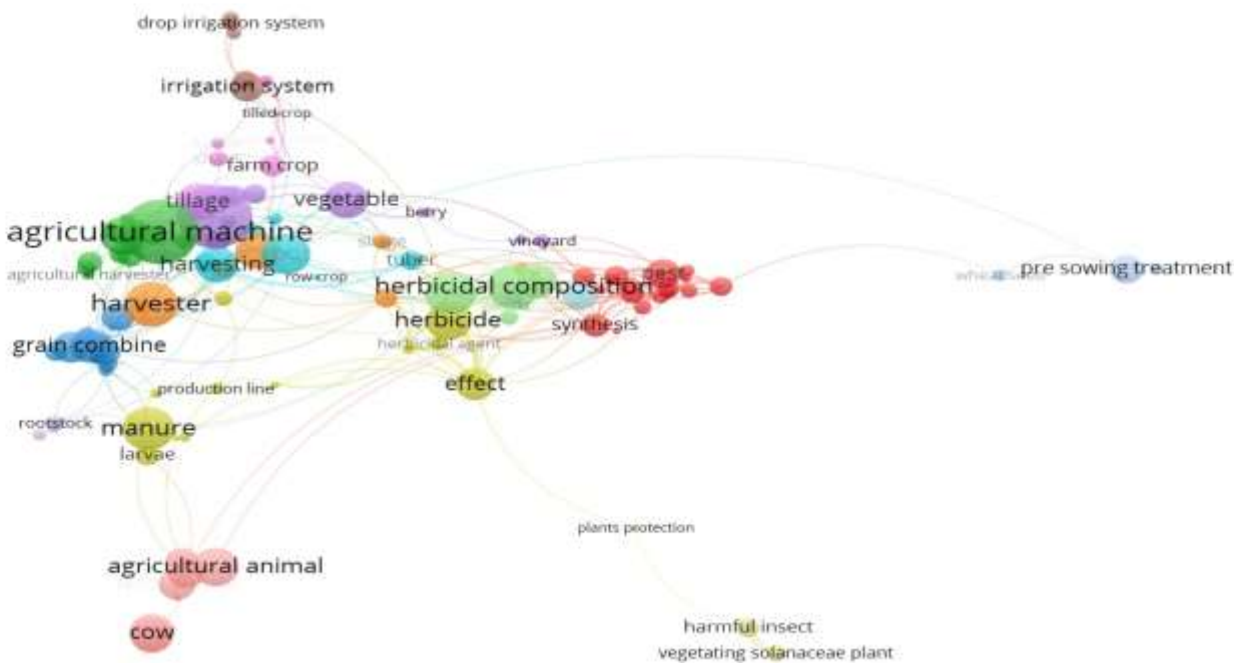

Fig. 4. Bibliometric map of the relationship between areas of agricultural science according to patent applications of Russian researchers
Source: Own calculations.

The main areas of patent activity are: innovative developments related to agricultural engineering; plant protection, soil cultivation, livestock farming, drip irrigation systems, harvesting, growing vegetables and berries.

Analysis of the constructed bibliometric map shows the presence of several clusters: dark green – agricultural engineering; purple – soil treatment; blue – harvesting; red – pest control; pistachio – production of herbicides and their components.

Patent activity in the agricultural engineering cluster is tied to soil cultivation and irrigation systems. The greatest number of references relates to the terms: mechanisms, tools, cultivators, tillage.

In the “pest control” cluster, there is a relationship with the areas of “vegetable growing” and “grain harvesting”. The most significant terms in this cluster are: harvesting, herbicides, granaries.

Scientometric analysis provides systematization of indicators of large information arrays. Its use made it possible to assess the degree of patent activity in the process of forming the high-tech agricultural sector of the Russian economy.

Increasing the degree of implementation of agricultural knowledge largely depends on the measures of government support for the scientific sector, as well as stimulating the promotion and implementation of intellectual property.

The form of intellectual property support introduced by the Russian government in the form of subsidies to finance part of the costs of registration in foreign markets will help strengthen the patent activity of economic sectors, including the agricultural sector.

CONCLUSIONS

An analysis of global experience in researching scientific activity and patent activity made it possible to identify the relationship between the implementation of scientific research results and the level of innovative development. Significant interregional and intercountry differentiation of patent activity has been revealed. Compared to developed countries, in Russia there is a gap between the total number of patents and the inventions being introduced into production. Based on bibliometric analysis, trends and patterns in the formation of promising patent developments in Russian agriculture have been identified. A study of Russian patent applications in agriculture for the period from January 2001 to January 2024 led to the conclusion that the main areas of patent activity are: innovative developments related to agricultural engineering; plant protection, soil cultivation, livestock farming, drip irrigation systems, harvesting, growing vegetables and berries.

Based on the scientometric analysis of patents with text mining, a bibliometric map was formed in the direction of the relationship between areas of patent activity in Russian agriculture.

The predominant clusters have been identified - agricultural engineering; soil treatment; harvest; pest control; production of herbicides and their components. The results of the analysis showed that patent activity in the “agricultural engineering” cluster is tied to soil cultivation and irrigation systems. The greatest number of references relates to the terms: mechanisms, tools, cultivators, tillage.

In the “pest control” cluster, there is a relationship with the areas of “vegetable growing” and “grain harvesting”. The most significant terms in this cluster are: harvesting, herbicides, granaries.

The results obtained determine the need to develop effective mechanisms for supporting patent activity in agriculture and stimulating the introduction of the results of intellectual activity into production, which will allow us to identify the most promising areas of agricultural scientific research.

ACKNOWLEDGEMENTS

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FACTORS AFFECTING THE FORMATION AND USE OF SCIENTIFIC AND INTELLECTUAL POTENTIAL OF THE AGRICULTURAL SECTOR OF THE ECONOMY

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Abstract

The development of the scientific and intellectual potential of the agricultural sector of the economy is undoubtedly a vector of sustainable development. The purpose of the article is to study the theory and methodology of factor analysis of the development of scientific and intellectual potential at the macro, meso and micro levels. A study of human resources in the agricultural sector was conducted from the perspective of improving human resources and research forces of society. Cross-country comparisons have been made of the area of agricultural land and the value of gross added value of agriculture in different countries, which may indicate an appropriate level of scientific and technological development of the agricultural sector of the economy. The article classifies positive and negative socio-economic, technological, demographic and organizational factors. Measures are proposed for the use of scientific and intellectual potential in agricultural production as a driver of scientific and technological development.

Key words: *scientific and intellectual potential, agricultural sector, factors, cross-country comparisons, principles, efficiency, innovation and investment support*

INTRODUCTION

Increasing the sustainability of the development of agricultural production is associated with the valorization of promising scientific developments and advanced innovative solutions. The level of development of human capital in the agricultural sector as a synthesis of skills, knowledge and competencies in the conditions of structural transformation is constantly growing. However, questions remain unresolved in the study of many factors influencing the formation and use of human resources in agricultural production.

Scientific research by T. Schultz and G. Becker is devoted to the study of human capital, its fundamental and practical aspects.

The most important characteristic of human capital is the ability to generate appropriate income for its owner [6].

G. Schultz substantiated the need for investment in human capital, especially in underdeveloped countries, considering the agricultural sector as a point of growth for the entire economy [5, 21].

Foreign researchers George N. Curry, Steven Nake, Gina Koczberski noted the priority role of technological transformations to increase the productivity of resources used in agriculture. At the same time, the unevenness of innovative development of agricultural organizations of various forms of management remains [8].

Amare, Darr, Dadi, Deressa note the financial difficulties in introducing new generation technologies among small farmers in developing countries, and therefore these processes are proceeding at a slow pace [4, 9].

Viaggi, D. noted the relationships between research results, innovation and resource productivity. It is noted that the development of new conceptual provisions on agricultural development raised the problem of measuring resource productivity. Researchers note the need to improve methodological approaches to measuring this indicator, taking into account the requirements of technological transformations, achieving economic and social sustainability, as well as increasing the efficiency of resource use. The authors propose to use, along with specific productivity indicators, also indicators of total factor productivity [24].

Widespread use of econometric models is recommended to study resource productivity factors. For example, the authors Alston, J.M., Andersen, Wang, S.L., Heisey, P.W., in their works considered research costs as one of the main factors of productivity [3, 25].

Along with established conceptual approaches to considering factors of production as a set of labor, land, and capital resources formed under the influence of scientific and technological progress and united by entrepreneurial abilities, there is now a need for a more detailed study of intellectual labor. In a narrow sense, intellectual work is characterized by the need for knowledge and skills, and the result of its use has a direct impact on reducing production costs. In the context of the formation of a new technological basis for economic sectors, intellectual work becomes a determining factor in increasing the scientific research potential of society, and the comprehensive formation of scientific and innovation chains in the agricultural sector made it possible to identify a new term “scientific research forces of society” [7].

These forces, as a set of scientific, research and educational organizations, are considered as the foundation for the acquisition of knowledge and innovative solutions that are introduced into the production process.

Russian researchers consider this new category of productive forces as a system for acquiring knowledge and introducing it into the production process.

A number of foreign scientists focus on the analysis of joint innovations based on the common values of participants in the institutional structure [11, 12, 22].

Using the example of Chinese agriculture, the positive role of general innovation among stakeholders, which includes universities, research institutes, business representatives and government agencies, is noted. Using the conceptual principles of the triple helix theory, the authors examined the structural transformation of innovation communications for the period 1985–2014, concluding that the innovation chain gradually developed from a single helix to a hierarchical network with a triple helix. To overcome the existing gap between the demand for innovation and its supply, investments in science and education are necessary, mainly in large agricultural regions of the country [15, 19].

Known in the global scientific community for his research on sustainable development, H. Daly considered various concepts distinguishing between environmental and social sustainability. He highlighted such important factors of sustainable development as climate change, fluctuations in oil production, and concentration of production [10].

William E. Rees explored the features of traditional and sustainable development on a global scale, since the increase in global production of energy and material resources results in the emergence of global environmental problems. For sustainable development, it is very important to preserve ecological diversity, mainly in underdeveloped regions[20].Fairly large number of works explore approaches to the relationship between investment in human capital and labor productivity in agriculture [17,18]. However, the issues of studying factors at various levels of management and their connection with sustainable growth are not sufficiently addressed.

MATERIALS AND METHODS

The purpose of the article is to study the theory and methodology of factor analysis of the development of scientific and intellectual potential at the macro, meso and micro levels.

The methodological basis of the study is regulatory documents and open data from the World Bank, OECD, Rosstat.

RESULTS AND DISCUSSIONS

The sustainable development of the country's agri-food complex largely depends on the rate of economic growth, improvement of the functioning of the rural environment, and compliance with environmental safety requirements.

A study of the area of agricultural land in various countries was carried out (Fig. 1).

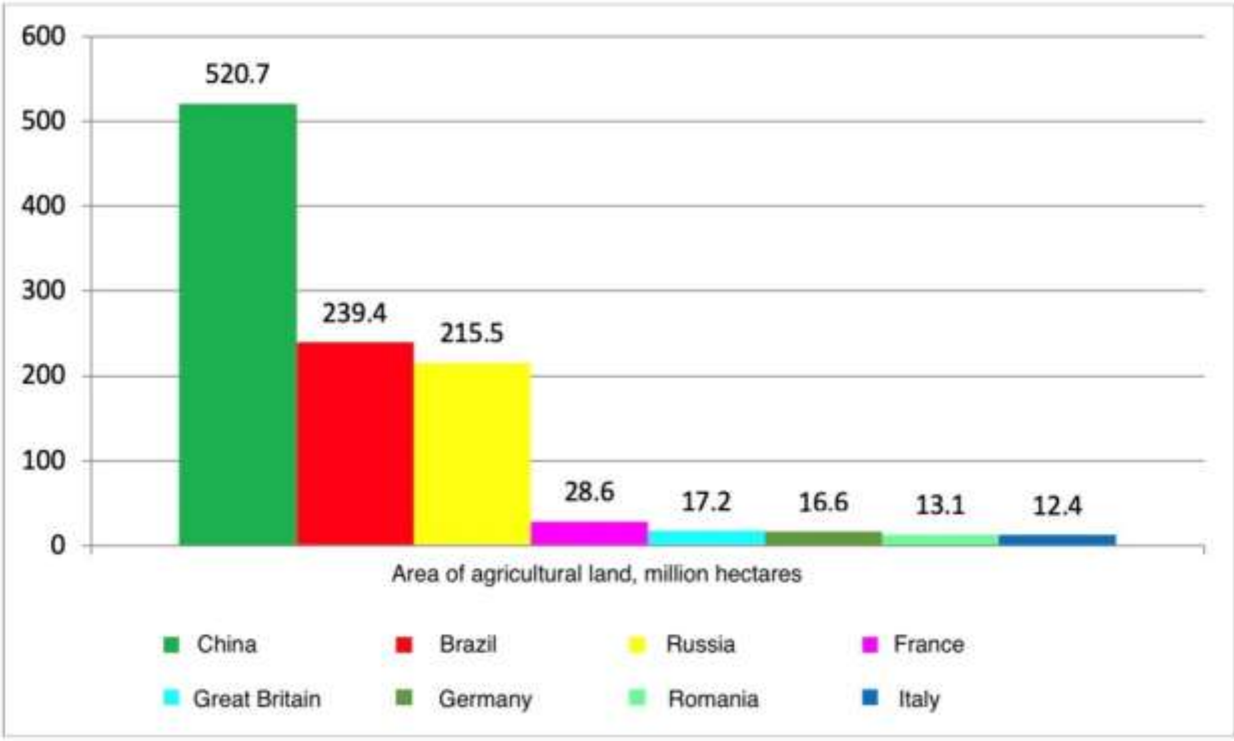

Fig. 1. Cross-country comparisons of agricultural land area (2021).
Source: Own calculations based on data [1].

Fig. 2 shows cross-country comparisons of agricultural value added. China ranks first in the world in terms of agricultural value added and agricultural area. Challenges to sustainable development and improved resource utilization remain for China's agricultural sector. According to experts, water use efficiency is 0.4-0.6, and nitrogen use efficiency is 30-35%, or 20% less than many developed countries. To increase the efficiency of use of land resources, a wider use of precision farming technology based on the design and production of domestic machinery and equipment is proposed [16].

Russia also occupies one of the leading places in the world in terms of agricultural land area and value added in agriculture.

However, under the conditions of sanctions and the need for national security in agriculture, the need for scientific and technological development is becoming more urgent.

Table 1 shows the dynamics of development of the main indicators of scientific research and development in Russia.

The analysis of the main indicators of the development of scientific activity in the country shows that scientific and innovative activity continues to develop.

During the period under study, the number of scientific organizations carrying out research and development increased by more than 16%.

In the overall structure of organizations, the number of research organizations over the past 10 years has decreased by 8%, while the number of design and engineering organizations has increased by more than 85%.

The number of personnel engaged in research and development decreased by 8%, including researchers with advanced degrees.

The number of people employed in agricultural sciences, according to Rosstat, has also experienced a decline. However, in recent years there has been an increase in funding for science from the federal budget, as well as internal expenditures on research and development, aimed at stimulating scientific and technological development and advanced production technologies as a priority direction for the country's development, improving scientific and innovative activities in many sectors of the national economy.

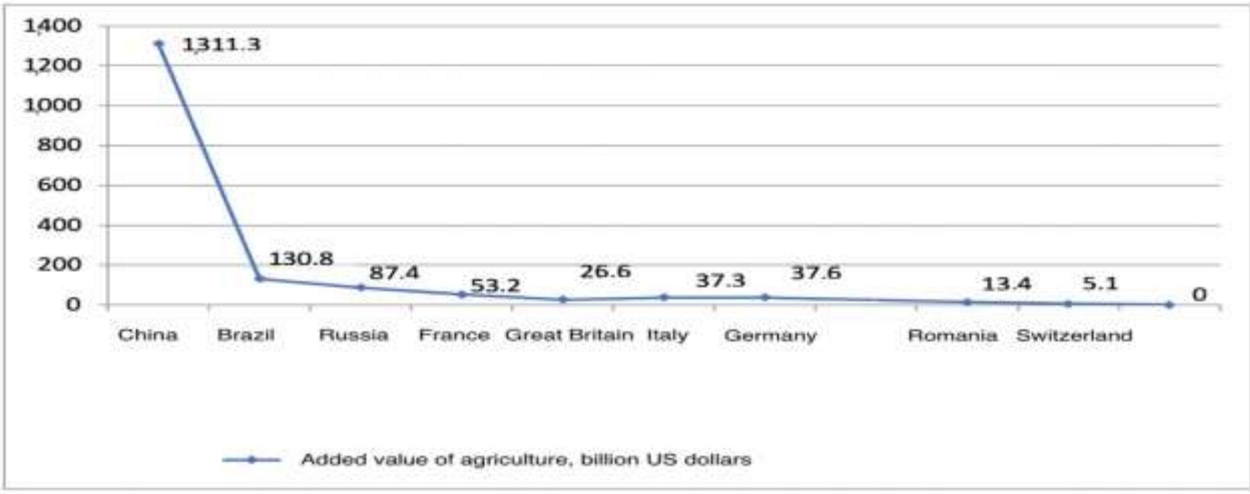

Fig. 2. The level of innovative activity of organizations in European countries, % (2021)
Source: Own calculations based on data [2].

Table 1. Dynamics of the main indicators of the development of scientific research and development in Russia in 2013-2022

Indicators	Years									
	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Number of organizations carrying out research and development	3,605	3,604	4,175	4,032	3,944	3,950	4,051	4,175	4,175	4,195
including: - researchorganizations	1,719	1,689	1,708	1,673	1,577	1,574	1,618	1,633	1,627	1,584
- designandengineeringdepartments	266	275	371	363	380	419	450	441	446	494
Number of personnel employed research and development, thousandpeople	727,029	732,274	738,857	722,291	707,887	682,580	682,464	679,333	662,702	669,870
Including those with an academic degree	108,248	109,598	111,533	108,388	103,327	100,330	99,912	99,122	97,537	95,204
Doctor of Sciences	27,485	27,969	28,046	27,430	26,076	25,288	24,844	24,473	24,074	23,306
PhD	80,763	81,629	83,487	80958	77,251	75,042	75,068	74,649	73,463	71,898
Funding of science from the federal budget, billion rubles	425,301.7	437,273.3	439,392.8	402,722.3	377,882.2	420,472.3	489,158, 4	549,602.2	626,574.3	631,701.6
Tofederalbudgetexpenditures	3.19	2.95	2.81	2.45	2.30	2.52	2.69	2.41	2.53	2.51
Internal costs for research and development, million rubles.	699,948.9	795,407.9	854,288.0	873,778.7	950,257.0	960,689.4	1,060,589.7	1,091,333.5	1,193,578.5	1,322,563.9

Source: Own calculations based on data [13].

The work contains a classification of positive and negative factors influencing the formation and application in the production process of the results of scientific and intellectual activity at the macroeconomic, territorial-industrial and local levels (Table 2).

Table 2. Classification of factors of scientific and intellectual capital

Name offactors	Impact on scientific and intellectual capital	
Macroeconomiclevel		
	Positiveinfluence	Negativeinfluence
Demographicfactors	Positive population dynamics and increasing life expectancy determine the possibilities for scaling scientific and intellectual capital	Reduction in the number of employees in the main sectors of agriculture. The outflow of human resources in the agricultural sector is associated with the insufficient level of importance of labor in rural areas.
	Positiveinfluence	Negativeinfluence
Economic forces	The growth of agricultural production and investment in R&D create the prerequisites for the scientific and technological development of agriculture.	Sanctions policy and macroeconomic instability create the preconditions for rising food prices, slowing technological breakthroughs and the development of the scientific and intellectual potential of agriculture.
Social factors	The social policy of the state predetermines the conditions for the development of rural areas on the basis of improving the knowledge, skills, and competencies of workers.	Lower levels of wages and income compared to other sectors of the economy, lower productivity growth labor is significantly lower than in other manufacturing industries
Institutionalfactors	A system of formal and informal institutions that implements effective mechanisms for regulating and supporting domestic science within the framework of the institutions of the Russian innovation system determines the prospects for the further development of scientific and intellectual capital	The insufficient level of support for agricultural producers (especially small businesses) limits the possibilities for the development of domestic agricultural science and the use of its results in production
Territorialandsectorallevel		
	Positiveinfluence	Negativeinfluence
Regional conditions, specialization and technical and technological features of the industry	Involvement in circulation of non-is used agricultural land values; diversification of the agricultural production structure; technical and technological modernization of the industry; development of new related industries and involvement of skilled labor in them determine the requirements for professional knowledge employees and develop appropriate competencies	Pronounced regional natural, climatic and economic conditions determine differences in specialization, level of innovation activity, technological transformations, and the need for skilled labor
Quality of life, income level of the rural population, availability of rural facilities infrastructure	Determine the comfort of work and rest in rural areas localities and contribute to the retention of personnel	Insufficient regional funding resources and income support reduce the quality of life and reduce motivation to acquire new knowledge
Local level (enterprise)		
	Positiveinfluence	Negativeinfluence
State of health and level of education of a person	Opportunities for generating income from the use of individual scientific and intellectual capital	Insufficient compliance of worker competencies with the requirements of the modern digital agricultural economy.
Personal investment in developing professional skills and acquiring new knowledge	Employee assessment of the results of implementing innovative technologies	Inversely proportional relationship between the existing level of human resources and the growth rate of agricultural production in the digital economy.
Personnelpolicy	Stimulating an employee to perform highly productive work is one of the most important factors in increasing individual productivity of workers	Ineffective personnel policy and the system of career guidance, training and retraining of personnel limit the opportunities for advanced training and acquisition of new knowledge
Social and psychological characteristics of personality- Personal qualities	Adaptability, receptivity to knowledge, absorption of innovative developments and technologies, pronounced leadership qualities contribute to increasing income from the use of individual scientific and intellectual capital	Insufficient level of education and professional training hinder the development of individual scientific and intellectual potential

Source: Own calculations.

At the macroeconomic level, the formation and development of the scientific and intellectual potential of agriculture is determined by the action of demographic, economic, social and institutional factors. Changes in population size and life expectancy determine the possibilities for scaling scientific and intellectual capital. Economic growth, macroeconomic stability, investment in science and education create conditions for its more effective use. Effective mechanisms for regulating and supporting domestic science within the Russian innovation system determine the prospects for the further development of scientific and intellectual capital [23].

At the territorial and sectoral level, great importance is given to regional climatic and economic conditions, which determine the specialization of agriculture and the possibilities of technical and technological modernization of the industry and the development of new industries. These factors determine the requirements for the professional knowledge of workers and form the corresponding competencies.

At the enterprise level, an important role is played by an effective personnel policy aimed at stimulating workers, organizing training and retraining of personnel, which contributes to the disclosure of personal qualities in the process of forming individual scientific and intellectual capital.

Demographic factors determine the resources of scientific and educational capital, forming restrictions and incentives for its further development [5].

For example, changes in the mortality rate of the working-age population cause immediate shifts in the number of certain categories of labor resources, and fluctuations in the birth rate make it possible to predict the labor market in the long term [14].

Territorial and sectoral factors explain the specifics of the formation of scientific and educational capital of regional agricultural systems from the standpoint of land use characteristics, seasonality of labor processes, agricultural profitability, technical and technological features of the industry, and quality of life. For example, the underdevelopment of production and social infrastructure, unprofitability of production leads to an outflow of labor resources from lagging regions for the purpose of employment in the city or regions with more favorable socio-economic conditions for the use of their professional qualities.

Local level factors determine the level of individual scientific and educational capital of agricultural workers. Receiving income from the use of your professional abilities and knowledge potential allows you to shape your quality of life and level of well-being. Further development of personal qualities through additional education, mastering new competencies and self-development increases labor productivity and allows one to receive higher wages. Investing in education is becoming a necessary condition in the process of neo-industrialization of agriculture and the use of digital technologies.

CONCLUSIONS

Conceptual aspects of the study of human resources potential in the agricultural sector have been developed based on the works of foreign and Russian authors.

Cross-country comparisons of the area of agricultural land and the value of gross value added of agriculture in different countries were carried out.

The article presents a systematization and classification of socio-economic, technological, infrastructural and demographic factors that constrain and accelerate the development of scientific and intellectual potential at the macro, meso and micro levels.

The article classifies positive and negative socio-economic, technological, demographic and organizational factors. Measures are proposed for the use of scientific and intellectual potential in agricultural production as a driver of scientific and technological development.

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AN ALGORITHM FOR ORGANIZING AND GROUPING DATA RELATED TO THE EXPENDITURESBY EDUCATION LEVELS

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Abstract

This paper presents an algorithm for organizing and grouping data related to the expenditures by education levels in Bulgaria. The built database is used as a source from which the necessary information is searched depending on the entered indicators and time interval.The considered indicators include the public and private expenditures by education levelsfor the period2012-2020.The extracted subsets of elements are processed and analyzed. In this connection, four groups of variables are calculated and discussed.The results show that the expenditures in four of the education levels (primaryand pre-primary education as well as upper and lower secondary education) grow over the last five years (2016-2020). The quoted indicator inpost-secondary, non-tertiary education isreduced gradually in 2016-2019. During 2015, as compared to 2014, the expenditures in the considered 7 levels of education decreased in the range from 0.29% to 7.81%.This work calculates the share of expenditure for tertiary education-bachelor, master and doctor in comparison with the totalexpendituresfor educationinthe indicatedtime period. The obtained value of the variable for this education level is the highest. It is 29.74%. The values of this variable are significantly lower for the following two levels of education - tertiary education-professional bachelor and post-secondary, non-tertiary education. They are 1.54% and 0.29% respectively.

Key words*: *algorithm, database, expenditures, education level

INTRODUCTION

Modern information technologies have widely entered various spheres of our life [18], [12]. In this regard, the employees in the relevant companies and organizations must have the necessary professional qualification [1], [11], [16]. According to Angelov (2019) [4],"Education is considered an investment in human capital with long-run return horizon" [4]. Gergova (2020) [10] indicates that the sustainable development of an economy has a direct relationship with the level of development of education and science [10]. In addition, the study of Dragoeva (2022) [9] notes that "Increasing the spending on education is a prerequisite for a country's prosperity" [9].

The present work considers part of these exposed problems.Data from time seriesrelated to theexpenditure by education level, general schools by type,teaching staff in general schools, etc. are provided on the website of the National Statistical Institute of Bulgaria [13], [14]. They are saved in Excelfiles. The information from the listed sources is extracted and organised in a created relational database. Relational databases can be used to store data from various fields (economy, tourism, agriculture, etc.) [3], [8], [15].

Subsequently, these data are processed in order to obtain information that is used in making certain decisions from the relevant organizations [2], [5], [6]. The created database in this work contains the following table schemas:

- Country (id_n, name);
- Education level (ID, education level, id_n);
- Expenditures (ID, expenditure, year, id_d);
- General schools (ID, schools, id_c);
- Number_schools (ID, year, number, id_s);
- Teaching staff (id_1,years, number, id).

The Country table is related to the tablesGeneral schools and Education level.TheGeneral schoolstableis related to the following two tables - Number_schoolsand Teaching staff. The Education level table is related to theExpenditures table.The created relationships between the mentioned abovetables are of type one-to-many.

The aim of this paper is to present an algorithm for organizing and grouping data related to the public and private expenditures by education levels in Bulgaria. The built database is used as a source from which the necessary information is searched depending on the entered indicators and time interval.

MATERIALS AND METHODS

Description of the algorithm: The investigated objects are stored into individual tables in the mentioned relational database.Differentqueriescould be formed [7], [17] from the presented information from the database on the basis of pre-defined indicators.These indicators include the following components:

•expenditure by education level;

•number of the general schools by type;

•number of the teaching staff in general schools;

•time interval.

The scheme of the algorithm is presented in Fig. 1.The current workexaminesthe period from 2012 to2020. But userscould choose a smaller time intervalaswell as non-consecutive years from the indicated period.

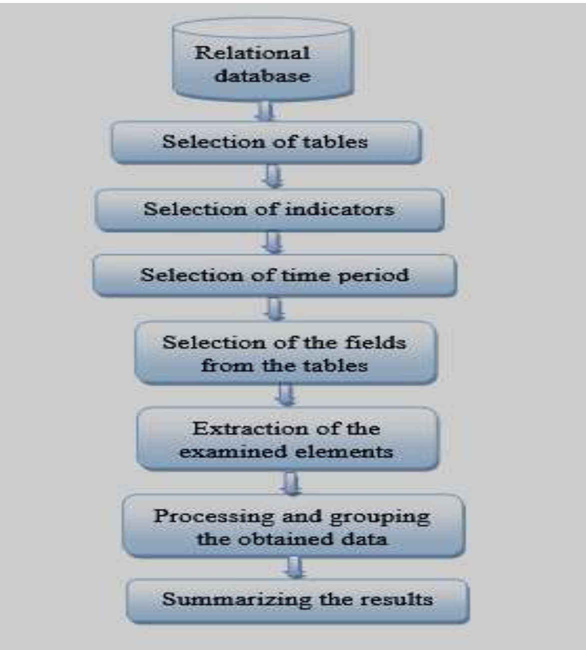

Fig.1. Scheme of the presented algorithm
Source: Own conception.

The tables containing the studied objects should be selected (Fig. 1). In this case, they are the following three tables:

•Country (id_n, name);

•Education level (ID, education level, id_n);

•Expenditures(ID, expenditure, year, id_d).

The consideredindicators include the public and privateexpendituresby education levelsin thementioned9-years time period.The choice of indicators determines the corresponding fields from the tables where the necessary data will be searched.

The extracted groups of elements are presented in separatequeries. Practically,the obtained information from these queries is processed and analyzed. In this regard, it is necessary to calculate the following four groups of variables in separate modules:

• $N_z = \sum_{k=1}^{b} w_{zk}$ .... (1)

where:

b=9,

$z \in \overline{1;7}$;

N_z - the sum of the expendituresin the relevant level of education during the examined period.

In addition, it should be noted that thestudiedexpenditures are for the followingeducation levels:

-pre-primary education;

-primary education;

-lower secondary education;

-upper secondary education;

-post-secondary, non-tertiary education;

-tertiary education - professional bachelor;

-tertiary education -bachelor, master and doctor.

• $P_{zk} = w_{zk} \cdot \frac{100}{\sum_{i=1}^{7} w_{zi}}$ .... (2)

where:

P_{zk} - the share of expenditure for the relevanteducation level in comparison with the total expenditures for education during the considered year,

w_{zk} -expenditurefor a given level of education for k-th year, $k \in \overline{1;9}$.

• $C_z = \dfrac{N_z.100}{\sum_{k=1}^{7} N_k}$ ....(3)

where:

C_z - the share of expenditure for the given level of education in comparison with the total expenditures for education for the studied time interval, $z \in \overline{1;7}$;

• $F_z = \dfrac{w_{z9}}{w_{z1}}$ ....(4)

where:

w_{z1} and w_{z9} -expenditurefor relevant level of education for the first and the last year from the investigated time period.

This workalso summarizesand discussesthepresented results.The obtained conclusions for each one of the considered indicators during the examined period are visualized.

RESULTS AND DISCUSSIONS

The choice of tables from the built database is determined depending on the examined information.The considered objects in this study are searched from the related tables Country, Education level and Expenditures.The values of the studied indicators are extracted from several fields from the listed tables.These are the relevant expenditures in the abovementioned education levels.

The extracted elements from the database are analyzed in the time segment 2012-2020.In this connection, the dynamics of changes in each of the expenditures in the relevant level of education are discussed.The linesin Fig. 2 presentthe values of theexpenditures inpost-secondary, non-tertiary education and tertiary education - professional bachelor(shown on the secondary vertical axis), whereas thecolumns present the expenditures for the rest five levels ofeducation(shown on the primary vertical axis). On the whole, the expenditures in 6 of the considered education levels grew rapidly in the years between 2013 and 2014.Onlytheexpenditures in post-secondary, non-tertiary educationare reduced in 2014.During 2015, as compared to 2014, the expenditures in the listed 7 levels of education decreased in the range from 0.29% to 7.81%.

More different situation is observed in theperiod 2016-2020.The expenditures in four of the considered levels of education grew. These levels include upper secondary education, primary education, lower secondary education as well as pre-primary education. In addition, the examined variable in the four-year time segment (2016-2019) for post-secondary, non-tertiary education isreduced. A decline in the indicated expenditures in tertiary education-professional bachelor is presented for 2016 and 2018. This indicator in tertiary education-bachelor, master and doctor reducedin 2017 (Fig. 2).The lowest values for the examined expenditures(w_{z1})in 6 of the considered educationlevelsare registered during 2012. While the expenditures (w_{z9}) in each of the mentioned 6 levels of education are the highest in 2020.

The obtained values of the variable (F_z)vary in the range from2.03 to 1.54.In this case, theexpendituresin primary education are increased more than 2 times during the 9-years time period. A similar result is obtained for theexpenditures in lower secondary education, upper secondary education and tertiary education-bachelor, master and doctor, where the growth of the studied indicator is more than 1.9, 1.8 and 1.7 times respectively, in the indicated period.

The expenditures for tertiary education-professional bachelor and pre-primary education are also increased by more than 1.6 and 1.5 times.An exception is also established. Only the expenditures for post-secondary, non-tertiary educationat the end of the time segment decrease compared to the first year from the consideredinterval (Fig. 2).

In addition, it should be noted that, during 2020 as compared to 2019, the expendituresin the studied education levels are greater. In this case, this is the period when the COVID-19 crisis occurred.

The present work analyzes the results concerning the calculated sum of the expenditures (N_z) for each of the listed education levels in the 9-years interval.

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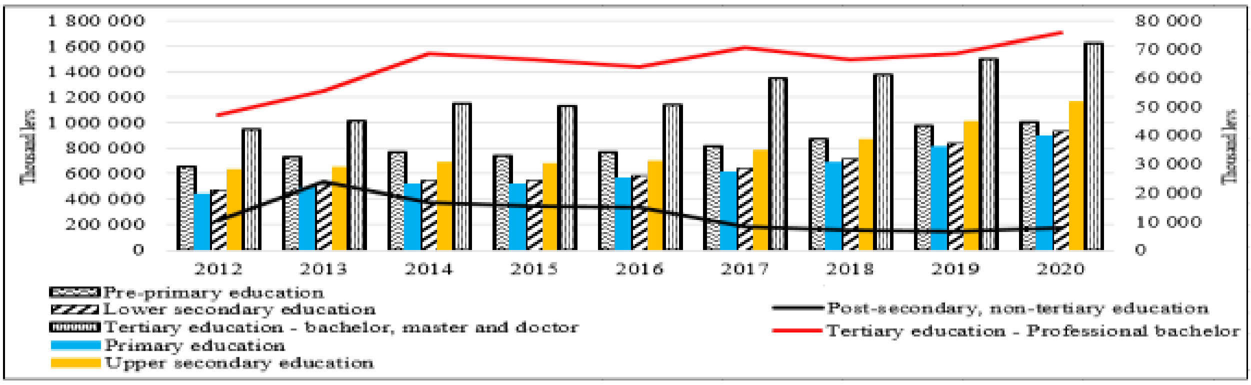

Fig. 2. Dynamics of changes in the relevant expenditures in the considered education levels for the period 2012-2020

Source: Data fromthe National Statistical Institute [13, 14].

The values of this indicator for tertiary education - bachelor, master and doctor are significantly higher, as can be seen from Fig. 3.

High values of the indicator are also obtained for 4 of the considered levels of education (lower and upper secondary education, primary educationas well as pre-primaryeducation). The total expenditures in two education levels (post-secondary, non-tertiary education and tertiary education-professional bachelor) are the lowest in the studied period.

Theresults for the variable P_{zk} are visualizedin the diagram in Fig. 4.

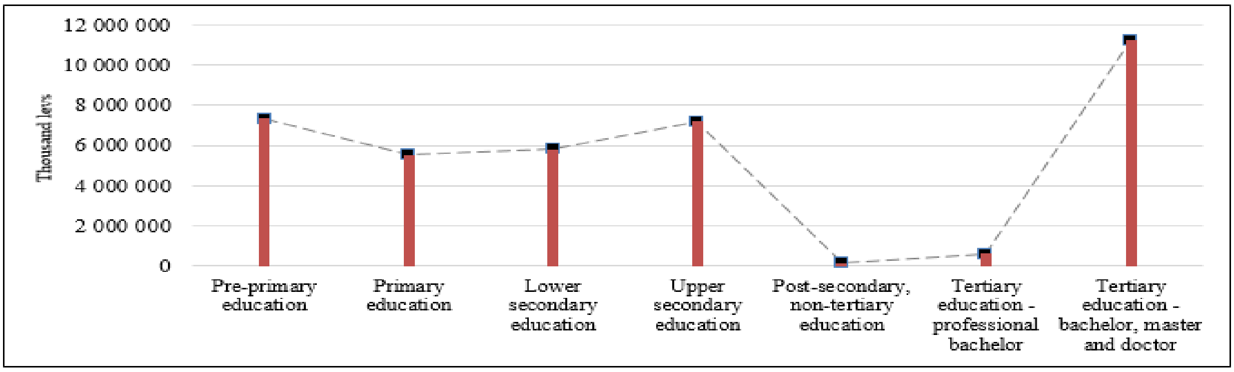

Fig. 3. Results concerning the calculated sum of the expenditures in each level of education during the examined time period.

Source: Own processing based on the data from [13, 14].

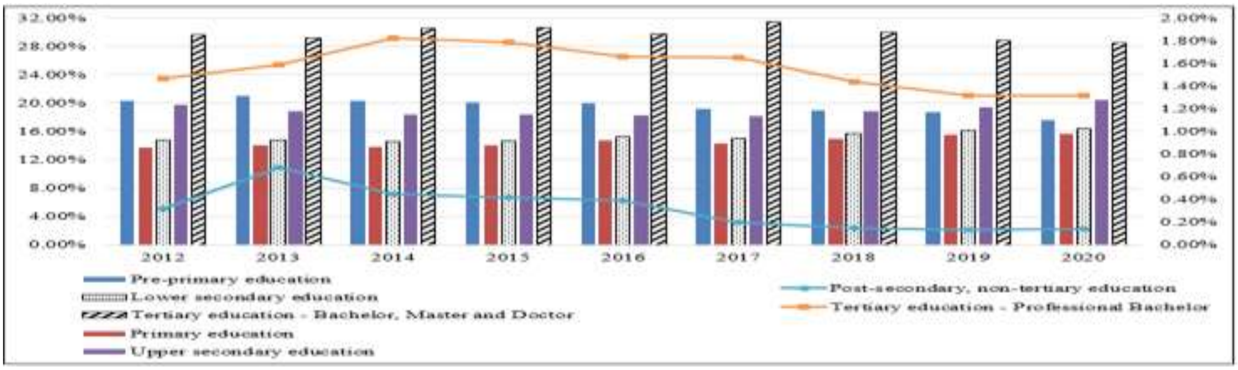

Fig. 4. Presentation of the obtained values of the variable P_{zk} in the 9-year time interval

Source:Own processing based on the data from [13, 14].

Thecolumns in Fig.4presentthe values of the indicator P_{zk} for fiveof the considered seven levels ofeducation (displayed on the primary vertical axis),while the lines present the values of this mentioned indicator (displayed on the secondary vertical axis) for the other two education levels which are tertiary education-professional bachelor and post-secondary, non-tertiary education.

Quite naturally, the highest relative shares (P_{zk})are calculated for expenditures in tertiary education-bachelor, master and doctor for each year during the studied time interval.This variable reaches values between 28.46%-31.45%.Quite high values of P_{zk} are obtained for two of thestudied levels of education (pre-primary education and upper secondary education). In this case, the calculated values change in the range from17.59% to 20.99%.

The relative shares of the expenditures in the next two education levels - primary education and lower secondary education vary from 13.75% to 16.40% in the indicated 9-years period (Fig. 4).

The situation regarding the considered variable (P_{zk}) is radically different for other two educationlevels. The relative shares of expenditures in post-secondary, non-tertiary education vary from 0.68% to 0.13% in the investigated period. Slightly higher values of this variable are calculated for tertiary education - professional bachelor.In this case, the values vary in the range from 1.82% to 1.32% (Fig. 4).

The values of the mentioned-above variable C_z are visualized in the diagram of Fig. 5. The presented results for the indicator in each of the considered levels of education are summarized. The share(C_z) of expenditure for tertiary education -bachelor, master and doctorin comparison with the total expenditures for education in the indicated time period is calculated. Quite expectedly, the obtained value of the variable for this education level is the highest.It is 29.74%.The indicated expenditure is slightly less than one-third of the total expenditures in the examined levels of education.

The indicator values(C_z) for two of the considered levels - pre-primary education and upper secondary education are 19.39% and 19.01%, respectively. Here, the calculations show that each of these expenditures is slightly less than one-fifth of the total expenditures. As can be seen from the results presented in Fig. 5, the values of C_z for primary education as well aslower secondary education are 14.66% and 15.37%.

As can be expected, the obtained values of C_z are significantly lower for the following two levels of education- tertiary education-professional bachelor and post-secondary, non-tertiary education.They are 1.54% and 0.29%, respectively.

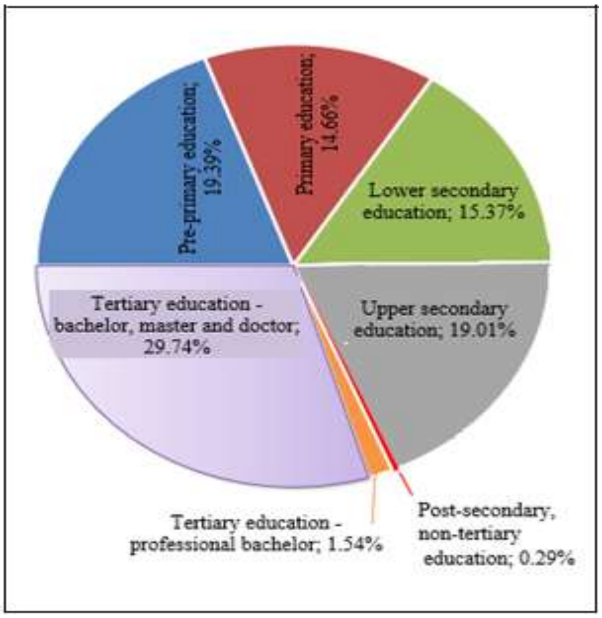

Fig. 5. Results for the variable C_z during the studied time segment
Source:Own processing based on the data from [13, 14].

CONCLUSIONS

This paper presents an algorithm for organizing and grouping data concerning the expenditures by levels of education in Bulgaria.The created database is used as a source from which the necessary information is searched depending on the entered indicators and time interval. The examined indicators include the public and private expenditures by education levels. The investigated period covers generally 9 years from 2012 to 2020.

The extracted subsets of elements are presented in separate queries.The information from these queries is processed and analyzed. In this connection, four groups of variables are calculated and discussed.Thepaper also summarizes and visualizes the obtained results.

The expendituresin primary education are increased more than 2 times during the considered period. A similar result is obtained for theexpenditures in lower and upper secondary education and tertiary education-bachelor, master and doctor, where the growth of the studied indicator is more than 1.9, 1.8 and 1.7 times respectively, in the examined time interval. The expenditures for tertiary education-professional bachelor and pre-primary education are also increased by more than 1.6 and 1.5 times. Only the expenditures for post-secondary, non-tertiary educationat the end of the period decrease compared to the first year from the indicated time interval.

The paper also calculates the share of expenditurefor tertiary education-bachelor, master and doctor in comparison with the totalexpendituresfor educationinthe mentionedtime period.The obtained value of the variable for this education level is the highest. It is 29.74%. The values of this indicator are significantly lower for tertiary education - professional bachelor and post-secondary, non-tertiary education. They are 1.54% and 0.29%, respectively.

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COMPONENT OF MARKETING IN AUTHENTIC ROMANIAN RURAL TOURISM

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Abstract

The article addresses the importance of marketing in authentic rural Romanian tourism, highlighting the close connection between local traditions and fundamental principles of tourism marketing. The article emphasizes the importance of providing authentic and quality experiences in traditional Romanian households, paying attention to details such as architecture, interior design, gastronomy, traditions, and local customs. To attract tourists to these authentic places, various promotional channels are employed, including specialized websites, social media, local partnerships, and themed events.The role of modern technology is highlighted in facilitating the tourist experience and collecting feedback, contributing to the continuous improvement of services and their promotion. Additionally, the article underscores the importance of active involvement of locals in the development and promotion of rural tourism, which can lead to the creation of authentic tourist products and sustainable community development. In conclusion, the essential role of marketing in promoting and developing authentic rural tourism is emphasized, with its positive impact on raising awareness of the concept of authenticity in rural areas, attracting tourists, strengthening brand image, and fostering economic growth in rural communities. Through a well-conceived and implemented marketing strategy, the resources and tourism potential of rural areas are leveraged, offering tourists authentic and memorable experiences.

Key words**:** *rural tourism marketing, authentic, marketing components*

INTRODUCTION

Relevant in the context of sustainable development and tourism promotion, authentic Romanian culture leaves its mark on rural tourism marketing [19, 9, 11]. Anticipanting to tourists seeking authentic experiences, unspoiled nature, local traditions, and genuine interaction with local communities, this domain marketing contributes to the sustainable development of rural areas and promotes Romania's cultural and natural heritage [16, 12]. This paper reviews elements of authentic Romanian culture represented by architecture, interior design, local gastronomy, customs and tradition closely tied to the basic principles of this specific sector of tourism marketing, highlighting their close connection and impact. In the context of a lack of coherence in the application of the principles of marketing and effective promotion of Romanian rural tourism, as it appears from the official documents, [17] of the lack of a public statistical reports regarding the topic addressed, the clarification of the theoretical concepts in relation to the Romanian authenticity, represents in our opinion a solid starting point for future research and development.

MATERIALS AND METHODS

Although it represents an area of permanent interest, marketing in rural tourism being addressed in local specialized literature through specific scientific works, the connection between the criteria of authenticity in rural tourism and the component elements of marketing in this sector is highlighted occasionally. This paper aim is to analyse and focus on identifying and satisfying the needs of tourists interested in authentic experiences, shaping an ideal customer avatar that includes a passion for traditions, the curiosity of an explorer, an appreciation for local gastronomy, community support, and a love for natural landscapes. We will further analyze the importance of authentic Romanian culture in (1) building relationships with customers, (2) understanding the tourist market and potential clients, (3) developing products offered in the tourism circuit, (4) promotion channels, and (5) receiving feedback.

(1). Understanding the tourist seeking authentic Romanian experiences is crucial for shaping the customer avatar and establishing an optimal relationship. The ideal customer avatar represents a symbolic image of a person who perfectly aligns with the products or services offered in this field [7] (Figure 1).

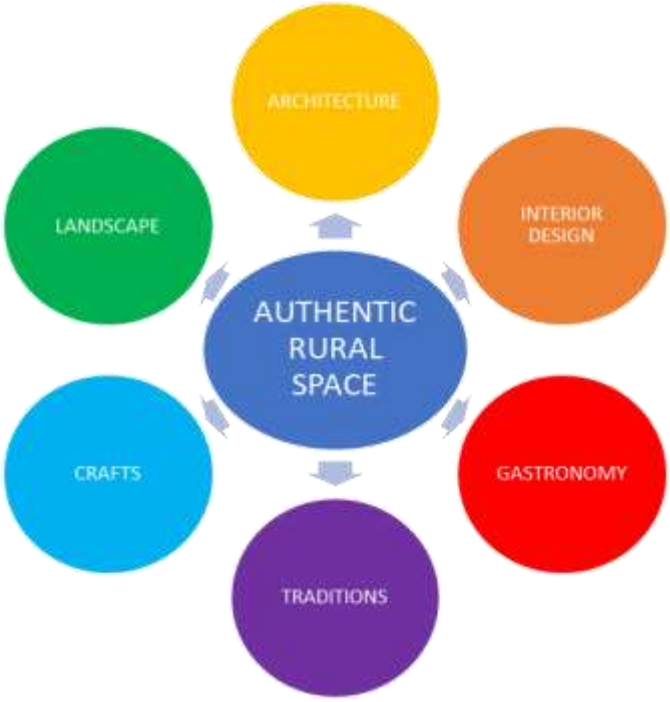

Fig. 1. Authentic rural space – product components
Source: own processing according to Dobre et al. [7].

Let's explore some characteristics of this avatar:

Tradition Lover: Tourists who appreciate authentic Romanian culture are passionate about traditions, customs, and local culture. They seek to experience the authenticity of Romanian villages.

Curious Explorer: This ideal customer is open to discovering new places, interacting with locals, and understanding their way of life. They seek authentic and unique experiences.

Local Cuisine Enthusiast: Tourists appreciate traditional Romanian cuisine, are interested in tasting local dishes, participating in traditional meals, and learning about the ingredients used, cooking in households alongside hosts.

Nature Lover: Tourists appreciate the beauty of nature and are drawn to the picturesque landscapes of Romanian villages. They seek peace, clean air, and landscapes untouched by human influence.

Community Supporter: The ideal customer understands the importance of local involvement, supports artisans, buys local products, and contributes to the sustainable development of rural communities.

In conclusion, the customer avatar appreciating authentic Romanian culture is someone passionate about authentic experiences, local culture, and the beauty of rural Romanian villages.

(2) In satisfying the needs and desires of tourists with all the concerns mentioned above, the host will meet them with a positive attitude, quality services throughout their stay, good customer service, attempting to connect them to all components of authentic Romanian culture starting from architecture,

traditional interior design, gastronomy, traditions, and customs, all stemming from a perennial cultural heritage perfectly reflected in the rural household. The customer represents the purpose of the entrepreneur's activity, and the experience thus obtained will be authentic, with the customer feeling part of rural life.

This tourist experience will represent the unique selling point (specificity, originality, individuality) highlighted through promotion channels [1].

Authentic Romanian culture develops in a tourist market characterized by several parameters: tourist profile (related to age, income, education, ethnicity, religion, living environment), biogeographic area (landscape, biodiversity), traditional activities specific to the rural destination (crafts, sale of local natural or manufactured products), travel trends (increased demand for cultural, ecological, adventure tourism), infrastructure and facilities, competition, and growth opportunities [18]. Understanding these aspects helps the entrepreneur continuously monitor and evaluate rural tourism performance, allowing for strategy adaptation based on market changes and customer feedback.

(3) In 1971, Grubb and Stern defined the concept of a product as congruent with the consumer's personal perception, who actually dominates this domain. In this context, a tourist educated in authenticity aspects in rural tourism will respond to product offers [10].

We can enumerate and exemplify some of the authentic tourist products: "From Wine Cellar to Wine Cellar", "Picking Plums in the Orchard", "On Horseback or On Foot on the Hill", "Carpentry in Grandpa's Workshop", "Wooden Flowers in Grandpa's Workshop" (original ideas from author). These types of products offer a note of originality, authenticity, and attractiveness, and can be found in rural tourism, especially at the level of traditional peasant households. The diversity of these products is ensured by the difference between the ethnographic areas of the country regions, each with its own attributes favorable to the development of quality, sustainable rural tourism. In addition to the concrete elements ensuring absolute tourist quality necessary for hosting (services for which the tourist pays at the assumed tariff category level, they benefit from equipment and facilities in perfect working order, and last but not least, they must be protected from the hygiene, health, life, and personal property points of view). Furthermore to these absolutely necessary principles of modern tourism, the tourist benefits from specific aspects of authentic Romanian culture (rooms built according to recognized traditional methods as offering clean, airy, and comfortable spaces, room design is specific to each area, etc.). The staff interacting with the tourist must have a proper attitude and appropriate attire [2].

(4) To meet the needs of tourists and attract them to authentic Romanian households, entrepreneurs rely on using educational marketing in a mix of promotion channels. Thus, ethnocultural biographies will be developed and exhibited through traditional channels: TV, radio, press - especially through articles and shows - but also through social networks (Facebook, podcasts, Instagram, YouTube, TikTok, QR codes, Pinterest); own websites. The variety of existing promotion channels, especially through the development of the online environment, offers a vast promotion framework and, with constant efforts from the entrepreneur, but also through a well-defined strategy, they can reach the above-defined target audience. Here are some promotion channels that, used together, can ensure the entrepreneur's visibility:

Specialized websites: Creating a website dedicated to rural tourism in Romania can be a crucial step. It should provide detailed information about destinations, available experiences, accommodation facilities, and outdoor activities.

Social media: Using social platforms such as Facebook, Instagram, and YouTube to promote destinations and tourist experiences is essential in the digital age. Regular posts, beautiful images, and interaction with the community can increase awareness and engagement.

Local partnerships: Collaborating with local authorities, tour operators, local producers, and other businesses in the area can help mutual promotion and create attractive tourist packages.

Participation in tourism fairs: Presence at tourism fairs and exhibitions, both domestically and internationally, can draw attention to rural tourism in Romania and generate potential partnerships or sales.

Blogging and influencer marketing: Collaborating with travel bloggers and influencers with a relevant audience can generate visibility and credibility for rural destinations and experiences.

SEO (Search Engine Optimization): Ensuring that the website and associated content are optimized for search engines can increase online visibility and attract organic traffic.

Publications and specialty magazines: Publishing articles and advertisements in travel magazines and specialty publications can help draw attention to authentic Romanian rural tourism.

Themed tours and excursions: Organizing themed tours and excursions in rural areas, focusing on traditional and authentic experiences, can attract tourists eager to discover local culture and traditions.

Local events and festivals: Participating in and promoting local events and cultural or gastronomic festivals can draw attention to rural tourism and offer tourists opportunities to experience local authenticity.

Reviews and testimonials: Gathering and promoting positive reviews from previous tourists can strengthen confidence in rural destinations and tourist experiences.

The mix and match of these channels according to the specifics of each destination and target audience can contribute to the efficient promotion of authentic Romanian rural tourism [14].

(5) Recent studies demonstrate the beneficial influence of smartphone usage on the tourist experience [6]. Modern technology facilitates the collection and analysis of various types of information with great accuracy, allowing for spatial and temporal knowledge of tourist activities [4]. Entrepreneurs can benefit from a better understanding of social media's influence on consumer perception and how this perception influences tourists' behavior and choices [5]. An important component of marketing is the feedback provided by tourists. The level of tourist satisfaction is easily transmitted using modern technology. Collecting tourists' reactions contributes implicitly to better promotion of the services offered. Parameters such as the perception of the value of the tourist product [3, 15,], service quality [13], tourist-personnel relationship, and tourist-tourist relationship characterize the customer satisfaction level [8].

RESULTS AND DISCUSSIONS

This paper highlights the importance of authentic Romanian culture in rural tourism marketing by emphasizing the connections between marketing principles and authentic Romanian elements. Each component of rural tourism marketing finds applicability in authentic rural tourism. The transition between traditional and modern facilitated by technology benefits both tourists and bearers of authentic Romanian culture (Figure 2).

There is a constant concern for the growth and development of tourism, as it appears from the National Strategy of Romania for the Development of Tourism 2023-2035, in terms of the marketing component, the aspects are being developed [17].

It can be noted the lack of various institutional instruments, at government level, for the collection and analysis of statistical data necessary for a relevant market analysis, for example surveys on the level of satisfaction of tourists, as well as instruments for monitoring and evaluating the results and effectiveness of marketing instruments and promotion [17].

Statistical studies regarding the impact of marketing in the field of rural tourism were not identified through the analysis of public databases at the national level.

Development direction is crucial for assisting research-intensive activities in the field of tourism marketing, carried out by higher education institutions and competent centers.

Fig. 2 .Marketing in rural tourism main components
Source: own processing.

These activities enable the creation and implementation of the instruments required for market studies (authenticity in marketing integrated parameters) that analyze tourist flows, visitor behavior patterns, segmentation of the market, and adaptation of customer attraction strategies.

We have demonstrated that rural tourism relies on authentic experiences, linked to traditions, customs, and the lifestyle of local communities.

Authenticity is a key factor in attracting tourists and creating a positive image of rural destinations. Promoting regional cultural diversity can attract tourists interested in authentic and unique experiences.

Marketing in rural tourism can educate tourists about the locals' way of life, traditions, and their impact on the community. Thus, tourists can become more aware and respectful of rural environments. Active involvement of locals in the development and promotion of rural tourism is essential. This can lead to the creation of authentic tourist products and the sustainable development of communities.

CONCLUSIONS

In conclusion, marketing plays an essential role in promoting and developing authentic rural tourism, contributing to raising awareness of authenticity in rural areas, attracting tourists, strengthening brand image, and boosting economic growth in rural communities.

Although it is easy to intuit the impact of this concept in the development of rural tourism, further research is needed through specific statistical validation tools to be able to monitor various market indicators, to provide an objective image of tourism activity focused on authentic local elements: landscape, regional/national cultural heritage.

Through a well-conceived and implemented marketing strategy, the resources and tourism potential of rural areas can be exploited, offering tourists authentic and memorable experiences.

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INCREASING PROFITABILITY OF MEAT PROCESSING UNITS BY ADDING VALUE FOR MEAT TRIMMINGS

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Abstract

In the meat industry, after the cutting, deboning and trimming phases, meat trimmings result from which minced meat is usually made. From an economic point of view, the superior utilization of meat trimmings is of interest. A method analyzed in this paper consists of the injection of trimmings in the meat muscle. The results obtained indicated a lower weight gain if the meat is injected with brine emulsion (between 8.37% and 9.84%) compared to samples injected only with brine (41.20% for pork ribeye and 45.7% for beef ribeye). However, protein content is inversely correlated with weight gain (r^2=-0.88). The main disadvantage of the method lies in the fact that it decreases the preservability of the meat injected with meat emulsion compared to the control samples.

Key words*: *meat, injecting, trimmings, emulsion, economic, processing

INTRODUCTION

Meat and meat products are valuable sources from a nutritional point of view, and their consumption shows an increasing trend [3].
For various meat products, larger pieces of meat are used, which must be salted. In most cases this salting process is carried out by injection with brine [5]. The brine used contains, in addition to salt, different ingredients such as: dextrose, citric acid, phosphates [9]. Later, the notion of extender was used, for brines with the addition of various substances to reduce the costs of meat processing [7]. These extenders can be extracted from various sources. For example, hydrocolloids can be added to improve the functional properties of meat products [1]. Starch from various sources and modified starch are also frequently used to increase the water retention capacity of meat [2, 8].
Fu *et al.* (2022) showed that marinating meat with edible mushroom powder leads to improved meat tenderness and water retention capacity [4]. For the same purpose, Hu *et al.* (2019) injected chicken breast with brine containing whey [6].
The desire of consumers is to add ingredients of other origin as little as possible to meat products. Meat processing units want the highest possible profit, and this goal can be achieved by adding value to low-cost components [12]. An example of this components is the pieces of meat that result from operations such as cutting, deboning and trimming meat. By fine chopping these pieces of meat, obtaining of a brine emulsion and injecting it into the meat brings added value to these by-products and simultaneously meets consumer demand. In this way, meat trimming is sold at the price of a meat product obtained from a whole muscle instead of being marketed at the price of minced meat
Until now, there are processing lines that allow the injection of meat with brine emulsion, but the results of this type of processing are missing in the scientific literature.
The purpose of the present paper is to analyze from a technological and economic point of view the injection of trimmings in whole muscle.

MATERIALS AND METHODS

For the analysis, ribeye obtained from pork carcass and beef carcass was used. From pork and beef trimmings an emulsion was obtained by using brine with 15% salt, in a ratio of 1:2. Emulsification was done using IKA, T 25 digital ULTRA-TURRAX (Germany).
The samples obtained are shown in Table 1.

Table 1. Sample codes and description

Samples	The method of obtaining the samples
PR	Pork ribeye as a control sample
PR_S	Pork ribeye injected with brine with 15% salt
PR_P	Pork ribeye injected with an emulsion consisting of pork trimmings and brine with 15% salt, in a ratio of 1:2
PR_B	Pork ribeye injected with an emulsion consisting of beef trimmings and brine with 15% salt, in a ratio of 1:2
BR	Beef ribeye as a control sample
BR_S	Beef ribeye injected with brine with 15% salt
BR_P	Beef ribeye injected with an emulsion consisting of pork trimmings and brine with 15% salt, in a ratio of 1:2
BR_B	Beef ribeye injected with an emulsion consisting of beef trimmings and brine with 15% salt, in a ratio of 1:2

Source: Original data.

Weight gain was determined by weighing before and after injection, and the result was expressed as a percentage. The moisture content of the samples was determined by drying at 103°C, with a moisture analyzer ML-50, A&D Company, Limited (Japan). According to SR ISO 937:2007, the nitrogen in the samples was determined by the Kjeldahl method and using the conversion factor equal to 6.25, the protein content of the samples was determined. The preservation of the samples was established by determining the easily hydrolysable nitrogen according to SR 9065-7:2007 [10, 11]. This determination was made on the first day after injection and then after 2 days, during which time the samples were kept at 4°C.

RESULTS AND DISCUSSIONS

After brine or emulsion injection, weight gains were recorded as seen in Figure 1.

It is observed that the samples injected only with brine have the highest weight gain, the values being 41% and 46% respectively. Since beef has a higher water retention capacity than pork, it is normal for injected beef samples to have a higher weight gain than pork. For samples injected with emulsion, the weight gain was similar, but much lower than in the case of samples injected with brine. For them the weight gain varied between 8.37% and 9.84%. This observation can be explained by the change in viscosity and the increase in pressure required during emulsion injection compared to brine injection.

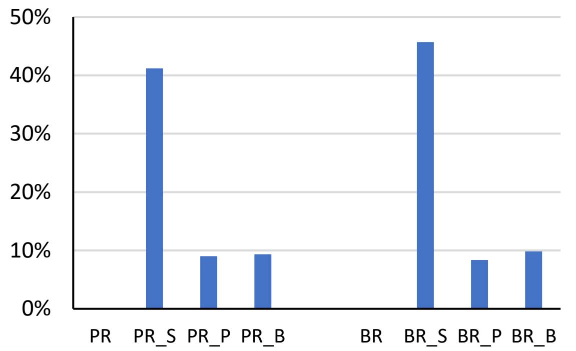

Fig. 1. Weight gain percentage after injection compared to the initial amount
Source: Author's determination.

Taking into account that the price of injected and heat-treated meat products is 2 to 3 times higher than the price of the raw material, it follows that from an economic point of view it is much more profitable for the injection to be done with brine.

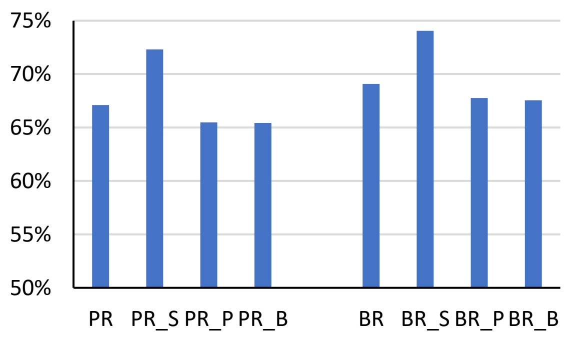

Fig. 2. The percentage of moisture in the samples
Source: Author's' determination.

The increase in weight is mainly due to the increased moisture content of the injected samples. From Figure 2 it can be seen that in the case of injection with brine, the humidity of the samples has the highest values (72.33% and 74.06% respectively) and these values are higher than those of the control samples (67.12% and 69.08%). All samples injected with meat emulsion have lower moisture content than the other samples, which means that they have a higher content of nutrient compounds.

The results shown in Figure 3 support this assumption.

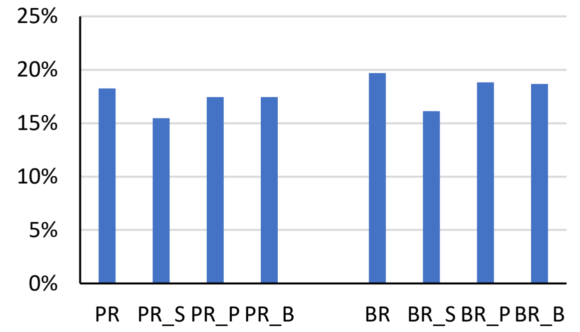

Fig. 3. The percentage content of protein and protein related to dry matter
Source: Author's determination.

The highest protein content is observed in the control samples. Due to the injection with brine, there is a decrease in the protein percentage by 84.82% and 81.96%, respectively, compared to the 2 control samples. The decrease is much smaller in the case of the samples injected with meat emulsion and varies, for the 4 samples, between 94.84% and 95.69% compared to the protein in the control samples.

This means that, from a nutritional point of view, injecting with brine containing an emulsion of trimmings is much more advantageous, especially since the injected protein is a good quality protein.

Regardless of the product and the brine recipe used, for microbiological reasons, the meat is injected at temperatures as low as possible.

On the other hand, as previously shown, after the injection of the meat, the moisture increases which leads to a reduction in the shelf life. In Romania, the determination of easily hydrolysable nitrogen is an objective and standardized method (SR 9065-7:2007) for monitoring the freshness of meat and meat products [12]. The obtained results are shown in Figure 4. Normally, as time passes, the values of easily hydrolysable nitrogen increase. From Figure 4 it can be seen that after 2 days the values of easily hydrolysable nitrogen increased for all the samples, but the most significant increase was registered for the samples injected with trimmings emulsion. The highest value was obtained for the BR_B sample, namely 36.20 mg/100g. Expressing as a percentage the evolution of the values recorded after 2 days compared to the first day, the range in which they fall is between 27.98% and 45.13%, while for the control samples the values were 6.19% for PR and 18.88 % for BR.

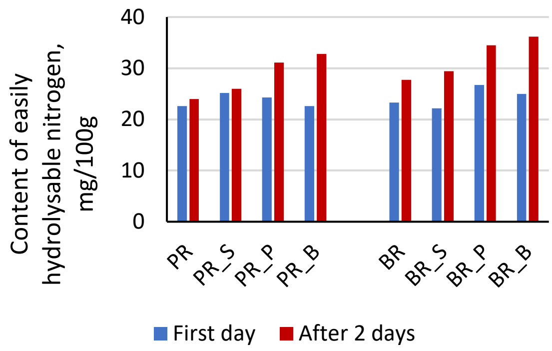

Fig. 4. Content of easily hydrolysable nitrogen on the first day and after 2 days
Source: Author's' determination.

From these data it can be concluded that in the case of trimmings emulsion injection, it is necessary to pay more attention to the quality of the raw material and the ingredients, and the processing and hygiene conditions to be much stricter.

To these results must be added the fact that, from a visual point of view, the injection of pork with beef emulsion and the injection of beef muscles with pork emulsion are not recommended due to the difference in color of the muscle tissues.

Analyzing the results presented previously, correlation coefficients are obtained presented in Table 2. From these data, there is a direct correlation between the weight gain due to meat injection (r^2 =0.85) while the protein content of the injected samples decreases proportionally to the weight gain (r^2=-0.88).

From an economic point of view, it is desirable that after the injection the weight gain is as high as possible. By comparing the prices displayed online, the ratios shown in Figure 5 can be calculated.

All values are above units, and in the case of finished products, depending on their type, the ratio can be double. It should also be noted that this analysis did not take into account the other factors that influence prices.

Table 2. Correlation coefficients for the obtained results

	Weight gain percentage after injection compared to the initial amount, %	Moisture %	Protein %
Weight gain percentage after injection compared to the initial amount, %	1		
Moisture, %	0.85	1	
Protein, %	-0.88	-0.55	1
The percentage variation of easily hydrolysable nitrogen content	-0.11	-0.32	0.20

Source: Own calculation.

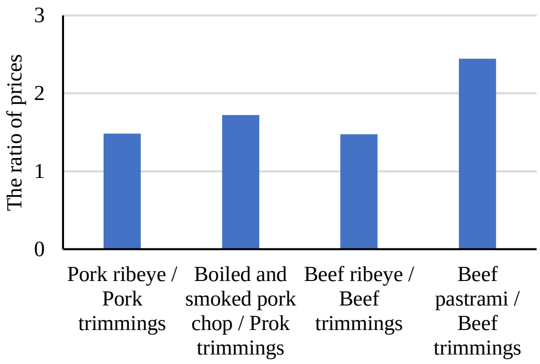

Fig. 5. Reporting the price of ribeye muscle and the price of a finished product to the price of trimmings
Source: Author's determination.

CONCLUSIONS

Using meat trimmings comes in meeting the demands of consumers and processors. Currently, consumers prefer that there are no ingredients of other origin in meat products. Processing units want the highest possible profit, and one way to achieve this goal is to add value to meat trimmings. The obtained results show that following the injection into the muscles of the brine with meat trimmings emulsion, the weight gain percentage is significantly lower (below 10%) than in the case of injection with brine (over 40%). At the same time, the good quality protein content is higher in emulsion brining compared to brine injection. the correlation coefficient between weight gain and good quality protein content is -0.88. From an economic point of view, the price for ribeye muscles is 1.5 times higher than the price of meat trimmings, while the ratio between the price of an injected finished product and the price of meat trimmings can vary between 1.72 and 2.45 depending especially on the way the muscles are processed.

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IMPORTANCE OF ECONOMIC EFFICIENCY IN CHOOSING FERTILISER AGGREGATES

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Abstract

The purpose of this paper is to test the aggregates chosen for an efficient application of granulated chemical fertilisers of different types during the optimal period, as well as to reduce the time and costs required for the agricultural work performed. The experiments were carried out within the IF Raicsics Mihailo Dragan Farm in the Commune of Sânpetru Mare, Timiș County, Romania. Depending on the capacity of the fertiliser hoppers of these machines, we chose the tractor with which to work in the aggregate. Obtaining high-quality crops at the lowest possible costs can only be achieved through the application of specific, perfected technologies, which allow a superior utilisation of both natural resources and inputs. Therefore, comparing the fertiliser machines studied, we notice a difference in terms of direct costs due to the technological characteristics of each one. That is why it is very important to calculate the economic efficiency of the types of aggregates chosen for different agricultural works.

Key words: *economic efficiency, fertilising aggregates, fertilisers*

INTRODUCTION

Equipping a modern and sustainable agriculture according to the experience of leading countries in this field is done with a wide range of machines and installations, of which the machines that constitute the energy base are of great importance and economic efficiency [25], [23]. Agriculture should become much more productive and much more sustainable in order to face the continuously growing demands [2], [10]. Solving the future problems of agriculture involves the use of high-yield tractors, as well as complex aggregates capable of solving the large volume of mechanized works on time and with increased efficiency [22]. Machines and equipment for applying solid mineral fertilizers are used for spreading on the soil surface or distributing and incorporating into the soil quantities of fertilizers or amendments according to agrotechnical requirements [11]. The machines and equipment should ensure compliance with the fertilizer norm, achieving uniformity of distribution and incorporation at the required depth [14], [19]. The execution of agricultural works with mechanized means contributes, in a decisive way, to the increase of the productivity of agricultural works, because they give the possibility of carrying out the works in due times and of superior quality [17], [5]. The execution of agricultural works in optimal terms and with as little costs as possible depends, to a large extent, on the working capacity of the aggregates used [13].

The administration of fertilizers and amendments at optimal times contributes to an increase in agricultural production [4]. On the other hand, fertilizers can represent an important cost, and their efficient distribution is more and more important in obtaining a high production at the lowest possible costs [20]. Fertilizers are inorganic and organic chemical substances that have the role of enriching the soil and, therefore, the vegetation with nutrients (phosphorus, nitrogen, potassium, etc.), indispensable for the growth and development of plants, while amendments are mineral substances (limestone, marl) in the form of dust or granules, which have the role of maintaining or correcting the physical structure of the soil [16]. The machines for the administration of fertilizers and amendments are intended for spreading on the soil surface or for incorporating into the soil adjustable quantities of mineral or organic fertilizers, uniformly distributed over the surface area [21], [18].

In today's conditions, most agricultural producers use complex chemical fertilizers, particularly fertilizers that have nitrogen as their active substance [1], [7]. Improper storage and use of chemical nitrogen fertilizers can cause serious harm and poisoning to humans and animals [24], [9]. The irrational use of fertilizers causes an excess of nitrogen and phosphates to appear, which has a toxic effect on the microflora in the soil and leads to the accumulation of these elements in the vegetation [15], [6].The limit between deficiency and excess of an element is difficult to estimate, everything depending on the nature of the plants and the environment [3], [12].

The purpose of this paper is to test the aggregates chosen for an efficient application of granulated chemical fertilisers of different types during the optimal period, as well as to reduce the time and costs required for the agricultural work performed.

MATERIALS AND METHODS

The studies whose results are presented in this paper were carried out in the Commune of Sânpetru Mare, Timiș County, Romania, at the IF Raicsics Mihailo Dragan Farm, established in 2014. The studies refer to the comparison of aggregates for the application of granulated chemical fertilisers on the farm. Fertiliser spreading works were carried out with the following machines:

SAME 60 tractor + mounted fertiliser spreader ZA-M 1001

The SAME 60 tractor is an universal tractor equipped with a mechanical transmission and with a four-cylinder diesel engine, with the following operational parameters: Nominal power Pm = 60 HP = 45 kW; Nominal engine speed nm = 1,800 rpm; Nominal motor moment Me = 26 daNm; Hourly fuel consumption Gh = 10.5 kg/h;

Specific fuel consumption gs = 175 g/CPh;

Weight G = 3,620 daN; Wheelbase L = 2.4 m; Drive wheel radius r = 0.74 m.

Deutz-Fahr 150 tractor + mounted fertiliser spreader ZA-V 1400

The DEUTZ-FAHR 150 tractor has the following operating parameters: Nominal power Pm = 150 HP = 112 kW; Nominal engine speed nm = 2,300 rpm; Nominal motor torque Me = 57 daNm; Hourly fuel consumption Gh = 24 kg/h;

Specific fuel consumption Gs = 190 g/CPh;

Weight G = 5,700 daN;

Drive wheel radius r = 0.78 m; 4 x 4 all-wheel drive; Independent power take-off with a speed of 1,000 rpm;

Hydraulic lifter with a maximum lifting capacity of 4,600 kg.

The force of resistance to the idle movement of the tractor is: $F_r = f \cdot G = 0.05 \cdot 5{,}700 = 285$ daN

The tractor's maximum adhesion force is determined by the relationship:

$$F_{\max} = \mu_a \cdot G \cdot = 0.7 \cdot 5{,}700 = 3{,}990 \text{ daN}$$

The traction force of the DEUTZ-FAHR 150 tractor is:

$$F_t = F_{\max} - F_r = 3{,}990 - 285 = 3{,}705 \text{ daN}$$

John Deere 6930 tractor + ZA-TS 4200 mounted fertiliser spreader

The John Deere 6930 tractor has the following operating parameters:

Nominal power Pm = 163 HP = 120 kW; Nominal engine speed nm = 2,100 rpm; Nominal motor torque Me = 62 daNm; Displacement – 6.8 l;

Weight G = 6,300 daN.

The force of resistance to the idle movement of the tractor is:

$$F_r = f \cdot G = 0.05 \cdot 6{,}300 = 315 \text{ daN}$$

The tractor's maximum adhesion force is determined by the relationship:

$$F_{\max} = \mu_a \cdot G \cdot = 0.7 \cdot 6{,}300 = 4{,}410 \text{ daN}$$

John Deere 6930 Tractor Traction Force is:

$$F_t = F_{\max} - F_r = 4{,}410 - 315 = 4{,}095 \; daN$$

John Deere 6190R tractor + trailed fertiliser spreader ZG-B 5500

The John Deere 6190R tractor has the following operating parameters:

Nominal power of the Power Tech PVX diesel engine: Pm = 190 HP = 140 kW; Nominal engine speed Nm = 1,900 rpm; Nominal motor torque Me = 71 daNm; Hourly

fuel consumption Gh = 27.3 kg/h; Specific fuel consumption Gs = 195 g/kWh; Weight G = 7,700 daN.
The resistance force to the idle movement of the John Deere 6190R tractor is:
$F_r = f{\cdot}G = 0.05{\cdot}7{,}700 = 385\ daN$
The maximum adhesion force is calculated with the relation: $F_{max} = \mu_a{\cdot}R_2{\cdot}G = 0.7{\cdot}7{,}700 = 5{,}390\ daN$
John Deere 6190R tractor traction force is:
$F_t = F_{\max} - F_r = 5{,}390 - 385 = 5{,}005\, daN$
Fendt 824 tractor + trailed fertiliser spreader ZG-TS 10001
The Fendt 824 tractor has the following operating parameters:
Nominal power Pm = 240 HP = 180 Kw; Nominal speed of the engine nm = 1,900 rpm; Nominal engine torque Me = 86 daNm; Weight G = 8,200 daN.
It is equipped with two gearboxes (Turboshift hydrostatic gearbox with reverse + 6-speed mechanical gearbox) and can achieve several 44 forward and reverse speeds (24 fast speeds + 20 slow speeds).The resistance force to the idle movement of the Fendt 824 tractor is:
$F_r = f{\cdot}G = 0.05{\cdot}8{,}200 = 410\ daN$.
The maximum adhesion force is calculated with the relation: $F_{max} = \mu_a{\cdot}R_2{\cdot}G = 0.7{\cdot}8{,}200 = 5{,}740\ daN$
The tractive force of the Fendt 824 tractor is:
$F_t = F_{\max} - F_r = 5{,}740 - 410 = 5{,}330\ daN$ [8].

RESULTS AND DISCUSSIONS

The Amazone ZA-M 1001 fertiliser machine works in aggregate with the SAME 60 tractor. It is a machine carried and operated from the tractor's PTO shaft.
The technical characteristics of the ZA-M 1001 machine are: Weight (loaded) = 2,200 daN;
Fertiliser bin capacity = 1,000 l;
Fertiliser dispenser with adjustable slot and adjustable speed;
Spreading width = 8 m; Mass of the car = 309 kg; Number of spreading discs = 2 pcs;
Speed of the spreading discs = 720 rpm.
The spreading discs are driven from the tractor's PTO shaft. The fertiliser dispenser is electrically operated.
Considering the agrotechnical requirements for mechanical fertilising with chemical fertilisers and the traction force of the tractor, fertilisation was carried out at a speed of 6 km/h, the aggregate using the shuttle method.
The hourly productivity of the aggregate to be fertilised is determined using the relationship:
$W_h=0.1{\cdot}B_l{\cdot}V_l{\cdot}K\ [ha/h]$
where:
B_l = 8 m, the fertiliser spreading width;
V_l= 6 km/h, the speed at which the work is carried out;
K = 0.8, the working time utilisation coefficient.
By substitution in the relation below, we get:
$W_h = 0.1{\cdot}8{\cdot}6{\cdot}0.8 = 3.84\ ha/h$
Therefore, the daily productivity of the aggregate to be fertilised, for 8 hours worked, will be:
$W_Z = 8{\cdot}W_h = 30.72\ ha/day$
Diesel consumption for fertilising one hectare was determined as follows. In the morning, before starting working, the tank was filled with diesel. In the evening, they filled up with diesel once more. The difference represents the daily consumption (C_Z = 74 l) for the fertilised area of 32 ha. Diesel consumption per hectare was determined as follows:
$D_{Cha}= C_Z/W_Z = 74/30.72=2.40\ l/ha$
Direct costs D_C for fertilising one hectare include: Wage costs W_C; Fuel costs F_C; Technical maintenance costs M_C; Overhead charges costs OC_C.
A salary of 4,000 RON/month for 160 hours of work corresponds to 25 RON/h. The hourly productivity is 4 ha/h, so the remuneration will be:
$W_C=25\ lei/4\ ha = 6.25\ RON/ha$
Fuel costs F_C;
Considering that the price of diesel is 7 RON/l, the fuel costs are:
$Fc = 7{\cdot}2.40=16.8\ RON/ha$
Technical maintenance costs and depreciation costs represent part of the value of the tractor and fertilising machines. On average, they are about 30% of the value of diesel, respectively 4 RON.
Therefore, direct costs are:
$D_C=W_C+F_C+M_C+A_C=$
$6.25+16.8+1+3=27.05\ RON/ha$

The Amazone ZA-V 1400 fertiliser machine works in aggregate with the Deutz-Fahr 150 tractor, being carried and operated from the tractor's PTO shaft.

The technical characteristics of the ZA-V 1400 machine are: Weight (loaded) = 3,700 daN;

Fertiliser bin capacity = 4,000 l;

Fertiliser dispenser with adjustable slot and adjustable speed;

Maximum spreading width = 17 m.

The spreading discs are driven from the tractor's PTO shaft. The fertiliser dispenser is electrically operated.

The movement speed of the aggregate to be fertilised was 8 km/h, and the spreading width of the fertilisers was 17 m.

Hourly productivity was determined with the help of the relationship:

$W_h = 0.1 \cdot B_l \cdot V_l \cdot K = 0.1 \cdot 17 \cdot 8 \cdot 0.8 = 10.88$ *ha/h*

Therefore, the daily productivity of the aggregate to be fertilised, for 8 hours worked, will be:

$W_Z = 8 \cdot W_h = 87.04$ *ha/day*

Daily fuel consumption was 170 l of diesel. It means that for one fertilised hectare the average diesel consumption was:

$C_{ha} = 170$ *l/87.04 ha=1.95 l/ha*.

Remuneration costs were:

$W_C = 25$ *RON/ha x 10 ha/h = 2.5 RON/ha*,

Fuel costs were:

$Fc = 7 \cdot 1.95 = 13.65$ *RON/ha*.

To these costs are also added the costs for technical maintenance and depreciation, which were 5 RON/ha.

The direct costs of the mechanised fertilisation with the Amazone ZA-V 1400 machine, for one hectare are:

$D_C = W_C + F_C + M_C + A_C = 2.5 + 13.65 + 1 + 4 = 21.15$ *RON/ha*.

The Amazone ZA-TS 4200 fertiliser machine works in aggregate with the John Deere 6930 tractor. It is a machine carried and operated from the tractor's PTO shaft. The technical characteristics of the ZA-TS 4200 machine are:

Weight (loaded) = 4,900daN;

Fertiliser bin capacity = 4,200 l;

Fertiliser dispenser with adjustable slot and adjustable speed;

Maximum spreading width = 36 m.

The 2-vane spreading disc is driven from the tractor's PTO shaft.

The fertiliser dispenser is electrically operated. Considering the agrotechnical requirements for mechanical fertilisation with chemical fertilisers and the traction force of the tractor, the fertilisation was carried out at a speed of 10 km/h, on a width of 36 m, the aggregate using the shuttle. Hourly and daily productivity was determined with the help of the relationship:

$W_h = 0.1 \cdot B_l \cdot V_l \cdot K = 0.1 \cdot 36 \cdot 10 \cdot 0.8 = 28.8$ *ha/h*.

$W_Z = 8 \cdot W_h = 230.4$ *ha/day*

Daily fuel consumption was 400 l of diesel. It means that for one fertilised hectare the average diesel consumption was:

$C_{ha} = 400$ *l/230.4 ha= 1.73 l/ha*

Remuneration costs were:

$W_C = 25$ *RON/hx 28 ha/h = 0.89 RON/ha*

Fuel costs were:

$F_C = 7 \cdot 1.73 = 12.11$ *RON/ha*

Technical maintenance and depreciation costs were 4.3 RON/ha.

The direct costs of the fertilisation per hectare are:

$D_C = W_C + F_C + M_C + A_C = 0.89 + 12.11 + 1.3 + 4.3 = 18.6$ *RON/ha*

The Amazone ZG-B 5500 fertiliser spreader is a towed machine and driven from the PTO shaft of the John Deere 6190R tractor with which it works in aggregate.

The technical characteristics of the ZG-B 5500 machine are:

Weight (loaded) = 8,500daN;

Fertiliser bin capacity = 5,500 l;

Fertiliser dispenser with adjustable slot and adjustable speed;

Maximum spreading width = 36 m.

The machine is equipped with two spreading discs.

The operation of the spreading discs is done from the tractor's PTO shaft through cardan transmission and gearbox.

The fertiliser dispenser is electrically operated. The transport wheels have high inflation tires to reduce ground pressure and ground settlement.

The large volume of the fertiliser bin allows fertilising with granulated mineral fertilisers over a large area.

The mechanised work with the aggregate to be fertilised was carried out at a speed of 12 km/h, the spreading width was 36 m.

With these primary data, the hourly productivity of the aggregate to be fertilised was calculated, using the relationship:

$W_h = 0.1 \cdot B_l \cdot V_l \cdot K = 0.1 \cdot 36 \cdot 12 \cdot 0.8 = 34.56$ ha/h

Daily productivity was:

$W_Z = 8 \cdot W_h = 276.48$ ha/day

In one working day, the tractor consumed 460 l of diesel. So, when fertilising the surface of one hectare, the fuel consumption was:

C_{ha} = 460 l/276.48 ha= 1.66 l/ha

Remuneration costs were:

W_C = 25 RON//h x /34 ha/h = 0.73 RON/ha

Fuel costs were:

$F_C = 7 \cdot 1.66 = 11.62$ RON/ha

Technical maintenance costs were 1 RON/ha.

The depreciation costs were 3 RON/ha.

Therefore, for the fertilisation with the aggregate tractor John Deere 6190R + the machine Amazone ZG-B 5500, the direct costs for one hectare are:

$D_C = W_C + F_C + M_C + A_C = 0.73 + 11.62 + 1 + 3 = 16.35$ RON/ha

The Amazone ZG-TS 10001 fertiliser machine works in aggregate with the Fendt 824 tractor. It is a towed machine driven from the tractor's PTO shaft.

The technical characteristics of the ZG-TS 10001 machine are as follows:

Weight (loaded) = 12,500 daN;

Fertiliser bin capacity = 10,000 l;

Fertiliser dispenser with adjustable slot and adjustable speed;

Maximum spreading width = 50 m.

The 2-vane spreading discs are driven from the tractor's PTO shaft. The fertiliser dispenser is electrically operated.

Considering the agrotechnical requirements for mechanical fertilisation with chemical fertilisers and the traction force of the tractor, fertilisationwas carried out at a speed of 15 km/h, at a spreading width of 50 m, the aggregate using the shuttle method.

The hourly productivity of the aggregate to be fertilised is determined using the relationship:

$W_h = 0.1 \cdot B_l \cdot V_l \cdot K = 0.1 \cdot 50 \cdot 15 \cdot 0.9 = 67.5$ ha/h

The daily productivity, for 8 hours worked is

$W_Z = 8 \cdot W_h = 540$ ha/day

The average diesel consumption for a fertilised hectare was 1.5 l/ha.

The direct costs of the mechanised fertilisation include:

Remuneration costs:

W_C = 25 RON/h x 34 ha/h = 0.7 RON/ha

Fuel costs:

$F_c = 7 \cdot 1.5 = 10.5$ RON/ha

Technical maintenance costs were 1.6 RON/ha.

The amortization costs were 3 RON/ha. So, the direct costs of the work have the value:

$D_C = W_C + F_C + M_C + A_C = 0.7 + 10.5 + 1.6 + 3 = 15.8$ RON/ha.

CONCLUSIONS

This paper presents a study on aggregates fertilizing with granulated chemical fertilizers. When establishing agricultural aggregates with direct tractor-agricultural machine reference, the energy source should be rationally loaded using machines with high work capacity so that energy consumption is as low as possible.

Thus:

Amazone fertilizing machines, through the wide range of construction types, fully ensure the mechanization of fertilizations, both for small and large farms, meeting the following main requirements:

Superior work quality indices, corresponding to the agrotechnical requirements of modern agriculture;

High working capacity;

Rational use of energy sources by optimally loading the tractors from the aggregate;

High reliability at a low-cost price;

Convenience of service (driving, adjustments, maintenance), requires minimal service personnel;

Security of the service staff's work.

Therefore, comparing the fertiliser machines studied, we notice a difference in terms of direct costs due to the technological characteristics of each one. That is why it is very important to calculate the economic efficiency of the types of aggregates chosen for different agricultural works.

The Amazone ZG-TS 10001 fertiliser machine stands out for the following performances:
Large capacity of the bin allows a high autonomy;
Large spreading width ensuring high productivity and low diesel consumption;
Regulation of the fertiliser rate per hectare within broad limits thanks to the high flow rate of the dispenser which can reach the value of 650 kg/min. All these facilities lead to a decrease in direct costs for fertilizing one hectare, compared to other fertilizing machines.
The main problem of a rational mechanization technology is to ensure the most judicious correlation of works and machines on the entire technological process to obtain the product with the lowest labour costs and energy consumption. The use of modern technologies of mechanization, chemicalization, and fertilization, the use of varieties suitable for different types of technologies have a great efficiency from an economic point of view, in the sense that higher productions are obtained with reduced costs with reference to fuel consumption and, not least, in order to perform the work during the optimal mechanization period.

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ECONOMIC EFFICIENCY OF THE MECHANISATION TECHNOLOGY IN MAIZE

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Abstract

The choice of aggregates is also made depending on the direct operating costs. If two aggregates, according to the cost of the works, require the same production costs, the one that satisfies the requirements of the machine system is chosen. When performing works with different agricultural aggregates, the optimal option is always chosen, which is evaluated according to the minimum value of the number of aggregates that take part in the execution of the work or according to the minimum value of time, respectively according to fuel consumption. Agricultural aggregates, while moving on the ground, consume a large amount of energy, which is why the problem arises of determining, on a scientific basis, some constructive and operating parameters at which the energy consumption is minimal. The present work presents an analysis of the consumption and costs of mechanised works and materials used in maize in the territory of Gurasada commune, Hunedoara County, Romania, in the year 2022-2023, in order to optimize the cultural technology. The mechanization technology for corn crop in the studied area was realized on a soil with high fertility. The agricultural machinery used for the applied technology is the one that the farm has. The main mechanization works for corn cultivation were: land fertilization, land preparation, ploughing, sowing, weeding, mechanical harrowing, as well as harvesting. After studying the corn crop over a longer period taking into account the pedo-climatic conditions as well as the productions obtained, we can conclude the following: can be obtained good yields if a series of recommendations given in the conclusions will be respected. In order to obtain a profit in the corn culture, it is recommended to use drought-resistant hybrids with high production potential.

Key words: *economic efficiency, mechanic aggregates, maize technology*

INTRODUCTION

Agriculture has been, since ancient times, the essential source of food and clothing production for the entire population of the globe [11]. The intensive use of agricultural machines ensures the increase of labour productivity in agriculture, making it possible that, parallel to the expansion of mechanisation, each agricultural producer can feed, through the products obtained, an increasing number of people [3]. Solving the future problems of agriculture involves the use of high-yield tractors, as well as of complex aggregates capable of solving the large volume of mechanised works on time and with increased efficiency [17]. Advanced and high-performance agriculture in terms of production and labour productivity in different countries is based on a particularly important techno-economic segment, the mechanisation of agricultural works. Equipping a modern and sustainable agriculture according to the experience of leading countries in this field is done with a wide range of machines and installations, of which the machines that constitute the energy base are of great importance and economic efficiency [9], [5]. Maize is the third most important crop in the world. Along with wheat and barley, they form the basis of the diet of the largest part of the world's population, directly or transformed into animal products [1]. This position, from an agricultural point of view, is motivated by a series of particularities, as follows:

-It has a high production capacity, about 50% higher than other cereals;

-It has a high ecological plasticity, which allows it to spread over a wide area, giving large and relatively constant harvests, less influenced by climatic changes;

-It is a weeding plant, a good precursor for most crops;

-It supports monoculture for several years;
-It has a high multiplication factor (150-400);
-It allows a better staggering of agricultural works since it demands a later sowing in the spring;
-Its culture is 100% mechanisable;
-Its harvesting is done without the risk of shaking;
-It makes very good use of organic and mineral fertilisers, as well as of irrigation water;
-Its production valorisation possibilities are very varied [25].

Thanks to the application of more and more efficient technologies, as well as to the creation and expansion of maize hybrids in culture, conditions have been met for maize production to increase continuously, in some countries even spectacularly [21].

Crop Rotation

Maize is little pretentious to the precursory plant and can be cultivated for several years in monoculture. However, the results are influenced by the precursory plant. Thus, the best precursors are legumes for grains and annual or perennial fodder crops (peas, alfalfa, clover, soybeans, etc.). Under the conditions of the current crop structure, maize enters the rotation with wheat. The main inconvenient of this rotation is the attack of fusariosis (a disease common to both plants), which causes crop losses in both wheat and maize. Sorghum, Sudan grass and millet are not recommended as precursors. Maize supports monoculture for many years, provided the correct technology is applied, especially in terms of fertilisation, weed control, and disease and pest control. However, its cultivation for more than 2-3 years on the same surface leads to a decrease in soil fertility, to a reduction in stable soil aggregates, and to an increase in the reserve of weeds, diseases, and specific pests.

Fertilisation

Maize is a plant that consumes a lot of nutrients. The specific consumption and related secondary production for 100 kg of grains is 1.8-2.8 kg N, 0.86-1.4 kg P_2O_5 and 2.4-3.6 kg K_2O; minimum limits are recorded at the level of some large productions and maximum ones in the case of small productions per unit area [24]. Maize reacts strongly to chemical fertilisation [23]. The yield increases are higher following the application of nitrogen fertilisers, reaching 14-16 kg grains/1 kg N a.s. Phosphorus fertilisers result in increases of 4-6 kg grains/1 kg P_2O_5 a.s. Potassium ensures increased yields, on brown-loamy soils of 3-6 kg grains/1 kg K_2O a.s. High yields can only be obtained through optimal fertilisation with all three elements [20]. The doses of chemical fertilisers are established depending on the planned production, specific consumption, soil fertility, precursor, and rainfall. Organic fertilisation gives good results on all types of soil. Maize, having a long vegetation period, makes good use of manure [22]. The effect of litter is very favourable on loamy brown and sandy soils: a rate of 20-30 t/ha is recommended [10]. Green fertilisers give very good results in maize culture. In areas with rainfall of over 650 mm, after a precursor with an early harvest, the cultivation of an intermediate plant (preferably a legume) is a measure of soil protection and, at the same time, of high maize yields in economic conditions [16].

Soil Works

Through soil works, the following objectives must be achieved:
-Obtaining a loose soil layer in depth and shredded on the surface;
-Storing and preserving as much water as possible in the soil;
-Intensifying biological activity;
-Reducing the degree of weeding of the soil;
-Ground levelling;
-Reducing erosion on sloping land;
-Eliminating excess water on heavy soils, etc.

Ploughing will be done immediately after harvesting the precursor [15].The depth of ploughing differs depending on the type of soil and it ranges between 20 and 30 cm [7]. On light soils or on soils with a thin arable layer, the depth will be 20-25 cm, and on normal or heavy soils, 25-30 cm [12].

Seeds and Sowing

The seed must be a hybrid, belong to a zoned hybrid, have a minimum purity of 98% and a germination rate of over 90%.

Maize sowing will start when, in the morning, at 8 o'clock, in the soil 10 cm deep, the temperature is 8^oC and the trend is increasing [8]. Sowing too early causes the "hatching" of a certain percentage of seeds, the delayed emergence of the others, and a reduced growth rate in the young plants [19].

When sowing is delayed, there is a risk of a water deficit necessary for germination, and the phenophases with high sensitivity for water (flowering-fertilisation) are "pushed" to the summer, during periods with high temperatures and low humidity [4].

Maintenance Works

Maintenance works must ensure weed, disease, and pest control [14].

Of the total increase in maize yield achieved through different phyto-technical methods, 26% comes from weed control, 20% from fertilisers, and 10% from density [6]. The amount of maize harvest losses caused by weeding, according to the results from 15 experimental stations in Romania, represents 30-90% of the harvest, i.e., 3,000-7,000 kg/ha [13]. Controlling weeds must be done in an integrated concept, primarily using agrotechnical methods (crop rotation, soil work, mechanical maintenance work) [2]. But effective weeds control cannot be done without the use of herbicides [4]. The choice of herbicides must be based on the dominant weed species, the rotation in which the crop falls, and the humus content of the soil. Weed control can be done only by mechanical and manual work, only with the help of herbicides or combined. Controlling weeds without the use of herbicides involves a large volume of mechanical and manual work.

Irrigation

In dry springs, a dawn watering is done with 300-400 m^3/ha. In the water-critical phenophases, the maintenance of soil moisture at a depth of 80 cm must be ensured by watering with rates of 400-800 m^3/ha. Maize is harvested at full ripeness, when the kernels have less than 30% moisture. Maize harvesting can be staggered over a longer period without crop loss. Losses can still occur when the harvest period is prolonged too much because of breaking the stems, of diseases and pests, or of climate phenomena – wind, rain, etc.In today's conditions, most agricultural producers use complex chemical fertilisers, particularly fertilisers that have nitrogen as their active substance. Improper storage and use of chemical nitrogen fertilisers can cause serious harm and poisoning to humans and animals. The irrational use of fertilisers causes an excess of nitrogen and phosphates to appear, which has a toxic effect on the microflora in the soil and leads to the accumulation of these elements in the vegetation. The limit between deficiency and excess of an element is difficult to estimate, everything depending on the nature of the plants and the environment.

In this context, the purpose of this research is to analyze the impact of mechanized works and consumption of materials and labor on the costs of mechanised works and economic efficiency of this used mechanized technology in maize grown in the territory of Gurasada commune, Hunedoara County, Romania, in the year 2022-2023, in order to optimize the cultural technology.

MATERIALS AND METHODS

Gurasada is a commune in Hunedoara County, Romania, located at the foot of the Apuseni Mountains near the Zamului Depression. The total area of the commune is 9,295 ha. In general, in this area, the soil is productive, it has a high fertility, and agricultural exploitation is carried out with means of improvement (chemical and natural fertilisers, etc.).

The studies in this paper were carried out in the Gurasada area during 2022-2023. The area cultivated with grain maize was 35 ha.

The main mechanised works in maize and the aggregates used were:

-Fertilisation: New Holland 8560 tractor + Lemken 110 fertiliser machine;

-Ploughing: New Holland 8560 tractor + Lemken Opal 110 reversible plough;

-Soil preparation: New Holland 8560 tractor + Terradisc Barella disc harrow;

-New Holland 8560 tractor + Kunh 300 rotary harrow;

-Maize sowing: Case IH 9056 tractor + Gaspardo SP 530 seeder;

-Herbicide: Preciculture UT 140 self-propelled sprayer;
-Mechanical weeding: Case IH 9056 tractor + CPU 6 cultivator;
-Maize harvesting: Case IH 1660 combine + Oros 6039 cob picker.

Choice of tractors and combines

The types of tractors are chosen depending on the technological process of the works and on the biological properties of the crops, according to the following indicators: ground clearance, gauge, gauge dimensions, plot size, energy consumption of agricultural machines, land condition, soil moisture, and manoeuvrability aggregate. The choice of aggregates is also made depending on the direct operating costs. If two aggregates, according to the cost of the works, require the same production costs, the one that satisfies the requirements of the machine system is chosen. When performing works with different agricultural aggregates, the optimal option is always chosen, which is evaluated according to the minimum value of the number of aggregates that take part in the execution of the work or according to the minimum value of time, i.e., according to fuel consumption. Agricultural aggregates, moving on the ground, consume a large amount of energy, which is why the problem arises of determining, on a scientific basis, some constructive and operating parameters at which the energy consumption is minimal. The power source of an aggregate is the tractor. It is included in the composition of all agricultural aggregates, being the essential element in mechanisation technology.

Two types of tractors (New Holland 8560 tractor, Case IH 9056 tractor) and a self-propelled combine harvester (Case IH 1660) equipped with an Oros cob picker were used to perform the mechanised work on maize.

The New Holland 8560 tractor was used to fertilise, plough, and prepare the soil for sowing. The operating parameters of the New Holland 8560 tractor are:
-Engine type: Ford, 6 cylinders in line;
-Total displacement: 7.5 l;
-Nominal power: 160 HP;
-Nominal speed: 2,000 rpm;
-Nominal engine torque: 670 Nm;
-Gearbox: SemiPowerShift – 18 steps, 4 x 4 all-wheel drive;
-Tractor weight: 5,443 daN;
-Diesel tank capacity: 321 l.

The Case IH 9056 tractor was used for sowing and weeding.

The operating parameters of the Case IH 9056 tractor are:
-Engine type: Case IH D358, 6 cylinders in line;
-Total displacement: 5.9 l;
-Nominal power: 95 HP;
-Nominal speed: 2,200 rpm;
-Nominal engine torque: 465 Nm;
-Gearbox: mechanical – 16 steps, all-wheel drive 4 x 4;
-Tractor weight: 4,672 daN;
-Diesel tank capacity: 128 l.

The self-propelled combine Case IH 1660 was used to harvest maize in the form of grains. It is equipped with a 190 HP diesel engine, and has cylinder capacity 7.6 l. The bunker has a volume of 5,780 l. The combine has an axial threshing machine, and the cleaning system has a screening area of 4 m^2. Combine weight = 9,000 daN.

The cob picker Oros 6039 is equipped with a 6-row cob chopper. The technical, technological, and economic performances of agricultural aggregates are assessed through the following technical indices, also called use or exploitation indices: working depth, working width, working speed, traction resistance force, driving power, working capacity, load level of the energy source, and fuel consumption.

RESULTS AND DISCUSSIONS

For the maize crop in the Gurasada area, three fertilisations were carried out:
-One basic fertilisation in the fall of 2022;
-Two fertilisations in vegetation (when sowing and weeding) in the spring of 2023.

Basic fertilisation was done with the Eurospand Jolly 32 fertiliser spreader carried and driven by the New Holland 8560 tractor. Basic fertilisation was done with complex fertilisers (16:16:16), the amount administered being 250 kg/ha. The spreading width was 24 m, the working speed was 10 km/h, the diesel consumption was 2 l/ha.

The cost/ha of basic fertilisation includes:

-Wage costs W_C;

-Fuel costs F_C;

-Amortisation costs A_C;

-Daily maintenance costs DM_C;

-Overhead charges costs OC_C.

The costs of basic mechanised fertilisation work/ha are synthesised in Table 1.

Table 1. Costs of basic mechanised fertilisation works

Costs per ha	Symbol	Value RON/ha
Wages costs	W_C	4
Diesel costs	F_C	12
Amortisation costs	A_C	5
Daily maintenance costs	DM_C	4
Overhead charges costs	OC_C	5
TOTAL COSTS	T_C	30

Source: Own calculation.

Mechanized ploughing

The ploughing works on the plots cultivated with maize were carried out in the fall of 2018. For these works, the Lemken Opal 110 reversible plough was used in combination with the New Holland 8560 tractor. Ploughing was carried out by turning the furrows in the same part of the plot, by reversing the plough, the ploughing depth being 26 cm. The Lemken Opal 110 plough is a reversible plough with four double bodies.

The plough bodies have lamellar furrows, and the ploughing width on the body is 35 cm. The plough is equipped with front bodies for incorporating plant residues, and the reversal of the plough frame is done by hydraulic control of the force cylinder.

The working speed was 8 km/h, and the working capacity was 0.8 ha/hour, i.e., 7 ha/day.

For one ploughed hectare, 24 l of diesel were consumed. The costs of the ploughing are synthesised in Table 2.

Table 2. Costs of mechanised ploughing

Costs per ha	Symbol	Value RON/ha
Wages costs	W_C	26
Diesel costs	F_C	144
Amortisation costs	A_C	12
Daily maintenance costs	DM_C	8
Overhead charges costs	OC_C	38
TOTAL COSTS	T_C	228

Source: Own calculation.

Soil mechanized preparation

The preparation of the soil for sowing was carried out in the spring of 2023. For a good preparation of the germinal bed, two mechanised works were carried out: discking and harrowing. These works were aimed at destroying weeds, levelling the soil, breaking up clods, and loosening the soil.

This work was carried out with the Terradisc Barella disc harrow in aggregate with the New Holland 8560 tractor. The Terradisc Barella disc harrow is a battery-mounted disc harrow. The mass of the harrow is 2,200 kg, the distance between the batteries with discks is 900 mm, and the working width is 4 m. The harrow has several 34 notched discs with a diameter of 510 mm and is equipped with lamellar rollers at the rear. This work was carried out at a speed of 10 km/h, at a working width of 4 m, at a working depth of 12 cm, with a daily productivity of 14 ha with a diesel consumption of 10 l/ha.

The costs of this work are presented in Table 3.

Table 3. Costs of discking

Costs per ha	Symbol	Value RON/ha
Wages costs	W_C	15
Diesel costs	F_C	60
Amortisation costs	A_C	12
Daily maintenance costs	DM_C	13
Overhead charges costs	OC_C	20
TOTAL COSTS	T_C	120

Source: Own calculation.

The work with the Kuhn 300 rotary harrow was carried out in aggregate with the New Holland 8560 tractor. It is equipped with 20 vertical knives and has a working width of 3 m.

Table 4. Costs of the mechanised work with the rotary harrow

Costs per ha	Symbol	Value RON/ha
Wages costs	W_C	16
Diesel costs	F_C	48
Amortisation costs	A_C	8
Daily maintenance costs	DM_C	8
Overhead charges costs	OC_C	16
TOTAL COSTS	T_C	96

Source: Own calculation.

The work was carried out at a speed of 12 km/h, the diesel consumption was 8 l/ha, and the productivity was 10 ha/day. The costs of the mechanised work with the rotary harrow are synthesised in Table 4.

Sowing

The sowing work was carried out with the Gaspardo SP 530 seeder in aggregate with the Case IH 9056 tractor. Along with the sowing, phase fertilisation was also carried out by incorporating mineral fertilisers into the soil with the fertilisation equipment of the seeder. The Gaspardo SP 530 seeder is equipped with 6 sections for sowing in nests at a distance between rows of 75 cm and has a working width of 4.5 m. As a precision seeder, it is equipped with an on-board device and reading sensors for each row, which monitor the number of grains, the area sown, etc. Sowing density was 68,000 grains/ha, seed Pioneer 9903. Fertilisation with complex fertilisers (16.16.16) rate was 120 kg/ha. The working speed of the sowing aggregate was 7 km/h, the productivity was 3 ha/h, with an average diesel consumption of 5 l/ha. The costs of sowing and fertilising are presented in Table 5.

Table 5. Costs of sowing and fertilizing

Costs per ha	Symbol	Value RON/ha
Wages costs	W_C	18
Diesel costs	F_C	30
Amortisation costs	A_C	7
Daily maintenance costs	DM_C	5
Overhead charges costs	OC_C	12
TOTAL COSTS	T_C	72

Source: Own calculation.

Protection against Weeding

Protection against weeding was done pre-emergently, 2-3 days after sowing, with the Preciculture UT 140 self-propelled sprayer. The technical characteristics of the Preciculture UT 140 spraying machine are:

-Fiat brand diesel engine, supercharged, 6 cylinders, displacement 5.9 l, power 150 HP;

-Mass = 6,890 kg;

-Volume of the pesticide tank = 4,000 l;

-Width of herbicide ramps = 27 m;

-Number of nozzle diffusers = 54 pcs.;

-Adjustable ramp height = 800-3,500 mm;

-Hydrostatic transmission with 4 hydromotors (4 x 4 traction);

-Flow rate of the hydraulic pump = 870 l/min.

The pesticide Adengo was used in a dose of 400 ml/ha. For uniform distribution over the entire area, the work was done in compliance with the following technological requirements: constant work speed and constant solution flow. The solution rate applied was 250 l/ha. The working speed was 14 km/h, the working width was 27 m. First, we did the test with water and adjusted the flow of the nozzles and the working pressure according to the flow of the machine (125 l/min). The working pressure of the nozzles was adjusted to the value of 2.4 bar for a flow rate of each nozzle of 2.2 l/min. Diesel consumption was 1.2 l/ha. The costs of the weeding are synthesised in Table 6.

Table 6. Costs of the protection against weeding

Costs per ha	Symbol	Value RON/ha
Wages costs	W_C	3
Diesel costs	F_C	7
Amortisation costs	A_C	8
Daily maintenance costs	DM_C	2
Overhead charges costs	OC_C	4
TOTAL COSTS	T_C	24

Source: Own calculation.

Mechanical weed control

Mechanical weed control was done with the aggregate consisting of the Case IH 9056 tractor and the CPU-6 universal weed cultivator equipped with fertilisation equipment. Together with the mechanical grid, 200 kg/ha of nitrolime were incorporated into the soil. The cultivator is equipped with 7 anti-weeding sections between the rows and performs mechanical weeding on 6 intervals between the rows, the sections on the edges rake half an interval. The sections were adjusted on the cultivator frame at 75 cm between the sections.

Table 7. Costs of mechanical anti-weeding + fertilizing

Costs per ha	Symbol	Value RON/ha
Wages costs	W_C	18
Diesel costs	F_C	24
Amortisation costs	A_C	4
Daily maintenance costs	DM_C	7
Overhead charges costs	OC_C	11
TOTAL COSTS	T_C	64

Source: Own calculation.

Table 7 shows the costs of mechanical weeding.

For weeding, the tractor was entered on the same tracks as for sowing. The average diesel consumption was 4 l/ha.

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Harvesting

Mechanised maize harvesting was carried out in the fall of 2023 with the Case IH 1660 self-propelled grain harvester, to which an Oros 6039 6-row cob picker was mounted instead of the header. Harvesting is of particular importance because it requires a large amount of work. Grain harvesting can begin when grain moisture drops below 30%. If there are no storage possibilities in the silo, where the maize can dry, then it is recommended to harvest when the humidity of the grains drops below 16%. Delayed harvest leads to crop losses and delayed tillage for crops that are sown in the fall after maize. In order to fit the optimal harvesting period, it is necessary to cultivate different varieties with different ripening times and to have high-performance mechanical equipment.

The average production obtained from the area cultivated with maize was 8 t/ha, the productivity was 2.5 ha/hour, and the average consumption of diesel was 20 l/ha.

Table 8. Costs of harvesting

Costs per ha	Symbol	Value	
		RON/ha	RON/t
Wages costs	W_C	16	2
Diesel costs	F_C	120	15
Amortisation costs	A_C	16	2
Daily maintenance costs	DM_C	8	1
Overhead charges costs	OC_C	32	4
TOTAL COSTS	T_C	192	24

Source: Own calculation.

Simultaneously with the harvesting, the maize cobs were also chopped and the harvest was transported. The costs per ha and per ton of harvesting are synthesised in Table 8.

Table 9 presents the costs of the transport.

Table 9. Costs of transport

Costs per ha	Symbol	Value RON/ha
Wages costs	W_C	8
Diesel costs	F_C	48
Amortisation costs	A_C	9
Daily maintenance costs	DM_C	7
Overhead charges costs	OC_C	14
TOTAL COSTS	T_C	86

Source: Own calculation.

Table 10 presents the costs per ha of the materials invested in maize.

Table 10. Costs of materials used in maize

Material	Amount	Value RON/ha
Pioneer 9903 seeds	68,000 seeds/ ha	684
Complex fertilisers (16:16:16)	250 kg/ha	320
Nitrolime	200 kg/ha	216
Herbicides	-	64
Overhead charges costs	-	256
TOTAL COSTS	-	1,540

Source: Own calculation.

Costs of mechanized works

Maize cultivation on 35 ha in the Gurasada area was completely mechanised. The values of the mechanised works performed (fertilising, ploughing, soil preparation, sowing, weeding, mechanical weeding, harvesting, and transport) are synthesized in Table 11.

Table 11. Costs of mechanised works in maize

Work	Costs					
	Wages	Diesel	Depreciation	Daily maintenance	Overhead charges	Total
Fertilisation	4	12	5	4	5	30
Ploughing	26	144	12	8	38	228
Discking	15	60	12	13	20	120
Harrowing	16	48	8	8	16	96
Sowing	18	30	7	5	12	72
Weeding	3	7	8	2	4	24
Mechanic weeding	18	24	4	7	11	64
Harvesting	16	120	16	8	32	192
Transport	8	48	9	7	14	86
TOTAL	124	493	81	62	152	912

Source: Own calculation.

Economic efficiency in using this mechanized technology in maize cropping

Grain maize is a profitable crop in the Gurasada area.

The costs per ha were 2,452 RON, of which inputs (materials used) represented 1,540 RON/ha (63%), and costs with mechanised works 912 RON/ha (37%).

At an average production of 8,000 kg/ha, it results a direct cost of 0.31 RON per kg.

The lowest purchase price of maize kernels, from the production of 2023, was 0.40 RON per kg, i.e., 400 RON/t, i.e., a price of 3,200 RON/ha. It follows that the minimum profit was 748 RON/ha cultivated with maize, i.e., and the profit rate is 30.50% (748/2,452 x 100) (Table 12).

Table 12. Economic efficiency in maize cultivation using the present mechanized technology

	MU	Value	%
Maize yield	Kg kernels/ha	8,000	
Production costs:	RON//ha	2,452	100.0
- Materials	RON//ha	1,540	62.80
-Mechanized works	RON//ha	912	37.20
Production cost	RON/kg	0.31	
Calculation at the minimum acquisition price of maize kernels in Hunedoara county in 2023			
Minimum acquisition price	RON/kg	0.40	
Minimum Income	RON/kg	0.09	
Minimum Income per ha	RON/ha	3,200	
Minimum profit	RON/ha	+748	
Minimum profit rate	%	30.50	
Calculation at the average acquisition price of maize grains in Hunedoara county in 2023			
Production	Kg grains/ha	6,000	
Average acquisition price	RON/kg	0.70	
Income	RON/ha	4,200	
Profit	RON/ha	1,748	
Profit rate	%	71.28	

Source: Own calculation.

Taking into consideration maize yield in kg grains, that is 6,000 kg/ha, and the average acquisition price of maize grains in Hunedoara county is RON 0.70/kg, the farmers could obtain 4,200 RON profit per ha and a profit rate of 71.28% (Table 12).

Of course, the actual profit can be higher if the maize is harvested at low humidity, stored in silos, and marketed later at a better price.

CONCLUSIONS

The studies presented in this work were carried out in the maize, on the territory of Gurasada commune, Hunedoara County, Romania. Following the experience accumulated in recent years in the culture of gain maize, and considering the soil and climate conditions of the studied area, and the productions obtained in recent years, the following conclusions and recommendations can be made.

The mechanised works worth 912 RON/ha have the following share of costs: 493 RON the diesel (54%), 124 RON the wages (14%), 81 RON the depreciation (9%), 63 RON the daily maintenance (7%), the difference of 16% (152 RON) representing the overhead charges. These mechanised work costs can be reduced if diesel fuel is subsidized. The diesel engines on the tractors and self-propelled machines we have worked with are supercharged engines with low diesel consumption. Good yields per ha in grain maize in the conditions of Gurasada can be obtained if:

-Optimal fertilisation with nitrogen, phosphorus, and potassium is ensured;

-Mechanical works are carried out in the optimal period, on time, and qualitatively;

-Sowing is carried out in the optimal season;

-Soil setting is avoided by repeated passes with agricultural aggregates;

-Soil is kept loose through germinal bed preparation and weeding. In order to obtain profit in maize cultivation, it is recommended to use drought-resistant hybrids with high production potential.

From an economic point of view, this mechanized technology is profitable assuring a minimum profit of 748 RON/ha if maize is marketed at 400 RON/ton maize kernels or a profit of 1,748 RON/ha if the maize grains are commercialized at the average acquisition price of 700 RON per ton.

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EVALUATION OF THE IMPACT OF AGRICULTURE-BASED INVESTMENTS ON SUSTAINABLE DEVELOPMENT: YOZGAT PROVINCE SAMPLE, TURKEY

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Abstract

In this study, the role and importance of agriculture-based investments in sustainable development were investigated. For this purpose, a situation analysis of these matters was conducted for Yozgat province, which is from the 1st Degree Priority Regions in development. In the study, interviews were conducted with managers or expert personnel of institutions and organizations related to the subject. Data obtained via the interview were the primary data of the study. Papers and books published related to the subject, and data obtained from the database of the Ministry of Agriculture and Forestry (MAF) and the Turkish Statistical Institute (TSI) were also the secondary data of this study. According to the research findings, it is seen that significant investments based on agriculture have been made in the province. Among these investments, there are sugar factory (2 units), Kabalı Integrated Orchard (Turkey's largest integrated orchard), geothermal greenhouses, flour production (12 units), milk and milk products (12 units), meat and meat products (11 units). and fruit and vegetable processing-packaging facilities (4 units). With investment depended on agriculture, there have been positive developments in per capita gross domestic product, employment, labor force participation rate and unemployment rate in the province. While in 2004, gross domestic product per capita was USD 3,272, employment rate was 31.6%, the participation rate to labor force was 36.2% and unemployment rate was 12.8%, in 2021 these were, respectively, USD 4,869, 48.5%, 55.1% and 12%. In Kabalı Integrated Orchard, which is one of the largest orchards in Turkey, in addition to orcharding, there have been animal breeding activities such as goose, sheep and beekeeping. The cherry orchard located in the integrated facility is the third-largest cherry orchard in Europe. This study is important in terms of the sustainability of investments depending on agriculture and the formation of strong expectations for rural development.

Key words: *agriculture-Based Investment, gross domestic product, rural employment, sustainable development*

INTRODUCTION

Economic development depends on agriculture. Economic development is not possible without agriculture. Agriculture contributes to economic development, especially for those three reasons. Firstly, it is the main income source for living people in rural, second one is a determinant for economic growth based on employment, and is the raw material source of most industries [2]. The share of agriculture in the total gross domestic product (GDP) is 6.5% in Turkey [9].15.8% of the active population is employed in agriculture [19]. Ergo, in Turkey, agriculture is an integral part of the general and rural development process. In this instance, the government must encourage investments in agriculture. For, every investment in agriculture means employment and socioeconomic development. Investments in agriculture directly contribute to rural development by creating revenue growth and employment in rural [2].

Investment in the agricultural sector of the world was initiated with the establishment of the green revolution between the 1940s and 1960s. The Green Revolution Special Studies Office was established in Mexico in 1943 to describe the complete transformation of agriculture in developing countries and to increase significantly in agricultural production. In 1951, Mexico was sufficient by itself in wheat production and even started to export wheat. The Office of Special Studies officially transformed into he International Corn and Wheat Improvement Center in 1963. Agriculture, which started the green revolution, got reciprocity the best [12].

Yozgat province, one of the important agricultural centers of Turkey, is known for its investments depended on agriculture. The investments made have been effective in increasing yield in crop production. There has been a remarkable increase in the yields of field crops such as wheat, dry beans, green lentils, and sugar beet. Ensuring agricultural and rural development at both national and local levels will be possible by investing in agriculture. Agricultural production resources are needed to achieve national development goals, and agriculture-based investments are important in this sense. For this, it is important to mobilize agricultural production resources and make rural investment operational [5]. While investments in agriculture are important for sustainable development goals, they are also used as an effective tool in fighting poverty. Agriculture is the first and only sector in people's nutrition and the supply of nutrients [8]; [7].

With this article, findings regarding the importance of agricultural investments in sustainable development have been revealed. The importance of agricultural investments in local development is clearly stated.

Sustainable development is a combination of concepts of development and sustainability and refers to development that aims at permanent environmental, social, and economic growth. Sustainable development can be defined in various ways, but there is a development approach that seeks to meet and balance the environmental, social, and economic needs of society at its core [17]. Sustainable rural development is defined as the process of stable socio-economic development of rural areas, increasing the efficiency of agriculture, achieving full employment of the rural population, and improving their living conditions [6].

There are many empirical studies linking economic growth with capital formation. Some of these studies are as follows: [11] in their study of the Middle East and North Africa region, stated that there is a strong causality between economic development and investments. [21], in his study in 2013, examined the relationship between investments and economic development in Sub-Saharan African countries and he stated that investments resulted in economic development. In the study conducted by [1] (2010) in Nigeria, capital formation was emphasized as the main determinant of economic growth and it was stated that capital formation is important to ensure short and long-term, rapid, and permanent economic growth.

In this study, information and concepts regarding investments dependent on agriculture are given in the introduction part of it. Agricultural investments in Yozgat province and their importance in sustainable development are given in the findings section of the study. In the conclusion section of the study, a series of measures are also lined up as to why investment in agriculture is necessary for sustainable development.

MATERIALS AND METHODS

The main material of this study consists of both primary and secondary data. Bilateral interviews were held with the managers or expert personnel of the Provincial Directorate of Agriculture and Forestry, Yozgat and Boğazlıyan Sugar Factories, Yozgat Chamber of Industry and Commerce, and the Provincial Coordination Office of the Agriculture and Rural Development Support Institution (ARDSI). These bilateral discussions/interviews constitute the primary data source of the study. In the study, in addition to bilateral interviews, it significantly benefited from papers and books published on the subject and the statistical database of the Turkish Statistical Institute and the Ministry of Agriculture and Forestry. These are also the secondary data of the study. In the analysis of secondary data, data for the period 2004-2021 were taken into account. In the study, bilateral interviews, used as the primary data collection tool, are a qualitative research method and are a technique based on verbal communication and taking place in a conversational atmosphere [3]; [13]. Thus, it was created for a direct meeting environment with the target organizations with this method. Information regarding the interview was enabled by note-taking. In interviews with target organizations; agriculture-based investments, employment, and production information, why these investments are needed, contribution to local and national development of investments, and sustainability issues were discussed. This information obtained from the interview was subjected to content analysis and tables were created. Descriptive statistics were used in the interpretation and evaluation of the tables. In the study, the place of investments depended on agriculture in the development of rural areas was also examined and the management strategies to be followed were discussed.

RESULTSAND DISCUSSIONS

Agriculture-based investments in Yozgat province

In the light of interview sheld with the Provincial Directorate of Agriculture and Forestry, the scope of investments depended on agriculture was determined.

Accordingly, the general objectives of agriculture-based investments are: to increase the income level in rural, to achieve integration of the agricultural sector and industry dependent on agriculture, to support small and medium-sized businesses and small-scale family businesses, to strengthen the agricultural marketing infrastructure and the rural economic infrastructure and to create alternative new income sources in rural. To achieve these goals, in other words, to carry through rural development, the Rural Development Investments Support Program (RDISP) is prepared by Agriculture and Forestry Organizations.

Within the scope of this program, 50% grant support is also provided to investors. RDISP is implemented in the fashion of Agriculture-Based Economic Investments and Rural Economic Infrastructure Investments (Table 1), [16].

In the interview, it was determined that a total of 5,216,000 TRY support was provided by the Yozgat Provincial Directorate of Agriculture and Forestry for 2 projects within the scope of economic investments in 2022. 50% of this (2,608,000 TRY) was given as a grant. Any projects were not supported within the scope of economic investments in Yozgat province in 2021.

11 projects were supported within the scope of rural infrastructure (rural development) investments in 2022, and a total of 1,100,000 TRY support was provided. 50% of rural development support was given as grants to investors.

Table 1. Agriculture-based investment types

Agriculture-Based Investments	
Agriculture-Based Economic Investments	Rural Economic Infrastructure Investments
• Processing, drying, freezing, packaging, and storage investments of crops, • Agricultural production investments, • Renewable energy resources investments, • Aquaculture breeding investments, • Investments for processing, packaging, and storage of fertilizers of animal and vegetable origin.	• Infrastructure systems for the development of family business activities, • Beekeeping and processing and packaging investments of bee products, • Smart agricultural practices, • Investments in handicrafts and value-added products, • Investments in silkworm breeding facility, • Aquaculture breeding investments, • Investments for machinery parks, • Investments in medicinal and aromatic plant cultivation.

Source: [16].

Those below can apply to investments depended on agriculture [10]:

• Natural and artificial persons registered in the farmer registration system formed by the Ministry of Agriculture and Forestry,

• Collective, Limited and Stock Joint Companies, Agricultural Cooperatives, Breeders' Associations for Breeding Purposes and Agricultural Producer Associations.

Agriculture-based investments are also supported by the Agriculture and Rural Development Support Institution (ARDSI). In the interview with the Provincial Coordination Office of ARDSI [23], it was stated that 442 rural development projects have been supported and 206,5 million TRY grant support has been provided since 2011. Thanks to the grants, total rural development investments in the province reached 400,8 million TRY. With rural development investments, Yozgat province was provided to 92 dairy farms, 42 breeding farms, 3 poultry meat production facilities, one milk processing facility, 3 milk collection centers, 4 red meat processing facilities, 225 plant production, processing, and marketing projects, 42 beekeeping projects, 8 craftsmanship and value-added products projects, 17 rural tourism facilities, 1 aquaculture production facility, 2 machinery parks and 2 renewable energy facilities.

In the interviews with the Yozgat Chamber of Industry and Commerce [15], and the Provincial Directorate of Agriculture and Forestry [16], agriculture-based investments were determined by sub-sectors in Yozgat province and given in Table 2.

Table 2. Investments depended on agriculture in Yozgat Province

Subjects	Number
Milk and milk products	7
Redmeat and redmeat products	11
Fruit-Vegetable Processing-Packing	4
Cereals and Pulses Production	7
Tea Sugar Production (excluding packaging)	2
Pastry Products Production	57
Flour Production	12
Bakery Products Production	110
Egg Packaging	11
Frozen food	1
Honey, Pollen, Royal Jelly, and Honeycomb Production andPackaging	2
Animal feed	6
Other	14

Source: [15], 16].

Major agriculture-based projects in Yozgat province:

Kabalı Integrated Orchard Project

An interview with the Yozgat Governorship was had for the Kabalı Integrated Fruit Garden project. According to this, it was stated that the first stage of the project was started in 2009. The project was carried out in Kabalı village of Kadışehri district. The facility is one of the rare examples of public, private sector and citizen cooperation in Turkey and covers a total area of 5,640 decares (Photo 1). In the project, irrigation and fertilization are carried out using a fully automated radio frequency system. It has Turkey's largest pond for irrigation purposes (25,000 tons of water capacity). The project includes 47,772 cherries, 276,021 semi-dwarf apples, 44,113 fully dwarf apples, 25,150 various peach and nectarine saplings, and 17,900 pear saplings. In Kabalı Integrated Orchard, which is one of the largest orchards in Turkey, in addition to fruit growing, animal breeding activities such as goose, sheep and beekeeping are also carried out. The cherry orchard in the garden is the third-largest cherry orchard in Europe.

Kabalı Integrated Orchard Facility is of great importance as it is an exemplary facility in Turkey. In the first stage of the project, 806 parcels of 353 farmers were combined and a huge Integrated Orchard was created. In the merged parcels, the farmer's ownership was left untouched and a rental method was used. Bozok Agricultural Products Production Market, which was established by the Kadışehri District Governorship, used the peasant lands. Tic. Inc. for 25 years [20]. Thus, the management of the project is carried out by this company.

Water is pumped to the Integrated Orchard from the Çekerek River. By means of this project, Kabalı village farmers, who have generated low revenue in arid terms, have obtained more income from rental.

In addition, approximately 60 people from the village were employed in permanent status and 600 people in seasonal status [4].

Thus, this project has also made a significant contribution to the employment problem in the region.

Even, some families who left the village returned to their villages.

Photo 1. Kabalı Integrated Orchard Facility
Source: [14].

Geothermal greenhouses

Geothermal is a renewable energy source that can be used for direct heating or electricity generation. It aims to keep the climate inside greenhouses as close to optimum growing conditions for plants as possible. Geothermal energy requires the usage of advanced computerizes to control the climate within the greenhouse. Geothermal energy can play a very important role in the energy balance, especially in developing countries.

Geothermal greenhouse farming is a plant production activity carried out in greenhouses in a geothermal heat environment by utilizing geothermal energy resources. Geothermal greenhouses are an important axis of agricultural development. Geothermal energy sources are extensively used in electricity production and in some areas of agriculture particularly in greenhouse heating. Geothermal energy, which is renewable energy, can attract attention within the framework of agricultural practices and economic and social development of rural areas because it is clean and usable.

Photo 2. Geothermal Greenhouse (Sorgun district)
Source: [22].

Photo 3. Geothermal Greenhouse (Boğazlıyan district)
Source: [22].

There are greenhouse enterprises where soil less greenhouse farming is carried out in a closed area of 30,000 m² (Photo 2) in Yozgat's Sorgun district and 60,000 m² (Photo 3) in Boğazlıyan district. Tomatoes grown in a geothermally heated greenhouse established by a company with the encouragement of the municipality in the Sorgun district are exported. Geothermal greenhouse farming activities are carried out successfully in Yozgat province, which has a continental climate. A company that makes a greenhouse investment of 10 decares or more in Yozgat province can receive regional incentives from the Ministry of Economy [4]. In geothermal greenhouse farming, which is brought into the economy, the cost is lower than coal and natural gas and the productivity also increases.

Sugar Factories

Yozgat Sugar Factory, which depends on Türkşeker, and Boğazlıyan Sugar Factory, which belongs to a private enterprise are active in Yozgat province. A total of 1,678 personnel work, 678 in the Yozgat Sugar Factory and 1,000 in the Boğazlıyan Sugar Factory. A total of 1,678 personnel work in these two factories. Sugarbeets produced in the region are processed in these factories.

Yozgat Sugar Factory

The Yozgat Sugar Factory, whose foundation was laid on August 23, 1990, was put into service on February 15, 1998. The factory, which had a daily sugar beet processing capacity of 3,000 tons when it was established, has increased its production capacity significantly with time. In the interview with Yozgat Sugar Factory officials [24], it was stated that a total of 678 people worked in the factory, 378 of whom were permanent staff and 300 were seasonal workers, thus contributing significantly to the Yozgat economy in terms of employment.

358,500 tons of sugar beet were processed, 50,500 tons of beet sugar, and 113,140 tons of beet molasses were produced at Yozgat Sugar Factory during the 2022 campaign period.

Boğazlıyan Sugar and Products Integrated Facility

In the interview with Boğazlıyan Sugar and Products Integrated Facility officials [25], it was stated that production has been made with the latest technology in the facility. The facility started production in 2006.

The facility was built on an area of 920 decares. It has a normal capacity of 10,000 tons/day and it has a maximum capacity of 12,000 tons/day. About 1,000 people were employed at the facility. Facility contributes

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significantly to the regional economy through employment and production. During the 2022 campaign period, 1,068,000 tons of sugar beet was processed, 157,000 tons of sugar and 30,000 tons of molasses were produced.

The role of investments depended on agriculture in sustainable development

Developments in animal existence and animal product production value

Developments in animal product production were given in Table 3 in Yozgat province for 2004-2021 period.

When the table is examined, it is seen that there was an increase in both animal existence and animal product production value in the examined period [19]. It can be stated that agriculture-based investments have a significant impact on in development of animal breeding production.

Developments in the yield of field crops

Yield status and total production value of some of the most produced field crops were given in Table 4 in Yozgat province for 2004-2022 period. During the examined period, there were significant increases in the yield of crop products and their production value [19]. There was an 80.6% increase in especially sugar beet yield from these crops.

Table 3. Animal existence and animal product production value in Yozgat province

Years	Sheep	Cattle	Animal Product ProductionValue (1,000 TRY)
2004	281,942	159,845	141,273
2005	279,282	215,242	159,173
2006	268,110	207,800	163,781
2007	281,159	207,785	180,430
2008	271,860	197,372	184,432
2009	258,034	194,426	220,024
2010	248,055	220,390	547,741
2011	285,332	210,203	235,847
2012	337,444	252,917	284,932
2013	377,269	273,412	348,943
2014	396,123	247,804	383,642
2015	407,867	244,350	427,068
2016	312,306	206,035	379,068
2017	348,673	235,527	488,058
2018	378,798	247,809	535,758
2019	340,094	245,825	508,089
2020	414,230	254,030	702,826
2021	456,097	242,653	-

Source: [19].

Table 4. Yields of the most produced field crops in Yozgat province

	Wheat (Kg/da)	Dried beans (Kg/da)	Chickpea (Kg/da)	Green lentil (Kg/da)	Sugarbeet (Kg/da)	Silage corn (Kg/da)	Crop product production value (1,000 TRY†)
2004	207	114	100	89	3,979	4,352	636,559
2005	235	101	109	96	4,575	3,591	655,057
2006	183	106	100	96	4,225	3,605	525,872
2007	149	116	101	79	3,648	3,966	505,815
2008	187	100	101	89	4,940	4,011	662,054
2009	249	120	120	105	5,258	4,063	755,713
2010	233	118	115	112	5,373	3,904	895,629
2011	259	135	126	116	5,258	4,092	1,017,775
2012	199	122	128	143	5,215	4,449	897,634
2013	254	135	120	95	5,458	4,512	979,970
2014	197	127	103	113	5,720	4,487	1,008,714
2015	283	138	116	122	5,700	4,550	1,326,712
2016	245	140	116	123	5,931	4,593	1,316,232
2017	225	117	106	132	5,930	4,615	1,540,165
2018	222	141	127	132	5,497	4,483	1,573,861
2019	193	131	114	109	5,516	4,263	1,841,168
2020	246	122	121	109	7,130	4,257	2,529,895
2021	161	186	104	90	6,091	4,563	2,688,175
2022	242	197	130	109	7,187	4,809	-

†TRY: Turkish currency
Source: [19].

Developments in gross domestic product (GDP) per capita

In the study, gross domestic product per capita was also examined in Yozgat province for the 2004-2021 period, and given in Table 5 [19].

According to this, gross domestic product value per capita declined partially after 2018. But, it increased generally during the examined period.

Table 5. Gross domestic product value per capita in Yozgat province

Yıllar	Total GDP ($)	GDP per capita ($)
2004	1,739,757,143	3,272
2005	2,062,017,910	4,002
2006	2,085,672,535	4,075
2007	2,553,726,923	5,147
2008	2,805,802,325	5,789
2009	2,471,233,116	5,072
2010	3,158,722,214	6,505
2011	3,249,271,257	6,873
2012	3,166,347,486	6,846
2013	3,181,002,105	7,078
2014	3,234,499,541	7,357
2015	2,884,959,409	6,769
2016	2,911,323,255	6,901
2017	2,597,287,912	6,173
2018	2,288,744,720	5,558
2019	2,134,443,738	5,037
2020	2,126,651,428	5,033
2021	2,069,249,265	4,869

Source: [19].

Developments in exports

Total exports and agricultural export data were also given in Table 6 for 2004-2021 period.

Table 6. Export figures for 2004-2021 period

Yıllar	Total exports (1,000 $)	Agricultural exports (1,000 $)
2004	10,884	472
2005	4,683	2,455
2006	7,340	1,713
2007	19,518	1,013
2008	5,155	740
2009	4,235	1,128
2010	11,393	5,044
2011	14,644	7,828
2012	16,405	7,688
2013	21,495	7,763
2014	16,921	8,434
2015	11,091	5,332
2016	10,648	5,256
2017	11,952	4,294
2018	9,522	3,105
2019	13,499	6,840
2020	15,284	3,726
2021	18,485	3,628

Source: [19]; [18].

When the table is examined, it is seen that the total exports of the province increased by years, but agricultural exports in total exports increased until 2014 and decreased after 2014 [18]; [19]. When the 2021 Basic Labor Force Indicators of Yozgat province were examined, the labor force participation rate was 55.1%, the employment rate was 48.5% and the unemployment rate was 12%. When these data were compared with the data from 2004, it was determined that there were significant improvements in all three. The study also examined the sectoral distribution of employment. Accordingly, in 2021, the service sector formed 53.5% of the total employment of the province, the industrial sector 26.1%, and the agricultural sector 20.4% [19].

CONCLUSIONS

Agriculture fulfills a very important function in food security for societies and providing self-sufficiency in food. Since economic development depends on agriculture, it is necessary to invest much more in agriculture. In this study, investments depended on agriculture and their standing in sustainable development were researched. Investing in agriculture means improving rural infrastructure, use rationally of land and water resources, reducing rural poverty, increasing employment, and contributing to sustainable development, that is, a "win-win" strategy. Investment in agriculture must be absolutely made for food supply. Although most of these investments are made by the public sector, they must be also carried out by the private sector. Public investments have an effect the facilitating and encouraging private investments.

The social benefits of investing in agriculture are examined under four headings:

1) Earning: Investors can generate a high net cash flow from agricultural investment and a good operating income.

2) Appreciation: The arable land has decreased due to its abandonment and non-agricultural use. Since this made agricultural lands very more valuable, it became a good investment area for investors. Especially if agricultural land is a in residential area, or

close to transportation, its value can increase much more.

3) Improvements: An investor investing in agricultural land can bring add value to their properties by making improvements to the land. This may be in the way of growing various crops on uncultivated land. In addition, higher-yield organic farming rather than conventional agriculture can further increase the value of the investment. Such applications can provide greater added value to the land investor.

4) Income stability: The value of agricultural lands has much less fluctuation than other types of investments, and so agricultural land investment provides constant stability.

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STOCHASTIC ANALYSIS OF ALLOCATIVE EFFICIENCY OF UPLAND RICE PRODUCTION SYSTEM IN SOUTH EAST NIGERIA

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Abstract

This study examined the allocative efficiency of South East Nigeria's upland rice producing system using stochastic analysis. The study's precise goals were to ascertain the elasticity of the upland rice production system in the study area, assess the costs and returns associated with it, and determine the allocative efficiency of the system. Purposive and multi-stage random sampling techniques were used to select one hundred and twenty (120) respondents for the study. Objectives (i) and (iii) were analysed using allocative efficiency model, while objective (ii) was realized using cost and returns analysis. The allocative efficiency analysis results showed that educational level, labour, seed (planting material), fertilizer, pesticides, herbicides and capital had positive coefficients while farm size had a negative coefficient. Upland rice production system had a return per hectare of 26.5% indicating that the venture is operating at the increasing returns to scale. However, there is need for government and Non-Government Organization (NGO) to aid farmers in procuring irrigation facilities to guide against poor rainfall distribution, which often affect their crop yield.

Key words**:** *Stochastic analysis, Allocative efficiency, Upland rice, Production system, Southeast Nigeria*

INTRODUCTION

Upland is the rainfed rice grown on free-draining fertile soils. This is also called dry uplands. Upland rice is the safest and most guaranteed investment platform in paddy rice production as it is less prone to flooding since it's planted on dry land, the species are long, durable and sweeter than lowland rice, the demand for upland rice is higher as it's use to complement lowland rice and the cost of production per hectare is lower compared to lowland [18]. Rice is one of the three major crops cultivated globally, alongside with wheat and corn [3]. More than one hundred countries cultivate rice, and during the 2018 growing season, an estimated 158 million hectares of harvested land were used for the crop. Each year, more than 700 million tons of rice (or 470 million tons of milled rice) are produced from a variety of ecologies [26]. In Nigeria, 20% of the total rice produced is generated in upland areas. In Nigeria, upland areas have the potential to yield optimal output. Approximately 4.6 to 4.9 million hectares of land are available for rice production, of which 1.7 million hectares are now under cultivation. Of the 1.7 million hectares, 25% are made up of the rainfed upland rice ecosystem. About 800,000 hectares is still available for rainfed upland rice across the following States; Benue, Delta, Edo, Ekiti, Kaduna, Kebbi, Kogi, Kwara, Niger, Ogun, Ondo, Osun, Oyo and Sokoto States. In the upland ecology, the rice crop depends strictly on natural rainfalls for its growth and productivity. This ecology accounts for 55 to 60 percent of the rice cultivated land areas, and yielding an estimated 30 to 35 percent of total national rice production. Rice yields in the upland ecology are generally low in production and range from 0.8 to 2 tonnes/ha [15]. Hence, the upland ecology accounts for 32 percent of the total rice area in Nigeria [14].

Efficiency as opined by [25] is the ratio of effective output to the required input. In addition, as reported by [17], efficiency measures how efficient the goal of the farm firm, which is often profit maximization is achieved. Farm efficiency measurement through frontier approach has been widely studied [12]. Frontier involves the concept of maximally in which the function sets a limit to the range of possible observation. The observation of points below the maximum possible output can occur but there cannot be any point above the production frontier given the technology. Deviations from the frontier are attributed to inefficiency. Allocative efficiency refers to the adjustment of inputs and outputs relationship until marginal value product (MVP) equals the marginal factor cost (MFC) for any single variable input, (the equi-marginal principle [24]. Allocative efficiency as put by Esheya [7] is the manipulation of available scarce resources and technical know-how to achieve the highest possible economic benefits within given resource where its' marginal value product is equated to its unit price. For rice farmers to be assisted to enhance their productivity, attentions should not only be paid on whether or not they have adopted productivity-enhancing technologies, but to evaluate how good the producers are in making maximum use of the technologies or inputs available to them [20].

In the southeast Nigeria, rice is cultivated primarily in upland and swamp production ecosystems. Upland is portions of plain that are conditionally categorized by their elevation of 200m-500m above the sea level [8]. Also, upland has major characteristics of dry soil, source of water for irrigation is hard to find, low rainfall from 1,000 to 4,500 mm annually and uses rain-fed for sufficient water needs [4]. Against the back drop, this study tends to stochastically assess the allocative efficiency, mean output and return to scale of the upland rice production system in the study area, as little is known about the exact level of inefficiency of resource allocation of smallholder farms. The allocative efficiency aids in facilitating the rice farmers' productivity through choosing an optimal set of inputs from the alternates especially when combined with good access to information and education. This study's main goal is to evaluate the upland rice production system in South East Nigeria's allocative efficiency using stochastic analysis. Its particular goals are to ascertain the elasticity of the upland rice production system in the research area, estimate the costs and returns in the system, and ascertain the allocative efficiency of the upland rice production system.

MATERIALS AND METHODS

The South East (Igboland) is the one of the six geopolitical zones of Nigeria representing both a geographic and political region of the country's inland southeast. It comprises five states: Abia, Anambra, Ebonyi, Enugu, and Imo. South-eastern Nigeria is an area covering about 76,358km^2 east of the lower Niger and south of the Benue valley. The region is located between latitudes 4 and 7 degrees north of the Equator and between longitudes 7 and 9 degrees east [22]. The area is one of the most populous regions in the country. Its population was 13,467,328 in the 1963 census, but by the 1991 census, it had increased to almost 22,000,000 of the 88.5 million people living in the country, or 25% of Nigeria's total population on just 8.5% of the country's total land [21]. The region is home to many diverse ethnic groups, with the majority of inhabitants being Igbo-speaking people. The majority of people in the region—nearly 70%—live in rural areas [9].

Purposive and multi-stage random sampling techniques were used to select respondents from each of the five states for this study. In stage one, four local government areas were purposively selected from each state to obtain a total of twenty LGAs. In stage two, two communities were purposively selected from each of twenty local government areas to bring a total of forty communities. In the third stage, three upland rice farmers were randomly selected from each community, making a sample size of one hundred and twenty (120) upland rice farmers for detailed study. A structured questionnaire and oral interview were used to elicit information on primary data. Secondary data were obtained from different literature sources related to this study such as published and unpublished survey articles, journals, textbooks, the internet, proceedings and other periodicals. Objectives (i) and (iii) were analyzed using allocative efficiency model, while objective (ii) was realized using costs and return analysis. Data analysis of the upland rice production was done using ordinary least square regression method. This can be explicitly represented as:

$$Y = f(X_1\ X_2\ X_3\ X_4\ X_5 + e): \text{.........................}(1)$$

where: Y = Output of upland rice in (Kg)
X_1=Age of the farmer (Years),
X_2,= Educational level (Years),
X_3 = Farm size (Ha);
X_4 = Seed (Dummy),
X_5 = labour (md);
X_6 = fertilizer (kg);
X_7 = pesticides (Litre),
X_8 = Herbicides (Litres),
X_9 = capital input (₦);
$b_1 – b_5$ = coefficient of the parameter;
b_0 = intercepts; and e = error term.

The data in this study were fitted with the exponential, semi-logarithmic, linear, and Cobb-Douglas functions. The coefficient of multiple determination, R2, adjusted R-2, regression coefficients, F-ratios, and t-values are among the statistical analysis or tests that were performed.

Linear functional form:

$Y = bo+ b_1X_1 +b_2X_2 +b_3X_3+b_4X_4 +b_5X_5 +U$ …...(2)

Double-Logarithmic or Cobb Douglas function:

$Ln\ Y = Lnb_0 + b_1lnX_1+ b_2lnX_2+ b_3lnX_3+ b_4lnX_4+ b_5lnX_5+ U$ ………………....................................(3)

Semi-Logarithmic functions:

$Y = Lnb_0 + b_1lnX_1+ b_2lnX_2+ b_3lnX_3+ b_4lnX_4+ b_5lnX_5+ U$ ……………………......................................(4)

Exponential functions:

$Ln\ Y = b_0 + b_1X_1+ b_2X_2+ b_3X_3+ b_4X_4+ b_5X_5+ U$ ………………………………...........................(5)

The choice of the best functional form was based on the magnitude of the R^2 value, number of the significant variables, size and the signs of regression coefficient as they relate to *a priori* expectation.

Efficiency Ratio

The Allocative efficiency was determined by equating the marginal value product of the resource to its unit price.

$MVP= p_yf_i = p_{xi}$…..(6)

Profitability

Profitability (net returns) is obtained by deducting the total cost of production from the total revenue.

Profitability = *TR – TC* ……….………..........(7)

Gross margin=
(G.M.) = TR – TVC ………….............(8)

Returns per Naira invested can be calculated as follows:

Returns/GH₵ = net income/TC ……......(9)

RESULTS AND DISCUSSIONS

Allocative Efficiency of Upland Rice Production System

The figure in parenthesis in Table 1 is the t-ratio. The model was estimated in four functional forms. Based on statistical and econometric reasons, double-log equation was chosen as the lead equation. In the model, the coefficient of determination was 0.8906, implying that 89.06% in the variations in output were explained by the explanatory variables of the model. The remaining 1.94% were explained by the error term. The coefficient of age of the farmers as expected was negative and statistically significant at 5.0% probability level. The indirect relationship could be related to conservative nature of aged people to adoption of new technology, as they preferred maintaining the status quo. Study by [10] corresponded to the above assertion. In addition, the coefficient of educational level of the farmer had direct correlation to the dependent variable and statistically significant at 1.0% alpha level. [1] and [13] had positive signs with the variable in their studies. Educated individuals as reported by [11] are more receptive to innovation, have more access information and have good managerial ability, thus could be more economically efficient through having good allocative and technical efficiency for high productivity. As well, farm size coefficient was positively related to farmers' output. In adoption and production literatures, there is mixed relation between adoption and farm size. In contrast to farmers with smaller farms, [4] suggested that farmers with larger farms are more likely to accept new technologies because they can afford to set aside a portion of their land for the experiment [6]. In addition, lumpy technologies such as mechanized equipment or animal traction require economies of size to ensure profitability. However, [19] noted that a small farm size could encourage the adoption of a technology, particularly when it comes to an input-intensive invention like a labor- or land-saving technique. Farmers with small land may adopt land-saving technologies such as greenhouse technology, zero grazing among others as an alternative to increased agricultural production [7].

Moreover, the coefficient of labour had a positive sign and significant to rice output at 1% significant level. The finding of [16] concurred to above relationship. They opined that labour cost contributed more than 75% of the total costs of production. Also, the coefficient of seed had a positive relationship with the dependent variable (rice output) and was significant at 5% alpha level. This was in resemblance with *apriori* expectation and in line with the findings of [24]. He reported that seed is a vital, cheapest and one of the most economical and efficient inputs use in improving crop productivity and profitability. Also, the estimated coefficient of fertilizer had direct relationship with output of rice and statistically significant at 1.0% probability level. This implied that a 5.0% increase in use of fertilizer would increase the rice output by45.87 %. Fertilizer particularly inorganic fertilizer when applied at right quantity and at right doses is capable of pushing crop production frontier forward. This result concurred to several findings [23]. As well, the pesticides coefficient was positive in line with to *apriori* expectations and significant at 10.0% alpha level. The finding of [2] was synonymous with the above assertion. They reported on the important of pesticides in pest control, especially where the resource is rightly applied. Additionally, the coefficient of herbicides was found to be positive and significant at 5.0% probability level. Herbicide use as reported by [15] reduces erosion, reduces fuel use and reduces greenhouse gas emissions.

Table 1. Estimated Production Function for Upland rice Production System

Variable	Linear	Exponential	Cobb- Douglas+	Semi Log
Age	0.0931 (1.8765)*	0.4421 (2.5409)*	2.8600 (4.0075)***	0.5521 (1.2390)*
Education	0.9213 (0.0035)	0.2130 (05402)	0.4389 (-1.7650)*	1.0098 (0.9321)
Farm Size	0.7654 (1.0098)*	0.3409 (1.0081)*	- 0.4210 (2.0421)**	0.4599 (1.7788)*
Seed	1.9012 (0.5620)	2.0033 (3.9800)***	0.6541 (2.0055)**	0.6500 (0.6501)
Labour	0.6543	0.6543	0.4587 (0.8114)	0.5321
Fertilizer	0.5321	0.7244	0.5688 (1.5498)	0.6522
Pesticides	1.7896 (0.7632)	0.9851 (3.9001)***	0.4488 (2.0055)***	0.1155 (0.6690)
Herbicides	0.7651 (1.9812)*	1.0092 (1.0076)*	0.3341 (3.0921)**	0.0087 (3.9011)***
Capital	0.3214 (0.6540)*	0.9351 (0.5032)	0.0736 (1,7320)*	1.2277 (2.0031)**
R^2	0.5467	0.6009	0.8906	0.7612

Source: Field Survey, 2022
NB: ***, **, * significant at 1.0%, 5.0% and 10.0% levels of probability respectively.

Elasticity of Production and Return to Scale

The elasticity of production is the change in output relative to unit change in input [5]. The elasticity of production of upland rice production system was estimated directly from Cobb Douglas coefficients. When the individual input resource used is less than one, indicating that the factor inputs and the rice production systems' outputs had inelastic relationship. This implied under-utilization of the input. Whereas, inverse relationship (that is when the individual input resource used is greater than one), implies over-utilization. Therefore, From Table 1 above, all the resources were over-utilized in the upland production system, with (herbicides, 0.4488; planting material. 0.6541; farm size, 0.4210; labour, 0.5688, pesticides, 0.3341 and capital, 0.0736).

However, one of the implications of over-utilization of all the inputs used by the farmers could be that the farmers having enough for least to break even.

Thanks to government numerous programmes (tractor hiring units, Agricultural Development Programme (ADP), seed certification programme etc), policies, research institutions and Universities in making some of the inputs available to the farmers for farm use [24].

However, the return to scale, which is the sum of the elasticity of all inputs used in rice production no matter the production system were elastic as their return to scales (upland, 3.0) was greater than 1, indicating that all the farmers were in stage 2 of production function.

Table 2. Elasticity of Production and Return to Scale of Upland Rice Production System

Variables	Upland
Farm size	0.4210
Seed (Planting material)	0.6541
Fertilizer	0.4587
Labour	0.5688
Herbicides	0.4488
Pesticides	0.3341
Capital	0.0736
Return to Scale	3.00

Source: Computed from Table 1 Above.

This implied that when all factor inputs were varied by 1%, the responsiveness of farmers' output cultivating in the upland production system would be 3.0%.

Cost and Returns of Upland Rice Production System

The viability of an enterprise is indicated by the amount of profit realized per period of time.

Profit is the difference between the monetary value of goods produced and the cost of the resources used in their production [1].

The amount of revenue realized and operating cost of a business venture determines how much gain or loss the enterprise can achieve within a certain period.

Total Variable Cost is the operating costs of the respondent which are the day-to-day cost incurred for producing rice.

The Total Variable Cost (TVC) incurred by the sampled upland rice farmers was N228,900.00 with Gross Margin (GM) of N607,100.00 as shown in Table 3.

Using the upland rice production strategy, the farmers' net returns per hectare came to N606, 916.00. Additionally, the upland rice production system had a 26.5% return on investment.

This meant that for every N1 invested in upland rice farming, N265.00 was returned. It is crucial to note that, under the upland rice production system, labor costs accounted for the majority of the TVC.

For instance, in upland production system, labour accounted for 79.2% of the total cost of production.

This is in line with a study by (16) that found that labor costs accounted for more than 75% of the total cost of production in rice-based production systems in Nigeria. Labor costs dominated the study.

This is also consistent with the results of [25], who discovered that labor accounted for the largest portion of the entire cost of manufacturing.

The employment of paid manual labor for significant rice-producing tasks (such as clearing land, planting, weeding, etc.) is responsible for the high cost of labor. Additionally, Nigerian migration from rural to urban areas contributes to inefficient labor use in agricultural output. This was followed by high cost of fertilizer and with the cost of seed being the least.

The majority of farmers use their old or previous stock as planting material, which accounts for the least amount of the seed's cost to TVC.

Additionally, the majority of farmers use inexpensive local rice cultivars to upgrade the variety on their rice farms.

Table 3. Cost and Returns of Upland Rice Production systems

Variable	Unit price	Quantity	Amount
(A) Revenue	380,000	2.2	836.00
Operating Capital			
Seed	N300/kg	30kg	N9,000
Agrochemical			
Herbicides	N500/litre	4L	N2,000
Insecticides	N300/Litre	1litre	N300
Fertilizer	N9,000/ 50kg	200kg	N36,000
Total Capital Operating Cost (TCOC)			47,300
Labour			
Land clearing	N3,000	7	21,000
Land preparation	4,000	12	48,000
Nursery	1,000	1	1,000
Planting/ Transplanting	2,500	12	30,000
Application of herbicides	1,200	4	4,800
Application of fertilizer	2,000	4	8,000
Weeding	3,000	10	30,000
Bird scaring	800	2	1,600
Harvesting	1,800	4	7,200
Threshing/winnowing	1,500	8	12,000
Others (Bagging)	500	2	1,000
Total Labour Input (TLI)			181,600
C. Total Variable Cost (TVC=TCOC+TLI)			228,900
D. Gross Margin (R-TVC)			607,100
Fixed cost			
Depreciation on equipment			56.8
Rent on land			68.8
Interest on operating capital(27%)			58,4
F. Total Fixed Cost			184
G. Total Cost (TC = TVC+TFC)	,		229,084
H. Net Return (R - TC)			606,916
I. Return on investment (H/G)			26.5

Source: Calculations based on Field Survey, 2022.

CONCLUSIONS

The upland rice production system demonstrated profitability, yielding a 26.5% return per hectare. Furthermore, by matching the value marginal product (VMP) to their factor prices, farmers in the upland rice production system failed to attain allocative efficiency. As a result, they failed to maximize profit and optimize input consumption. Thus, in upland rice production system, the following coefficients were positive; educational level, labour, seed (planting material), fertilizer, pesticides, herbicides and capital, with farm size coefficient being negative**.** In view of the fact that most production inputs were under-utilized, hence to achieve optimum or absolute allocative efficiency and hence, maximum profit, the farmers should be encouraged to increase the use of these under-utilized resources; through appropriate policies that would enhance their access to these production inputs.

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DISCRIMINATE THE SHORTAGE OF FERTILIZATION AND IRRIGATION FOR LEAFY PLANTS BY USING ALTERNATIVE REPRESENTATIONS OF THE RGB COLOR MODEL

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Abstract

This study demonstrated the possibility of using the digital image model and Detect The RGB Colour Vegetation Indicators for Cabbage and Lettuce Crop under nitrogen deficiency and water deficiency. For cabbage, the results show the relationship between the vegetation indicators based on colour indicators and the different fertilization levels of cabbage crops, which were at level (50 ETC), indicating that the Hue index and vegetative reached their heights indicators in the fourth level of fertilization (150%) respectively, which amounted to 2.23 and 2.03. While their minimum indicators were the third level of fertilization and amounted to 2.10 and 0.64 respectively. For Lettuce, the results demonstrated the correlation between the color indicators and the fertilization level (0%), which was at level (100% ETC), during the third stage of irrigation. The simple red-green ratio, green-red vegetation index, and visible atmospherically resistant index all reached their maximum indicators on irrigation, amounting to 0.9, 0.84, and 1.07 respectively, while the simple blue-green ratio, green leaf was increasing until it reached 0.22, 0.73, then followed by the normalized green-blue difference whose maximum indicator reached 0.67 in the same period. As a result of irrigation, the RGB-based vegetation indexes 2 and 3 attained their maximum indicators, which were 5.56 and 6.74, respectively. After watering, the Hue index and vegetative indicators attained their respective peak values of 2.23 and 2.81. While their minimum markers were 2.16 and 2, respectively, before irrigation.

Key words**:** *detect, RGB colour, vegetation indicators, cabbage and lettuce***,** *temperature, water, stress,monitoring*

INTRODUCTION

A rapid rate of urbanization is expected in the coming years, with approximately 66 percent of the world's population expected to live in urban areas by 2050, compared with 54 percent in 2014. Therefore, 40% of water demand in 2030 is unlikely to be met, and more than 20 percent of arable land is already degraded. Annual cereal production will need to increase by 3 billion tons by 2050 [2]. Lettuce has been counted as a significant functional food because of containing vitamins and minerals [12]. Cabbage is also in the 8th place in production of fresh vegetables with 34,761 and 33,467 tons, respectively in Bursa province in 2014 and 2015 years [19]. Despite the well-known key trends that the future of food and agriculture are facing: such as growing food demand, constraints in natural resources and uncertainties for agricultural productivity, the projected increase in world population from 7.6 billion in 2018 to well over 9.8 billion in 2050 has received a great deal of attention as an influence on world demand for food [20].
The area planted with vegetables makes up roughly 13% of the area planted with grain crops, whereas the amount of water consumed by vegetables makes up about 20% of the water used for grain crops. The Beijing-Tianjin-Hebei region currently has 58.7% of its vegetable planting area in greenhouses, and greenhouse vegetable planting area, water usage, and fertilizer amount are all rising yearly. According to reports, this region uses 1.3-5.8 times the recommended quantity of nitrogen (N) fertilizer to grow vegetables in greenhouses, and certain areas' groundwater contains more nitrate than others (between 37.5% and 44.8%) [22].Color can distinguish between different varieties of wheat imported

from different countries. It is also possible to distinguish between Ergot fungi sclerotia and between different types of imported wheat, and the color indicators used showed a clear contrast between wheat and Ergot fungi sclerotia, for example. The physical specifications also showed the differences that distinguish between mushrooms and wheat, which can be used to design the sieve holes for the specific separation. explicates the relationship between Hue and different varieties of wheat and Ergot sclerotia whereas, the ergot French was the highest 0.78 value and the Ukrainian was the lowest 0.47 value. There weren't clear Hue variances between different origin [7].Here, where the hue value was 0.626, there distinct distinctions between faba bean and soybean. In the faba bean, the intensity and browning index were 91.75 and 16.25, respectively, while in the soybean, they were 0.565, 85.33, and 21.79. While the hue value difference between corn and wheat was only 0. 699.Additionally, the intensity and browning index for corn were 100.08 and 17.30, respectively, while these values for wheat were 0.708, 97.94, and 13.38. Additionally, the hue value of 0. 634 showed a noticeable difference between cotton and sunflowers. Additionally, the Black & White band and intensity were both 87.40 in cotton while they were 0.480, 96.75, and 96.75 in sunflowers, respectively [1].

Color change for Cowpea seeds after stored effect by FIR and UVC irradiation intensity and hermetic bags (three & seven layers), the differences in Red color band increased by 60.6% when using the seeds that irradiated with UVC radiation and stored in woven bag, utilizing the seeds that had been exposed to FIR radiation and kept in woven bags caused the variations in the green color band to grow by 61.8%. the disparities in the blue color band increased by 65.5% when seeds were stored in woven bags after being exposed to FIR radiation, the differences in Hue increased by 7.14% when using the seeds that irradiated with UVC and stored in three layers bag, the differences in intensity I1 increased by 61.6% when using the seeds that irradiated with FIR and stored in woven bag, the differences in intensity I2 increased by 60.4% when using the seeds that irradiated with UVC radiation and stored in woven bag and the differences in R/G increased by 9.5% when using in the seeds that irradiated with FIR radiation and stored in three layers bag [8].

Optical sensors have been used to investigate a variety of topics, including: (a) how plants react to pathogens, pests, and abiotic stressors; (b) the identification of primary disease foci; (c) the resistance or susceptibility of various plant genotypes to various stress factors; (d) the severity of symptoms; and (e) the evaluation of plant biomass and yield. One of the most crucial physiological characteristics for plant growth and development is stomatal activity. By regulating transpiration and photosynthesis, it is incredibly important for maintaining the balance of carbon and water. Therefore, stomatal conductance to water (gs), which closely correlates with leaf temperature, is related to yield and to the tolerance of environmental challenges [14]. Examined the integration of TIR cameras with other sensors in phenotyping platforms, such as RGB, multi-, or hyperspectral cameras. To develop reliable approaches for the early diagnosis in crop fields, the discovery of geographical and temporal patterns of TIR parameters in conjunction with other pertinent vegetative indices (VIs) could be very helpful. To identify a stress-specific signature, a preliminary examination of a particular plant-stressor interaction is preferred [16].

Thermography-Based Biotic Stress Detection at Various Scales Stomatal closure typically occurs when a possible pathogen is detected by plants, however some pathogens have the ability to bypass the plant's signaling pathways and activate stomatal aperture instead. Other consequences of pathogen infection include changes in the metabolism, necrosis of the tissues, cell wall and leaf cuticle compositional or structural changes, and abnormalities in leaf growth. The water status of the plant is impacted by these physical and chemical disturbances, and thermography can be used to monitor it [17].Plant monitoring form an important part of the agriculture and horticulture sectors in our country as they can be used to grow plants under controlled climatic conditions for optimum produce. Automating a plant monitoring and controlling of the climatic parameters which directly or indirectly govern the plant growth and hence their produce. Automation is process control of industrial machinery and processes, thereby replacing human operators [15].

Summarized and discussed the benefits and limitations of phenotyping imaging methods (RGB, multispectral, and hyperspectral sensors, among others) that have been used to evaluate various abiotic stresses, such as salinity, drought, and nitrogen deficit. Here, we provide a thorough analysis of the features related to abiotic tolerance that have been measured using a variety of image sensors in high-throughput phenotyping labs or by unmanned aerial vehicles in the field. We also examine the advancement and difficulties in machine learning, including supervised and unsupervised models as well as deep learning, and present a current compilation of spectral tolerance indexes [3].

The results confirmed the possibility of pre-symptomatic detection of P. carotovorum subsp. carotovorum in lettuce at the canopy level. With respect to identifying healthy and infected lettuce plants by supervised classification, the best results were obtained at 4 and 8 DAI, especially when using the subsets derived from the Mapir Survey3W camera (RGN sensor), for both classifiers. The subsets obtained with the conventional visible sensor (RGB sensor) produced the best results at 20 and 24 days[5].

The main objectives of this study using the digital image model and Detect The RGB Color Vegetation Indicators for Cabbage and Lettuce Crop under nitrogen deficiency and water deficiency.

MATERIALS AND METHODS

Cabbageand lettuce seed, greenhouse, soil, and water, Phosphoric, Nitrogen fertilizer, and Canon ESO R. 4000 digital camera with MATLAP program as a materials were used under this study. The RGB colour model and digital camera, using the capture card to transferred the data and stored on the PC. MATLAP software package was used to analysed the digital images as showedin RGB monitoring system (Photo 1).

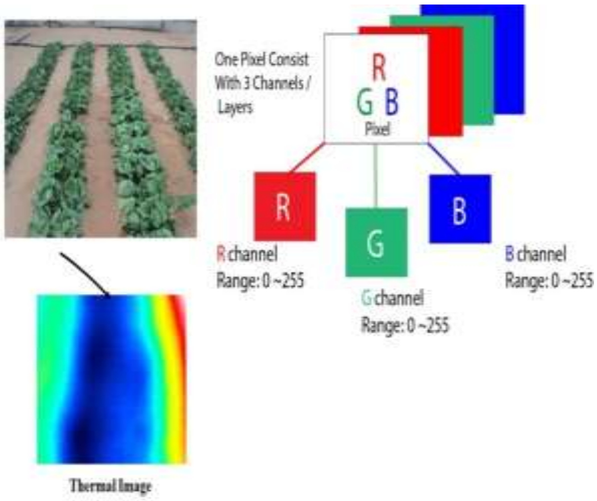

Photo 1. RGB monitoring system
Source: Authors' determination.

The digital camera

The Canon ESO R. With a DIGIC 8 image processor and a high-resolution 26.2MP full-frame CMOS sensor, still images and UHD 4K video can be captured with a wide sensitivity range, from ISO 100 to 40000, to accommodate working in a variety of lighting settings. For taking pictures of moving subjects, continuous shooting at up to 5 fps is also enabled. Additionally, the sensor enables a cutting-edge Dual Pixel CMOS AF system with 4,779 configurable on-sensor phase-detection points for fast and precisely focusing both stills and video operation(Photo 2).

Photo 2. The digital camera - Canon ESO R.
Source: From catalogue.

Photo 2 and Table 1 show and explain the Canon ESO R.

Table 1. The specification of digital camera - Canon ESO R

Brand	Canon
Effective still resolution	26.2 MP
Screen size	7.5 Centimeters
Item weight	440 Grams

Source: From catalogue.

MATLAP PC-Software

For Image Analysis system it was used MATLAP program. Samples were captured by digital camera, using the capture card to transferred the data and stored on the PC. The MATLAP software package was used to analyzed the images of Cabbage and lettuce. There were three bands, RGB, were derived for each image until obtaining color indices.

User interface

MATLAP Interface have many items ribbon, work space and status bar to detect image. Photo 3 Envi program interface, ribbon, work space and status bar.

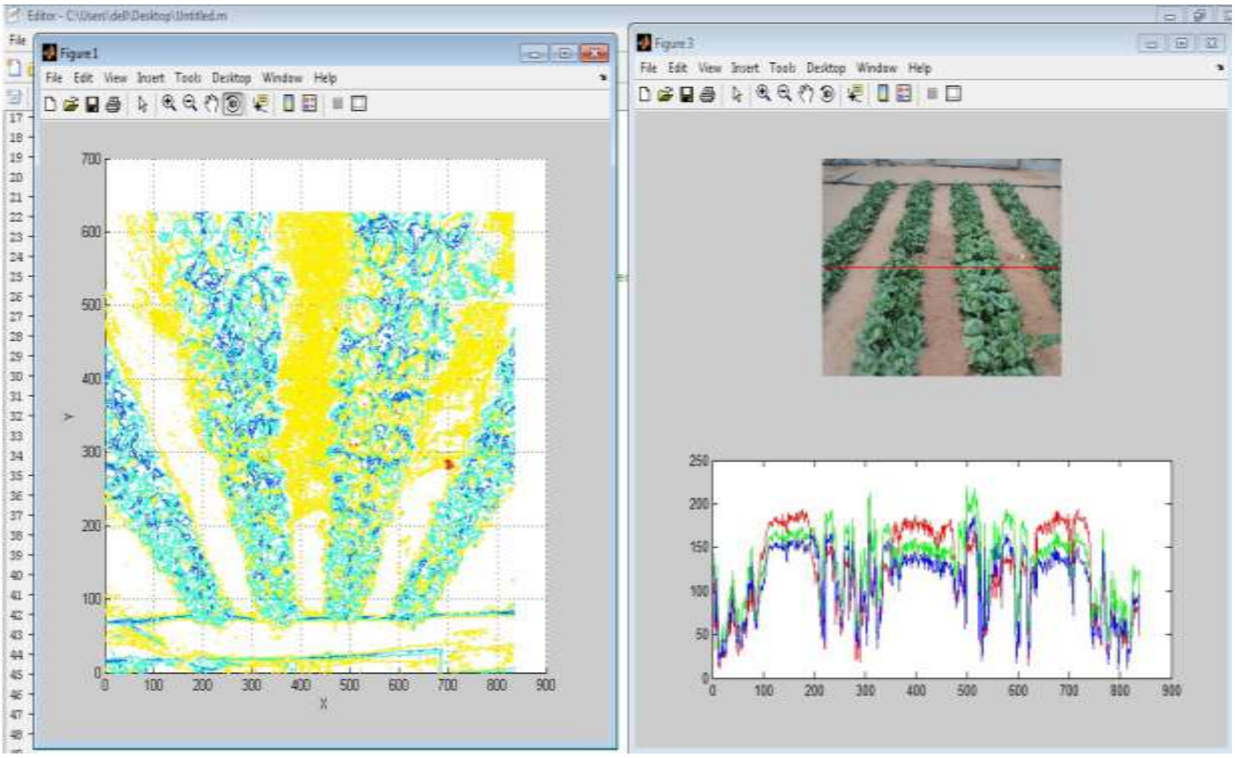

Photo 3. MATLAP interface, ribbon, work space and status bar
Source: Authors' determination.

Vegetation Indices Basics RGB

A Vegetation Index is a single value calculated by transforming the observations from multiple RGB bands.

It is used to enhance the presence of green, vegetation features and thus help to distinguish them from the other objects present in the image.

Depending on the transformation method and the RGB bands used, different aspects pertaining to the vegetation cover in the image could be evaluated say, the percentage of vegetation cover, amount of chlorophyll content, leaf area index and so on. All the ratio indexes, in general, are independent of the illumination conditions at the time of acquisition and slope effects.

Simple Ratio (SR)

This is a ratio between the reflectance recorded in the RGB bands as shown in Table 2.

This is a simple method for separating green leaves from other scene elements and determining the relative biomass that is visible.

Additionally, this value might be very helpful in differentiating between stressed and non-stressed vegetation.

Table 2. RGB bands vegetation indices

Acronym	Indices	Definition	Author and Year
GR	Simple red–green ratio	$\frac{R}{G}$	Gamon et al., 1999[9]
GRVI	Green–red vegetation index	$\frac{G-R}{G+R}$	Tucker et al., 1979[18]
RGBVI	RGB-based vegetation index	$\frac{G^2-(BXR)}{G^2+(BXR)}$	Bendig et al., 2015[4]
MGRVI	Modified green–red vegetation index	$\frac{G^2-R^2}{G^2+R^2}$	Bendig et al., 2015[4]
VARI	Visible atmospherically resistant index	$\frac{G-R}{G+R-B}$	Gitelson et al., 2002[10]
BGI2	Simple blue–green ratio	$\frac{B}{G}$	Zarco-Tejada et al., 2005[23]
VEG	Vegetative	$\frac{G}{R^2XB^{(1-a)}}$; $a = 0.667$	Hague et al., 2006[11]
GLI	Green leaf	$\frac{2G-R-B}{2G+R+B}$	Woebbecke et al., 1995[21]
ExG	Excess green index	2G-R-B	Du et al., 2017[6]
NGBDI	Normalized green-blue difference index	$\frac{G-B}{G+B}$	Du et al., 2017[6]
RGBVI2	RGB-based vegetation index 2	$\frac{G-R}{B}$	Proposed
RGBVI3	RGB-based vegetation index 3	$\frac{G+B}{R}$	Proposed
VARI	Visible Atmospheric Resistant Index	$\text{VARI} = \frac{green-\text{Re}\,d}{green+\text{Re}\,d-blue}$	Gitelsonet al., 2002[10]
Hue	Hue	$\text{H}=COS^{-1}(\frac{(2R-G-B)/2}{(R-G)^2+(R-B)(COSG-B)^{0.5}})$	Khojastehnazhand et al., 2009[13]
I	Intensity	$\text{I}=\frac{1}{3}(R+G+B+$	
I_2	Intensity-	I_2=(R-B)/2	

Source: Authors' determination based on the studied literature. [4], [6], [9], [10], [11], [13], [18], [21] and [23].

C++ plus model

The C++ programming language was used to build a set of algorithms to determine and predict the colorimetric indicators and to research the effects of water and fertilizer scarcity. The C++-written simulation and forecasting programs.

The program model test in this study the two Cabbage and lettuce seed in greenhouse, with sand soil, and water, Phosphor, Nitrogen fertilizer, using digital and thermal camera with MATLAP and IR soft program the programs flowchart model steps showed below in the coming Figures.

ColorVegetation (CVI) Program model I

using this technique to estimate the color indicesto distinguish the vegetative characteristics using alternative representations of the RGB Color Model Simulation and predicting programs model written by C++ to estimate the color calcification indices as showing in Figures 1 and 2.

-In put: RGB band color

-Calculate: I_2 and I_2 stand for hue, value, and saturation. ratio of red to green, a straightforward red-green ratio, a modified green-red vegetation index, an RGB-based vegetation index, visible index of atmospheric resistance, straightforward blue-green ratio Green leaf,RGB-based vegetation index, normalized green-blue difference index, excess green index, and vegetative 2

Vegetation Index based on RGB The Visible Atmospheric Resistant Index is three.

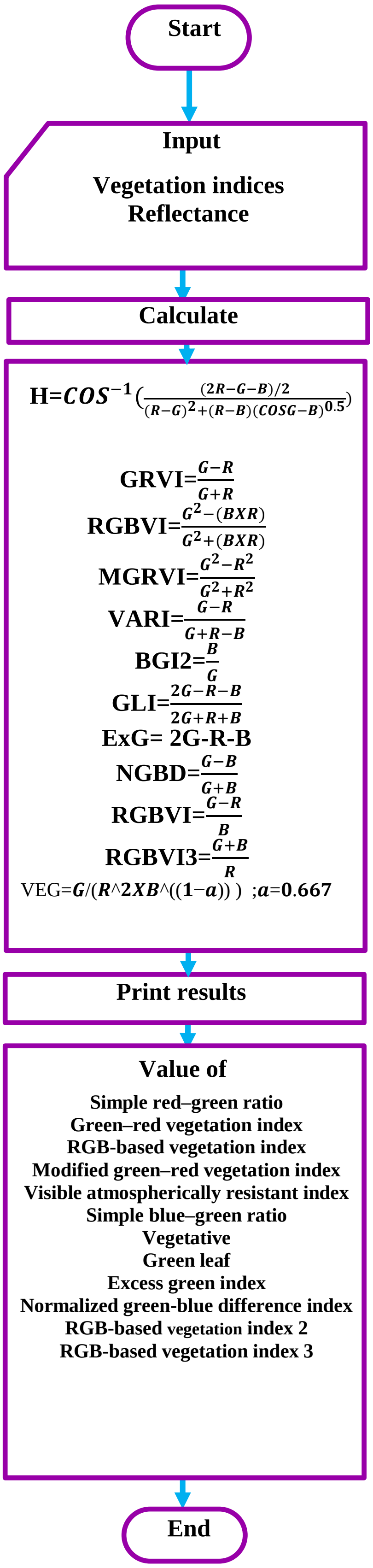

Fig. 1. Flowchart of Color Vegetation indices(CVI) program model I
Source: Authors' drawing.

-Predicting and determined Color indicesto monitoring toxic and protecting from plant stresses

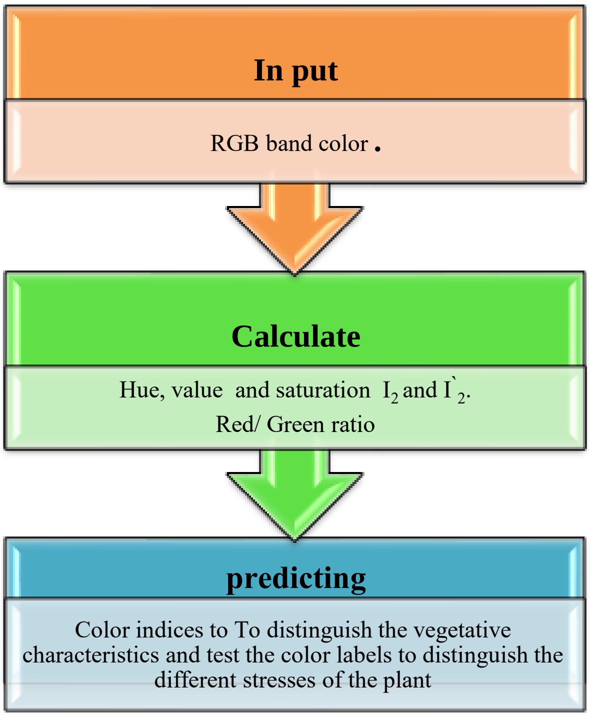

Fig. 2. Sequence for Color indices predictions to distinguish the vegetative characteristics and different stresses of the plant
Source: Authors' drawing

RESULTS AND DISCUSSIONS

Detecting By Digital Imaging For Monitoring Cabbage And Lettuce Crop At Late Season Stage Growth Periods

The digital imaging for showing plants monitoring data collecting to express about different levels of water regime and nitrogen fertilization with at late season stage growth periods. Red and blue bands, Hue, VEG, the simple red–green ratio, green–red and all vegetation index were tested to monter the effect different fertilization and irrigation levels. Monitoring RGB Color Indices With Fertilization And Irrigation Levels For Cabbage And Lettuce Crop**.**

Figure 3 with the levels of fertilization showed the maximum value of Hue and vegetative which were 2.36. and 2.61, also showed the minimum value for the same indices were 2.16 and 1.21. Linear regression analysis was performed, to predict the monitoring Hue and vegetative at different fertilization levels. The following equation represents the relationship.

Hue: y = 0.068x +2.105 R^2 = 0.9593

Vegetative: y = 0.4446x +0.7212 R^2 = 0.9511

Figure 4 with the levels of fertilization showed the maximum value of simple red–green ratio and Green–red vegetation index which was 0.16. and 0.83, and also showed the minimum value for the same indices were 0.12 and 0.74. Linear regression analysis was performed to predict the red–green ratio and Green–red vegetation index at different fertilization levels. The following equation represents the relationship.

GR: y = 0.0124x +0.1135 R^2 = 0.902

GRVI: y = 0.0293x +0.178 R^2 = 0.9627

The simple blue-green ratio and the visible atmospherically resistant index had maximum values of 0.99 and 0.29, respectively, and minimum values of 0.92 and 0.16, respectively, in Figure 5 with the amounts of fertilization.

The visible atmospherically resistant index and the blue-green ratio at various fertilization amounts were predicted using a linear regression analysis.

The following equation represents the relationship.

BGI2: y = 0.0205x +0.9134 R^2 = 0.9324

VARI: y = 0.0437x +0.1235 R^2 = 0.9598

The same trend accrued with simple green leaf and normalized green-blue difference index color indices, as Figure 6 expressed by

GLI: y = 0.0397x +0.5571 R^2 = 0.9083

NGBDI: y = 0.0361x +0.6201 R^2 = 0. 9811

Also, RGB-based vegetation index 2 and RGB-based vegetation index 3 at Figure 7 with different fertilization levels expressed by:

RGBVI2: y = 0.7478x +4.0979 R^2 = 0.958

RGBVI3: y = 0.6999x +2.8577 R^2 = 0. 9441

Figure 8 with the levels of irrigation showed the maximum value of Hue and vegetative which were 2.33. and 3.55, and also showed the minimum value for the same indices which were 2.16 and 1.7. Linear regression analysis was performed to predict the monitoring Hue and vegetative at different irrigation levels. The following equation represents the relationship.

Hue: y = 0.0571x +2.0957 R^2 = 0.9646

Vegetative: y = 0.6398x +1.0704 R^2 = 0.9881

The simple red-green ratio and the Green-red vegetation index in Figure 9 with the levels of irrigation indicated their highest values to be 0.26 and 0.85 respectively, as well as their minimum values to be 0.15 and 0.7. To forecast the monitoring simple red-green ratio and the green-red vegetation index at various irrigation levels, linear regression analysis was used. The relationship is represented by the equation below.

GR: y = 0.0375x +0.1073 R^2 = 0.9863

GRVI: y = 0.0544x +0.6427 R^2 = 0.9755

The simple blue-green ratio and the visible atmospherically resistant index had maximum values of 0.25 and 1.19, respectively, and minimum values of 0.19 and 0.85, respectively, in Figure 10 with the degrees of irrigation. The monitoring simple blue-green ratio and visible atmospherically resistant index at various irrigation levels were predicted using a linear regression analysis. The following equation represents the relationship.

BGI2: y = 0.0216x +0.165 R^2 = 0.9507

VARI: y = 0.1225x +0.715 R^2 = 0.9522

The normalized green-blue difference index and green leaf maximum values were 0.76 and 0.74, respectively, in Figure 11. The normalized green-blue minimum values were 0.64 and 0.65, respectively. To forecast the monitoring's green leaf and normalized green-blue difference index at various irrigation levels, linear regression analysis was used. The relationship is depicted by the following equation.

GLI: y = 0.0405x +0.6084 R^2 = 0.9789

NGBDI: y = 0.0306x +0.6265 R^2 = 0.9481

The RGB-based vegetation index 2 and RGB-based vegetation index 3 had maximum values of 5.21 and 6.79, respectively, and minimum values of 4.25 and 5.15, respectively, in Figure 12 with the degrees of irrigation. Linear regression analysis was performed to predict the monitoring RGB-based vegetation index 2 and RGB-based vegetation index 3 at different irrigation levels. The following equation represents the relationship.

RGBVI2: y = 0.3088x +3.915 R^2 = 0.965

RGBVI3: y = 0.5311x +4.5624 R^2 = 0. 9917

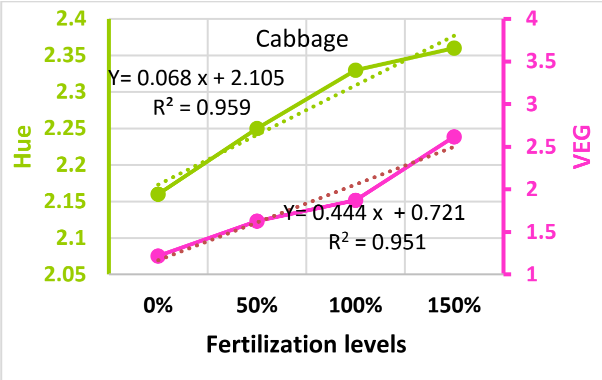

Fig. 3. The Hue and Vegetative Color Indices of the Cabbage Crop in Relation to Fertilization Levels
Source: Authors' determination.

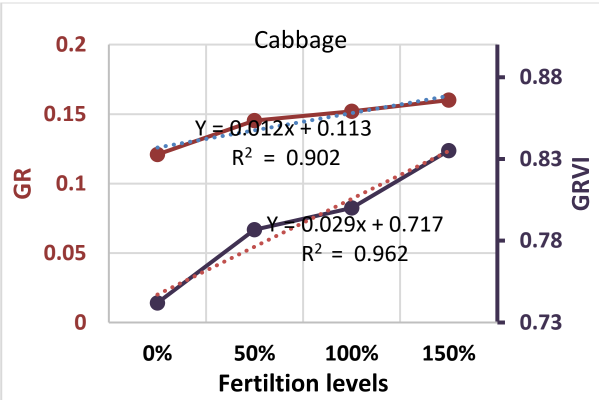

Fig. 4. The straightforward red-green ratio and the green-red vegetation index are color indices that correlate with the fertilization rates of cabbage crops.
Source: Authors' determination.

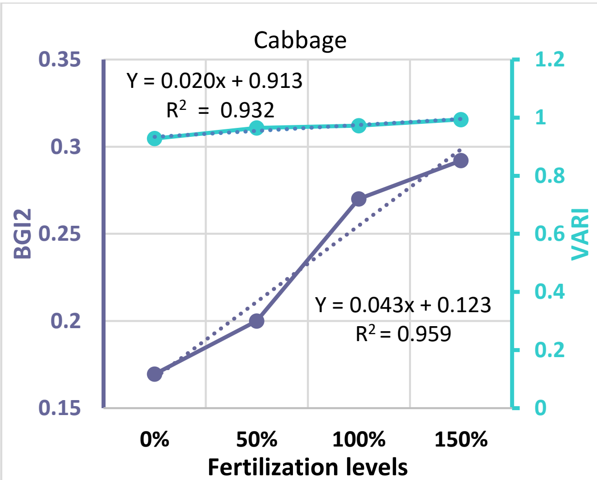

Fig. 5. The straight forward blue-green ratio and visible atmospheric resistance index color indices with cabbage crop fertilizer levels
Source: Authors' determination.

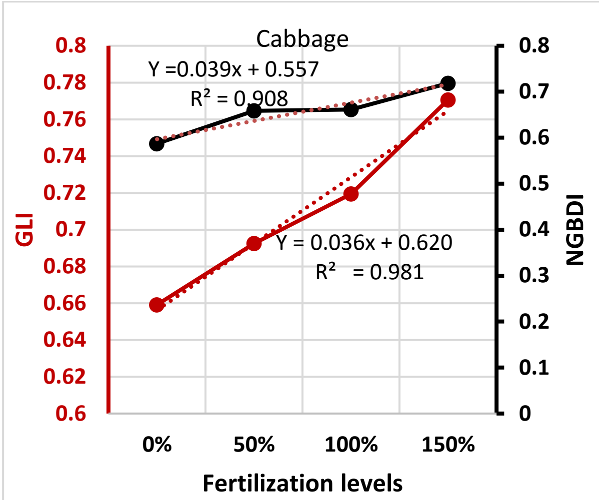

Fig. 6. The normalized green-blue difference index and basic green leaf color indices with cabbage crop fertilizer levels
Source: Authors' determination.

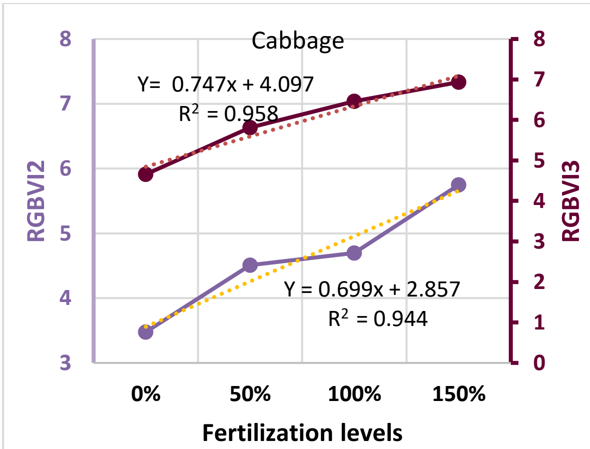

Fig. 7. The RGB-based vegetation index 2 and 3 color indices with levels of fertilizer in the cabbage crop
Source: Authors' determination.

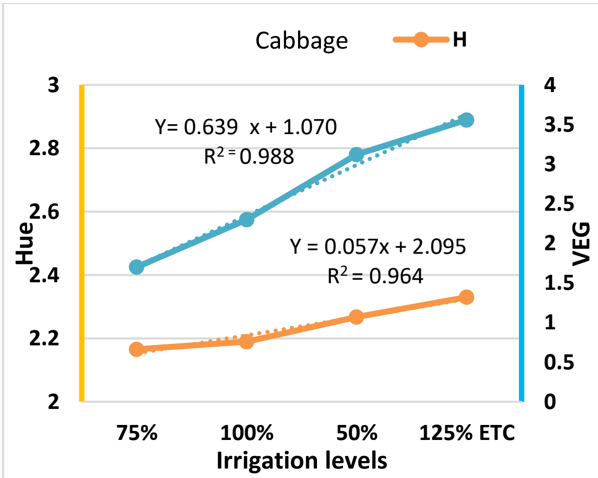

Fig. 8.The hue and vegetative color indices with irrigation levels of the cabbage crop at the first level of fertilization
Source: Authors' determination.

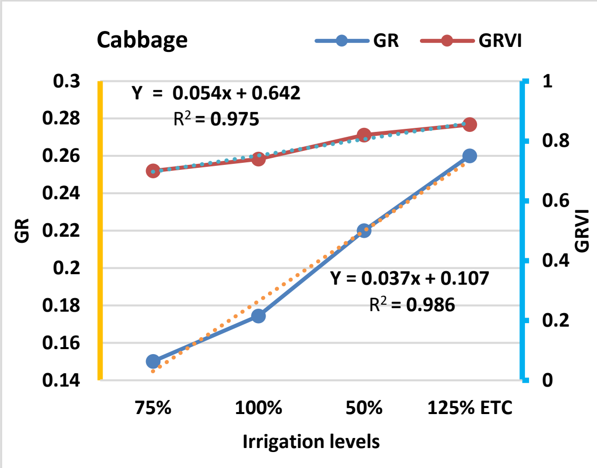

Fig. 9. The straight forward red-green ratio and the green-red vegetation index, along with the cabbage crop's irrigation levels at the first level of fertilization, are color indices.
Source: Authors' determination.

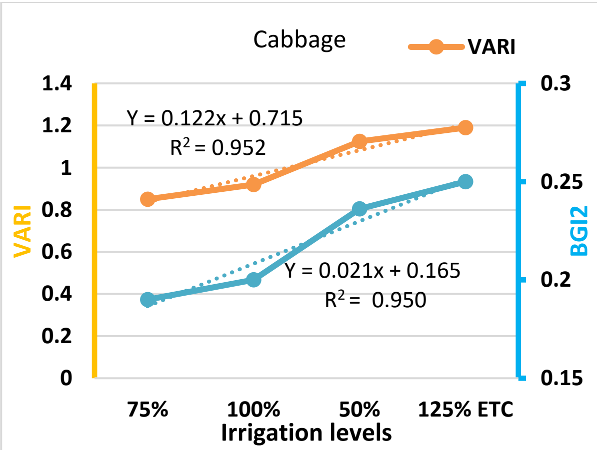

Fig. 10. The straightforward blue-green ratio, visible atmospheric resistance indices, and cabbage crop irrigation levels at the first stage of fertilizing
Source: Authors' determination.

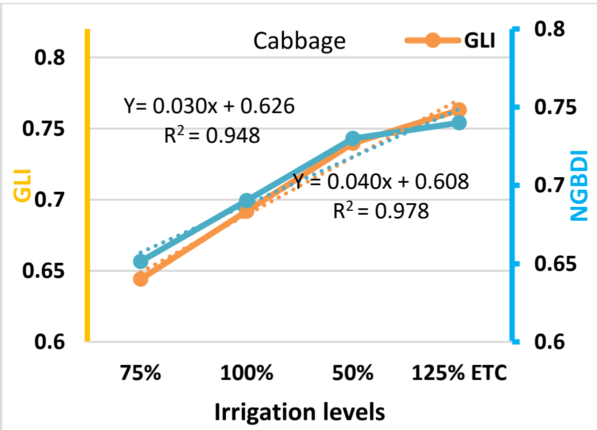

Fig. 11. Using irrigation levels of the cabbage crop at the first level of fertilization, the simple green leaf and normalized green-blue difference index color indices were calculated.
Source: Authors' determination.

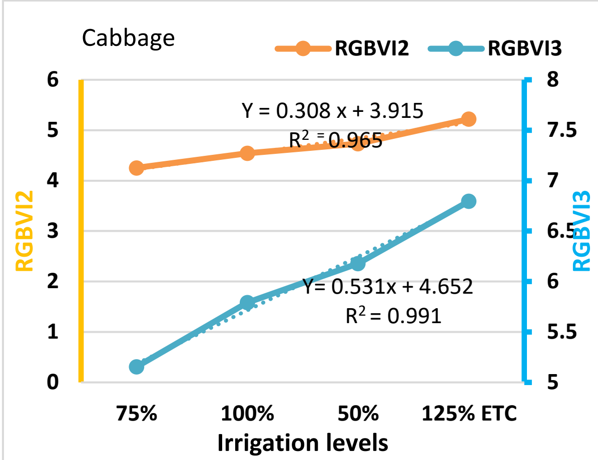

Fig. 12. The RGB-based vegetation index 2 and 3 color indices with cabbage crop irrigation levels at the first phase of fertilization
Source: Authors' determination.

Figure 13 with the levels of fertilization showed the maximum value of Hue and vegetative which were 2.22. and 2.44, and also showed the minimum value for the same indices which were 2.16 and 1.37. Linear regression analysis was performed to predict the monitoring Hue and vegetative at different fertilization levels. The following equation represents the relationship.

Hue: $y = 0.018x + 2.1426$ $R^2 = 0.9233$

Vegetative: $y = 0.3514x + 0.943$ $R^2 = 0.9462$

The basic red-green ratio and the Green-red vegetation index in Figure 14 with the levels of fertilization indicated their maximum values to be 0.18 and 0.83 and 0.12 and 0.74, respectively. At various fertilization amounts, the red-green ratio and the green-red vegetation index were predicted using a linear regression analysis. The following equation represents the relationship.

GR: $y = 0.0321x + 0.0562$ $R^2 = 0.9849$

GRVI: $y = 0.0322x + 0.6977$ $R^2 = 0.9305$

The simple blue-green ratio and the visible atmospherically resistant index had maximum values of 0.99 and 0.3 in Figure 15 with the levels of fertilization, and minimum values of 0.92 and 0.169, respectively. The visible atmospherically resistant index and the blue-green ratio at various fertilization amounts were predicted using a linear regression analysis. The following equation represents the relationship.

BGI2: $y = 0.023x + 0.901$ $R^2 = 0.9742$

VARI: $y = 0.0454x + 0.1227$ $R^2 = 0.9829$

The normalized green-blue difference index and green leaf maximum values were 0.77 and 0.8, respectively, in Figure 16. The normalized green-blue difference index and green leaf minimum values were 0.58 and 0.65, respectively. The normalized green-blue difference index and the green leaf were predicted using linear regression analysis at various fertilization levels. The following equation represents the relationship.

GLI: y = 0.059x +0.5314 R^2 = 0.9904
NGBDI: y = 0.045x +0.6054 R^2 = 0. 9321

The RGB-based vegetation index 2 and RGB-based vegetation index 3 were shown to have maximum values of 7.7 and 6, respectively, and minimum values of 4.65 and 3.47, respectively, in Figure 17 with the amounts of fertilization. The RGB-based vegetation index 2 and RGB-based vegetation index 3 were predicted using linear regression analysis at various fertilization amounts. The following equation represents the relationship.

RGBVI2: y = 0.9773x +3.7155 R^2 = 0.9871
RGBVI3: y = 0.826x +2.7314 R^2 = 0. 9932

Figure 18 with the levels of irrigation showed the maximum value of Hue and vegetative which were 2.23. and 1.63, and also showed the minimum value for the same indices which were 2.11 and 1. Linear regression analysis was performed to predict the monitoring Hue and vegetative at different irrigation levels. The following equation represents the relationship.

Hue: y = 0.0365x +2.0811 R^2 = 0.9589
Vegetative: y = 0.194x +0.8343 R^2 = 0.9859

The RGB-based vegetation index 2 and RGB-based vegetation index 3 were shown to have maximum values of 7.7 and 6, respectively, and minimum values of 4.65 and 3.47, respectively, in Figure 19 with the amounts of fertilization. The RGB-based vegetation index 2 and RGB-based vegetation index 3 were predicted using linear regression analysis at various fertilization amounts. The following equation represents the relationship.

GR: y = 0.026x +0.0418 R^2 = 0.9924
GRVI: y = 0.0233x +0.6864 R^2 = 0.9588

The simple blue-green ratio and the visible atmospherically resistant index had maximum values of 0.26 and 1, respectively, and minimum values of 0.16 and 0.85, respectively, in Figure 20 with the degrees of irrigation. The monitoring simple blue-green ratio and visible atmospherically resistant index at various irrigation levels were predicted using a linear regression analysis. The following equation represents the relationship.

BGI2: y = 0.0299x +0.1339 R^2 = 0.9544
VARI: y = 0.0523x +0.8013 R^2 = 0.9011

The normalized green-blue difference index and the maximum and minimum values for those indices, respectively, for Figure 21 with the levels of irrigation, were 0.69 and 0.65 respectively. To forecast the normalized green-blue difference index and monitoring green leaf at various irrigation levels, linear regression analysis was used. The following equation represents the relationship.

GLI: y = 0.0127x +0.6499 R^2 = 0.9448
NGBDI: y = 0.0342x +0.5214 R^2 = 0.9765

The RGB-based vegetation index 2 and RGB-based vegetation index 3 were shown to have maximum values of 4.25 and 5.67 in Figure 22 along with their respective minimum values of 3.22 and 4.54. The monitoring RGB-based vegetation index 2 and RGB-based vegetation index 3 at various irrigation levels were predicted using a linear regression analysis. The following equation represents the relationship.

RGBVI2: y = 0.3536x +2.8756 R^2 = 0.9909
RGBVI3: y = 0.3866x +4.0409 R^2 = 0. 9398

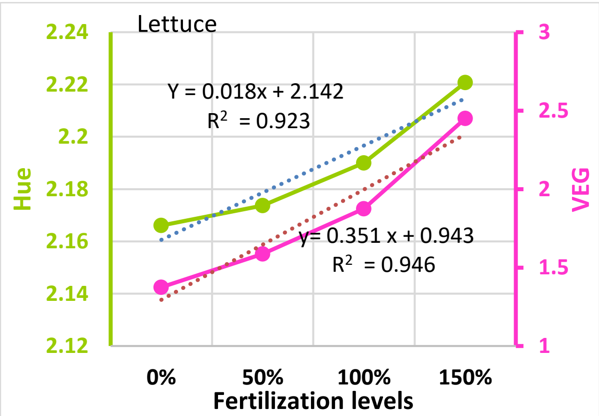

Fig. 13. The Hue and vegetative color indices with fertilization levels of lettuce crop
Source: Authors' determination.

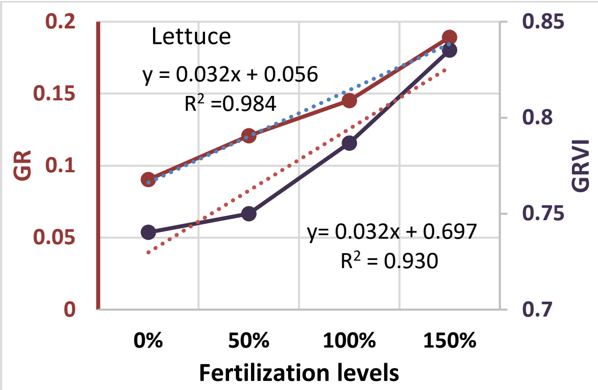

Fig. 14. The simple red–green ratio and Green–red vegetation index color indices with fertilization levels of lettuce crop
Source: Authors' determination.

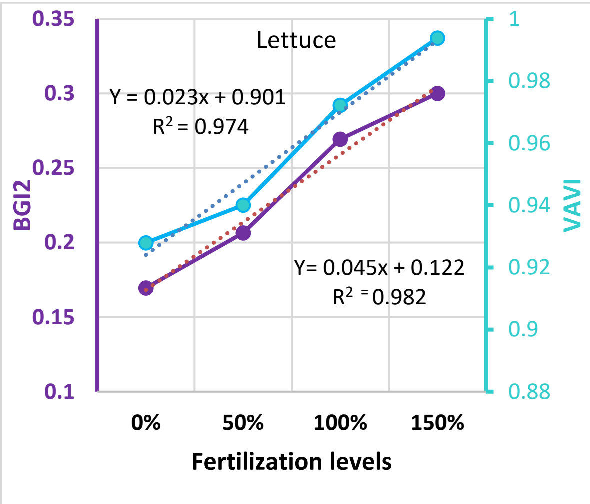

Fig. 15. The straightforward blue-green ratio and visible atmospheric resistance index color indices with lettuce crop fertilizer levels
Source: Authors' determination.

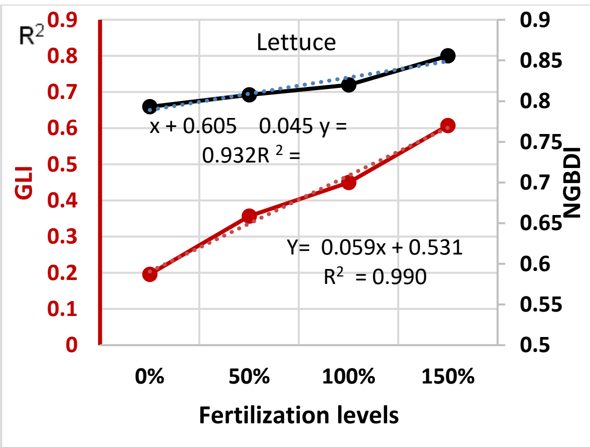

Fig. 16. The normalized green-blue difference index and basic green leaf color indices with lettuce crop fertilization levels
Source: Authors' determination.

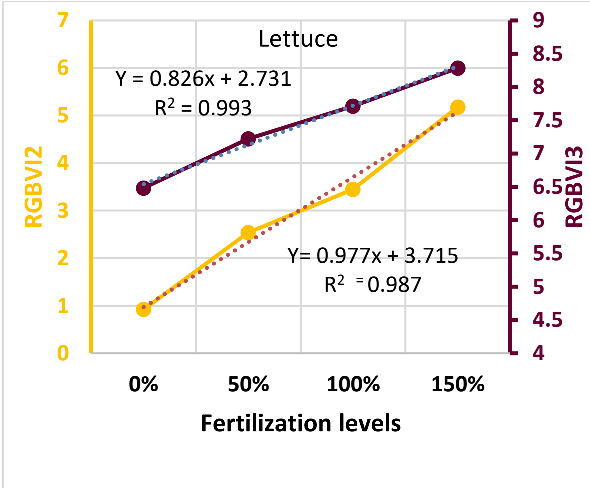

Fig. 17.The color indices for the RGB-based vegetation index 2 and 3 with lettuce crop fertilization levels
Source: Authors' determination.

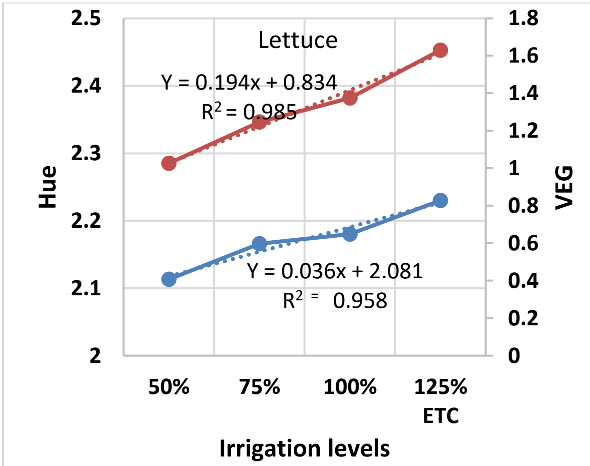

Fig. 18. The lettuce crop's hue and vegetative color indices and irrigation levels
Source: Authors' determination.

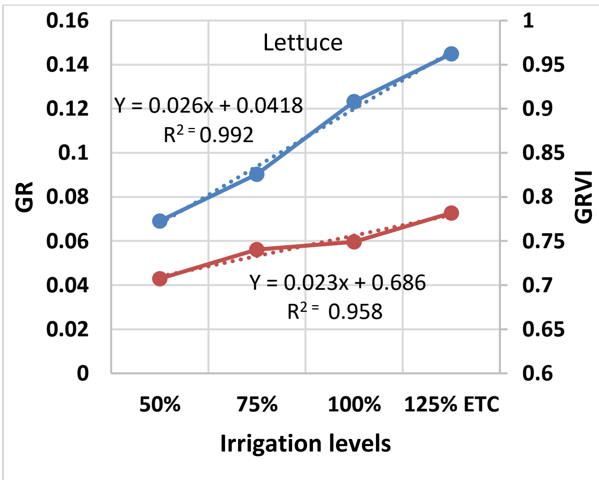

Fig. 19. The simple red-green ratio and the green-red vegetation index, along with the lettuce crop's watering levels
Source: Authors' determination.

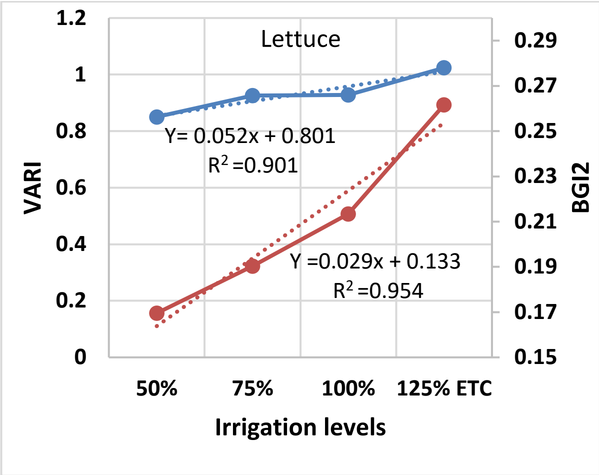

Fig. 20. The straight forward blue-green ratio and readily observable atmospheric resistance color indices with lettuce crop irrigation levels
Source: Authors' determination.

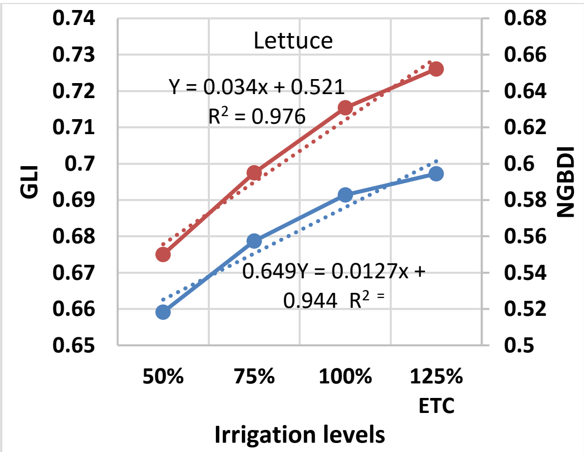

Fig. 21.The normalized green-blue difference index and simple green leaf color indices with lettuce crop irrigation levels
Source: Authors' determination.

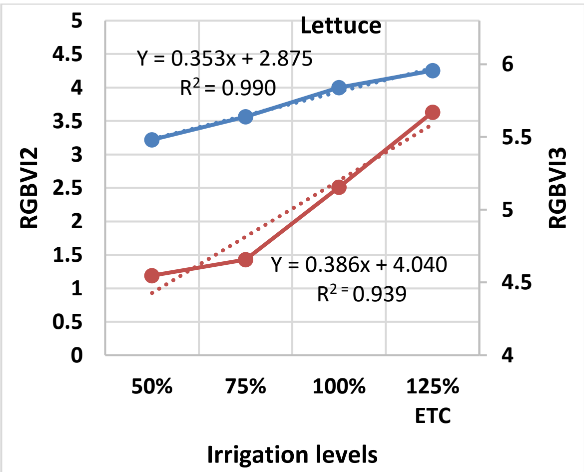

Fig. 22.The color indices for the RGB-based vegetation index 2 and 3 with lettuce crop irrigation levels
Source: Authors' determination.

CONCLUSIONS

To distinguish between the lack of irrigation and fertilization for leafy plants, a digital image form can be used. Detection of the RGB-colored vegetation indicators for lettuce and cabbage crops that are suffering from a nitrogen and water shortage. There was a significant association between the various amounts of fertilization and irrigation and the vegetation cover indicators based on color indicators.

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DISTINGUISHING HEAVY METALS CONCENTRATION IN GREEN LEAFY VEGETABLES BY USING THE RGB COLOR MODEL

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Abstract

The objective of this research was to study of the correlation between RGB colour indicators and lead concentration in leafy plants. Cabbage and lettuce crops were watered with 3 levels of Lead Pb-contaminated (2.4 and 6 mg/lit). To distinguish the heavy metal contamination and their impact on vegetative characteristics for plants, the results showed with the levels of poisoning (0,2,4, and 6 mg/lit) showed the maximum value of Hue and vegetative were 0.76. and 0.032, also showed the minimum value for the same indices were 2.15 and 1.51. Also with the levels of poisoning (0,2,4, and 6mg/lit) showed the maximum value of simple red–green ratio and Green–red vegetation index was 1.61. and 0.23, also showed the minimum value for the same indices were 1.28 and 0.12. for Cabbage crops while for lettuce the results showed with the levels of poisoning (0, 2, 4, and 6 mg/lit) showed the maximum value of Hue and vegetative were 0.71. and 0.027, also showed the minimum value for the same indices were 0.41 and 0.024. Also with the levels of poisoning (0,2,4, and 6 mg/lit) showed the maximum value of simple red–green ratio and Green–red vegetation index was 1.65. and 0.43, also showed the minimum value for the same indices were 1.6 and 0.2. Linear regression analysis was performed on the equations to predict the monitoring Hue and vegetative and simple red–green ratio and Green–red vegetation index The red, green, blue band and intensity, the simple blue–green ratio addition to visible atmospherically resistant index simple green leaf and normalized green-blue difference index The RGB-based vegetation index 2 and RGB-based vegetation index 3 at different poisoning levels. The existence of a strong relationship between them and contains a high coefficient of determination.

Key words: *cabbage and lettuce, lead, concentration, RGB, colour, indicators*

INTRODUCTION

Vegetable crops grown in water contaminated with heavy metals differ markedly in the pattern of mineral accumulation, uptake, and distribution. Some types of crops show a marked difference in the mineral concentration of different parts of the plant. Based on the accumulation of minerals in the edible parts and whole plants, Green Leafy Vegetables recorded the highest accumulation of almost all heavy metals.

Levels of heavy metals in the soil increased significantly with increasing application rates. The controls for both plants recorded the lowest heavy metal uptake. Cabbage had an uptake of 0.48 ± 0.13, 1.36 ± 0.23, and 2.60 ± 0.29 mg/kg for Pb, Zn, and Cu, respectively, while lettuce had 0.34 ± 0.19, 1.35 ± 0.31, and 2.30 ± 0.14 mg/kg uptake for Pb, Zn, and Cu, respectively. Highest metal uptake was recorded at the highest application rate in both plants (0.66 ± 0.17, 2.66 ± 0.09, and 4.33 ± 0.14 mg/kg for Pb, Zn, and Cu, respectively, for cabbage and 0.54 ± 0.01, 2.24 ± 0.17, and 3.88 ± 0.19 mg/kg of Pb, Zn, and Cu, respectively, for lettuce). The uptake of Zn and Cu was significant, while Pb uptake was insignificant for both plants [7].

The concentrations of Pb, Cd and Ni in the edible parts of some vegetables were higher than their permissible limit levels. Therefore, the edible parts of lettuce and spinach plants are not safe for human consumption. It is worthy to mention that irrigated edible vegetable crops irrigated with sewage wastewater should be avoided and Egyptian guidelines should be developed for the reuse of these waters in agriculture [5].

There was a direct positive correlation between the zinc and lead levels in soils with the levels in vegetables. Such relation was absent for the other heavy metals. Considering an average daily intake of only 202g of fresh vegetables per person per day, all the vegetables grown at Tabata and Buguruni had lead concentration which would be a health hazard for human consumption [9].

Presence of heavy metal in randomly collected samples of green leafy from various stations of Bengaluru city was detected. Heavy metals (cadmium, zinc, copper, iron, chromium, nickel and lead) were analyzed by tri-acid digestion method [1].

The RGB color images collected by the drone can make the distribution of Kimchi cabbage readable with the naked eye, but it is necessary to convert these data to numerical cover in order to calculate and quantitatively evaluate the variation in vegetation. Assessing variations in vegetation cover should be preceded by the process of separating Kimchi cabbage and soil. In general, ground DSM assesses agricultural land before or after vegetable crops are planted. In addition, the use of drones and sensors can reduce errors related to the subjective judgment of observers, such that quality information related to cabbage growth can be obtained. This highly reliable Kimchi cabbage growth stage prediction model will help to produce basic data to inform adaptation strategies in the agricultural sector under climate change scenarios [8].

Leafy vegetables namely spinach, amaranthus, mustard and fenugreek recorded higher accumulation of both essential and non-essential heavy metals, except cadmium (Cd) and nickel (Ni) which showed less accumulation in fenugreek. Potato and onion showed lower accumulation of zinc, copper and higher accumulation of cadmium and nickel. Cauliflower and cabbage, however, showed greater accumulation of lead and nickel but less accumulation of copper and cadmium. Among fruit type vegetables, pea, soybean and cluster bean showed greater accumulation of Pb and Ni and very less accumulation of Cd [13].

The results of the present analysis showed that the concentration of Pb in the leaves of spinach, coriander, lettuce, radish, cabbage and cauliflower from the vicinity of industrial areas of Faisalabad, Pakistan were 2.251, 2.652, 2.411, 2.035, 1.921 and 1.331 mg kg-1, respectively. Pb contents in the leaves of coriander were significantly ($p<0.05$) higher as compared to those in the other vegetables, whereas, the leaf samples of cauliflower were found to be significantly ($p<0.05$) lower in Pb contents [6].

Pb toxicity causes retarded growth and inhibits germination. Plants faced with lead toxicity have their photosynthetic pathways adversely affected as it disrupts ultrastructure of chloroplast and blocks synthesis of essential pigments including chlorophyll and carotenoids in addition to plastoquinone. The nonspecific symptoms of Pb toxicity are stunted growth, chlorosis and reduced root lengths. Once entered into the cell, Pb changes cell membrane permeability, hormonal changes, inhibition of various enzymes [12].

To quantify heavy metal levels and compare their accumulation in the stems, leaves and roots of *Lactuca sativa* (lettuce), *Brassica oleracea L. varcapitata* (cabbage) and *Daucus carrota varsativa (*carrot) irrigated with wastewater from Nagodi mining site. The highest concentration (0.221 mg/Kg) of Cu was found in D. carrota roots and the highest concentration (35.35 mg/Kg) of Zn was found in the roots of Brassica. Cd accumulation in L. sativa and B. oleracea was below detection limit (< 0.002 mg/Kg). Pb absorbed by the three genotypes was below detection limit (< 0.005 mg/Kg) [2].

The All plant-based N monitoring techniques share a fundamental limitation as a water quality protection practice. They can provide an indication of current crop N status. However, given the insensitivity of plant diagnostics to soil NO3-N availability, a sufficient tissue N value provides no indication of future N fertilization requirements and therefore cannot accurately identify fields where in-season N application can be reduced or delayed. In summary, seasonal N uptake in commercial lettuce fields averaged 145 kg·ha–1 with uptake over the last half of the growing season averaging 4 kg N/ha/d. Current commercial N fertilization rates can be reduced substantially with no reduction of crop yield. PSNT was a reliable technique on which to base N fertilization. Leaf N and midrib NO3-N monitoring were of limited value in guiding in-season N management [3].

The combined deficiency of two nutrients. Those are nitrogen and phosphorus and phosphorus and potassium. The researchers use the characteristics of Red, Green, Blue (RGB) color and Sobel edge detection for leaf shape detection. The data of plant images consist of 450 training data and 150 testing data. The results of identifying nutrient deficiencies in plants using back propagation neural networks are carried out in three tests. First, using RGB color extraction and Sobel edge detection, the researchers show 65.36% accuracy. Second, using RGB color extraction, it has 70.25% accuracy. Last, with Sobel edge detection, it has 59.52% accuracy [10].

The photosynthetic characteristics of flag leaf and the accumulation and remobilization of pre-an thesis dry mass (DM) and nitrogen (N) in vegetable organs in nine wheat cultivars under different source-sink manipulation treatments including defoliation (DF), spike shading (SS) and half spikelets removal (SR) were investigated. Results showed that the SS treatment increased the photosynthetic rate (Pn) of flag leaf in source limited cultivar, but had no significant effect on sink limited cultivar. The SR treatment decreased the Pn of flag leaf. Grain DM accumulation was limited by source in some cultivars, in other cultivars, it was limited by sink. Grain N accumulation was mainly limited by source supply. The contribution of pre-an thesis dry mass to grain yield from high to low was stem, leaf and chaff, while the contribution of pre-an thesis N to grain N from high to low was leaf, stem and chaff [14].

Developing an array of sensors and innovative technologies is important in meeting agricultural demands of a larger population. Current technology for measuring plant health or diagnosing disease is expensive, invasive, and often requires sending samples to central facilities for processing [11].

Canopy temperature variability (CTV) as the range (maximum minus minimum) of CT sensed with the infrared thermometer during a particular measurement period [4].

The main objectives of this research were The objective of this study was the possibility of using IR images to detect Lead Pb-contaminated and study of the correlation between color indicators and lead concentration for Cabbage and lettuce crops.

MATERIALS AND METHODS

Nine doses of Lead Pb were given with irrigation water during the growth period. Pb-contaminated plant was watered. The plants were irrigated with water contaminated with heavy metals and plant leaves with 4 levels of (2,4, and 6 mg/lit). Plant poisoning program with lead nitrate with 5 dose start on, Sunday 8/1/2021, end at 26/1/2021 Lettuce and cabbage crops were sprayed with three concentrations of lead nitrate as a control treatment only as follows: the first to end dose was on 8 Jan/2021, 12,17,21 and 26 Jan /2021. The plants were irrigated with water contaminated with heavy metals and Edible portions of two varieties of green vegetables, namely cabbage, and lettuce leaves, were analyzed for lead, plant leaves for this experiment were tested at Central Laboratory Tanta University laboratories.

The digital camera Canon ESO R. Featuring a high-resolution 26.2MP full-frame CMOS sensor along with a DIGIC 8 image processor, both stills and UHD 4K video can be recorded using a broad sensitivity range, from ISO 100-40000, to suit working in a variety of lighting conditions. Continuous shooting is also supported at up to 5 fps for photographing moving subjects. The sensor also facilitates an advanced Dual Pixel CMOS AF system, with 4,779 selectable on-sensor phase-detection points for quickly and accurately acquiring focus during stills and video operation.

MATLAP PC-Software for Image Analysis system it was used MATLAP program. samples were captured by digital camera, using the capture card to transferred the data and stored on the PC. The MATLAP software package was used to analyzed the images of Cabbage and lettuce. There were three bands, RGB, were derived for each image until obtaining color indices.

Vegetation Indices Basics RGB: A Vegetation Index is a single value calculated by transforming the observations from multiple RGB bands. It is used to enhance the presence of green, vegetation features and thus help to distinguish them from the other objects present in the image.

Simple Ratio (SR): This is a ratio between the reflectance recorded in the RGB bands. This is a quick way to distinguish green leaves from other objects in the scene and estimate the relative biomass present in the image. Also, this value may be very useful in distinguishing stressed vegetation from non-stressed are as follows:

The Indices Simple red–green ratio:

$\frac{R}{G}$..(1)

The Green–red vegetation index:

$\frac{G-R}{G+R}$...(2)

The RGB-based vegetation index:

$\frac{G^2-(BXR)}{G^2+(BXR)}$...(3)

The Modified green–red vegetation index

$\frac{G^2-R^2}{G^2+R^2}$...(4)

The Visible atmospherically resistant index:

$\frac{G-R}{G+R-B}$..(5)

The Indices Simple blue–green ratio:

$\frac{B}{G}$...(6)

The Vegetative Indices:

$\frac{G}{R^2 X B^{(1-a)}}$; $a = 0.667$................................(7)

The Green Leaf Indices:

$\frac{2G-R-B}{2G+R+B}$..(8)

The Excess green index:

$2G - R - B$..(9)

The Normalized green-blue difference index

$\frac{G-B}{G+B}$...(10)

The RGB-based vegetation index 2

$\frac{G-R}{B}$..(11)

The RGB-based vegetation index 3

$\frac{G+B}{R}$..(12)

The Visible Atmospheric Resistant Index

$VARI = \frac{G-R}{G+R-B}$.....................................(13)

The Hue Indices:

$$H = COS^{-1}\frac{(2R-G-B)/2}{(R-G)^2+(R-B)(COSG-B)^{0.5}}$$
....(14)

The Intensity Indices

$I = \frac{1}{3}(G+R+B)$.................................(15)

$I_2 = (R-B)/2$....................................(16)

The C++ programming language was used to build a set of algorithms to determine and predict the colorimetric indicators and to study the effect of, water and fertilization shortage. The simulation and predicting programs model written by C++.

The program model test in this study the two Cabbage and lettuce seeds in greenhouse, with sand soil, and water, Phosphor, Nitrogen fertilizer, using digital and thermal camera with MATLAP and IR soft program the programs flowchart model steps

Color Program model :using this technique to estimate the color indices to distinguish the vegetative characteristics using alternative representations of the RGB Color Model Simulation and predicting programs model written by C++ to estimate the color calcification indices.

-In put: RGB band color

-Calculate: Hue, value and saturation I_2 and $Ì_2$. Red/ Green ratio, Simple red–green ratio, Green–red vegetation index, RGB-based vegetation index, modified green–red vegetation index, Visible atmospherically resistant index, Simple blue–green ratio, Vegetative, Green leaf, Excess green index, Normalized green-blue difference index, RGB-based vegetation index 2 RGB-based vegetation index 3 Visible Atmospheric Resistant Index

-Predicting and determined Color indices to monitoring toxic and protecting from plant stresses.

RESULTS AND DISCUSSIONS

Figure 1 with the levels of poisoning (0, 2, 4, and 6mg/lit) showed the maximum value of red and green bands which were 122. and 92, and also showed the minimum value for the same indices which were 115 and 71. Linear regression analysis was performed on the equations to predict the monitoring red and green band at different poisoning levels. The following equation represents the relationship.

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Red band: $y = 2.3x + 113$ $R^2 = 0.9888$
Green band: $y = 6.9x + 66.5$ $R^2 = 0.92$

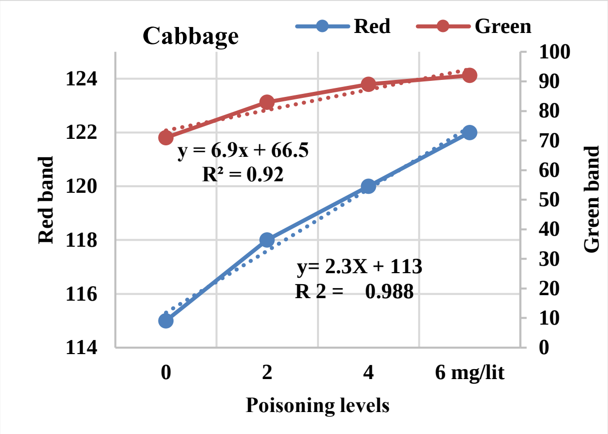

Fig. 1. The red and green band color indices with poisoning levels of cabbage crop
Source: Authors' determination.

Figure 2 with the levels of poisoning (0,2,4, and 6mg/lit) showed the maximum value of blue band and intensity which were 55. and 81.6, and also showed the minimum value for the same indices which were 28 and 79.3. Linear regression analysis was performed on the equations to predict the monitoring red band and intensity at different poisoning levels. The following equation represents the relationship.
Blue band: $y = 9.1x + 16.5$ $R^2 = 0.9524$
Intensity: $y = 0.7667x + 78.667$ $R^2 = 0.9888$

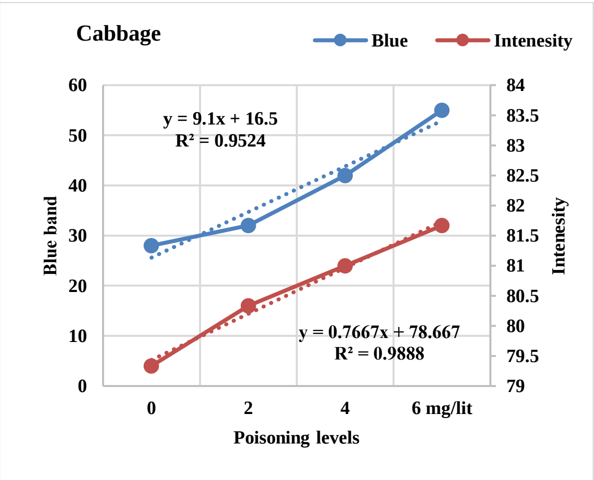

Fig. 2. The blue band and intensity with poisoning levels of cabbage crop
Source: Authors' determination.

Figure 3 with the levels of poisoning (0,2,4, and 6mg/lit) showed the maximum value of Hue and vegetative which were 0.76. and 0.032, and also showed the minimum value for the same indices which were 2.15 and 1.51. Linear regression analysis was performed on the equations to predict the monitoring Hue and vegetative at different poisoning levels. The following equation represents the relationship.
Hue: $y = 0.163x + 0.1557$ $R^2 = 0.9201$
Vegetative: $y = 0.002x + 0.0241$ $R^2 = 0.9811$

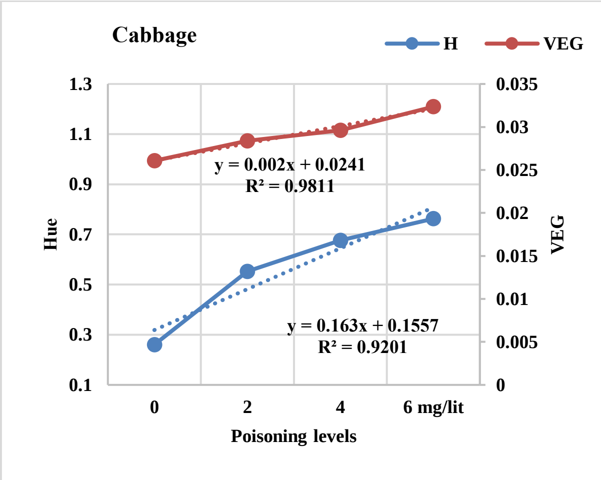

Fig. 3. The Hue and vegetative with poisoning levels of cabbage crop.
Source: Authors' determination.

Figure 4 and with the levels of poisoning (0, 2, 4, and 6mg/lit) showed the maximum value of simple red–green ratio and Green–red vegetation index which were 1.61. and 0.23, and also showed the minimum value for the same indices which were 1.28 and 0.12.

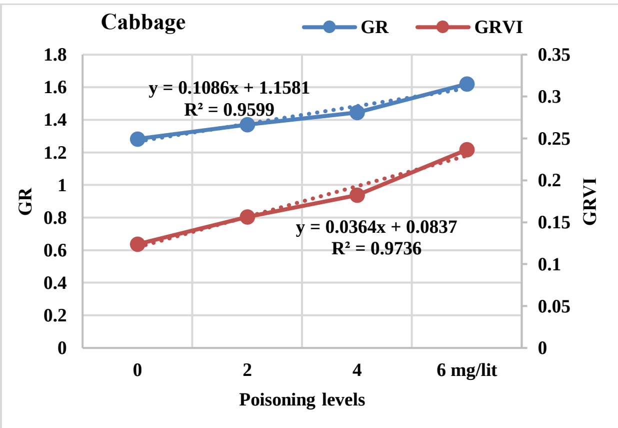

Fig. 4. The simple red–green ratio and Green–red vegetation index with poisoning levels of cabbage crop
Source: Authors' determination.

Linear regression analysis was performed on the equations to predict the monitoring simple red–green ratio and Green–red vegetation index at different poisoning levels. The following equation represents the relationship.

GR: $y = 0.1086x + 1.1581$ $R^2 = 0.9599$

GRVI: $y = 0.03649x + 0.0837$ $R^2 = 0.9736$

Figure 5 with the levels of poisoning (0, 2, 4, and 6 mg/lit) showed the maximum value of simple blue–green ratio and visible atmospherically resistant index which were 0.77 and 0.33, and also showed the minimum value for the same indices which were 0.3 and 0.14. Linear regression analysis was performed on the equations to predict the monitoring simple blue–green ratio and visible atmospherically resistant index at different poisoning levels. The following equation represents the relationship.

BGI2: $y = 0.1557x + 0.0968$ $R^2 = 0.9138$

VARI: $y = 0.0625x + 0.0671$ $R^2 = 0.9419$

Figure 6 with the levels of poisoning (0, 2, 4, and 6 mg/lit) showed the maximum value of green leaf and normalized green-blue difference index which were 0.11. and 0.52, and also showed the minimum value for the same indices which were 0.032 and 0.24. Linear regression analysis was performed on the equations to predict the monitoring green leaf and normalized green-blue difference index at different poisoning levels. The following equation represents the relationship.

GLI: $y = 0.0266x + 0.0108$ $R^2 = 0.9724$

NGBDI: $y = 0.0969x + 0.1484$ $R^2 = 0.9897$

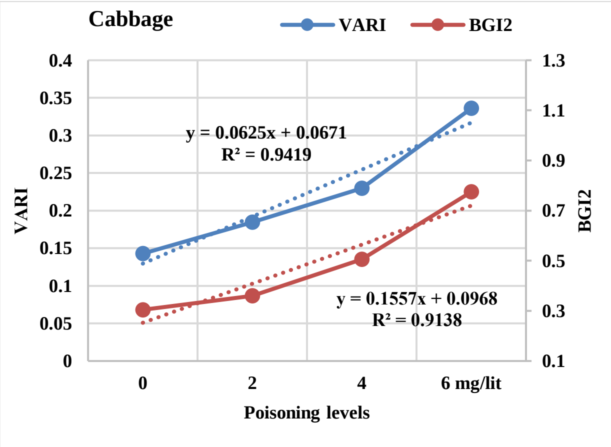

Fig. 5. The simple blue–green ratio and visible atmospherically resistant index with poisoning levels of cabbage crop
Source: Authors' determination.

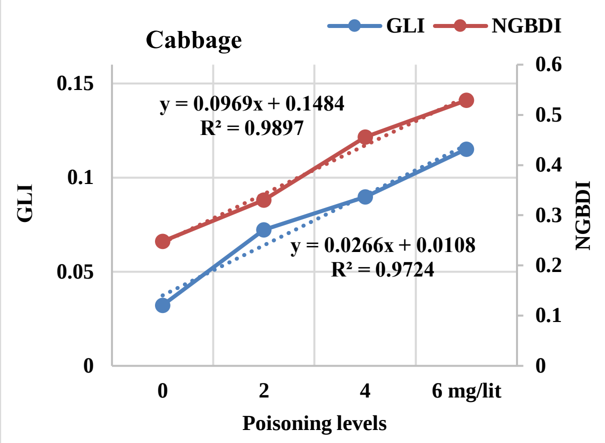

Fig. 6. The simple green leaf and normalized green-blue difference index color with poisoning levels of cabbage crop
Source: Authors' determination.

Figure 7 and with the levels of poisoning (0, 2, 4, and 6 mg/lit) showed the maximum value of RGB-based vegetation index 2 and RGB-based vegetation index 3 which were 1.03. and 7.5,and also showed the minimum value for the same indices which were 0.8 and 3.38. Linear regression analysis was performed on the equations to predict the monitoring RGB-based vegetation index 2andRGB-based vegetation index 3 at different poisoning levels. The following equation represents the relationship.

RGBVI2: $y = 0.0741x + 0.7249$ $R^2 = 0.9818$

RGBVI3: $y = 1.4115x + 2.0485$ $R^2 = 0.9859$

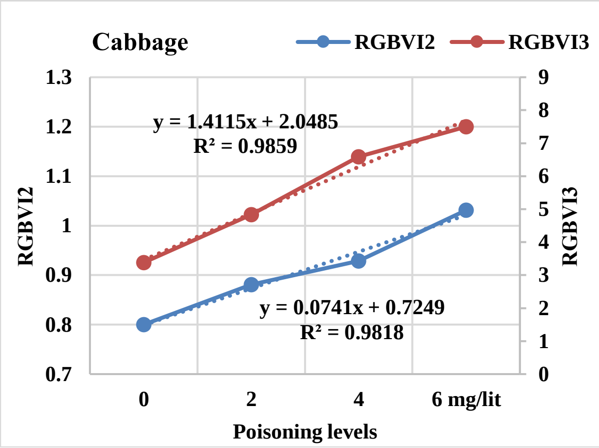

Fig. 7. The RGB-based vegetation index 2 and RGB-based vegetation index 3 color with poisoning levels of cabbage crop
Source: Authors' determination.

Figure 8 with the levels of poisoning (0,2,4, and 6mg/lit) showed the maximum value of red and green bands which were 123. and 84, and also showed the minimum value for the same indices which were 104 and63. Linear regression analysis was performed on the equations to predict the monitoring red and green band at different poisoning levels. The following equation represents the relationship.

Red band: $y = 6.5x + 98.5$ $R^2 = 0.9657$

Green band: $y = 6.79x + 55.5$ $R^2 = 0.9561$

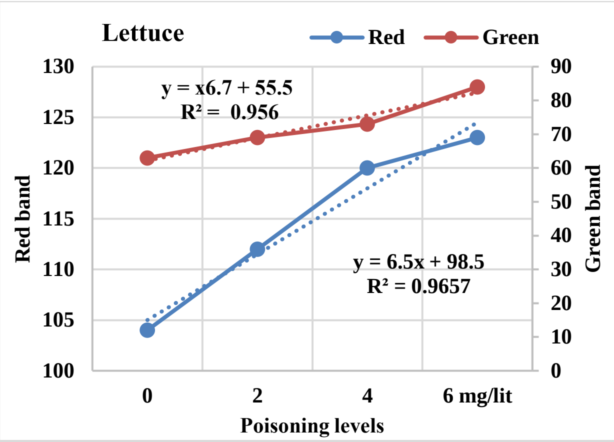

Fig. 8. The red and green band color indices with poisoning levels of lettuce crop
Source: Authors' determination.

Figure 9 with the levels of poisoning (0, 2, 4, and 6 mg/lit) showed the maximum value of blue band and intensity which were 48. and 85, and also showed the minimum value for the same indices which were 34 and 67.

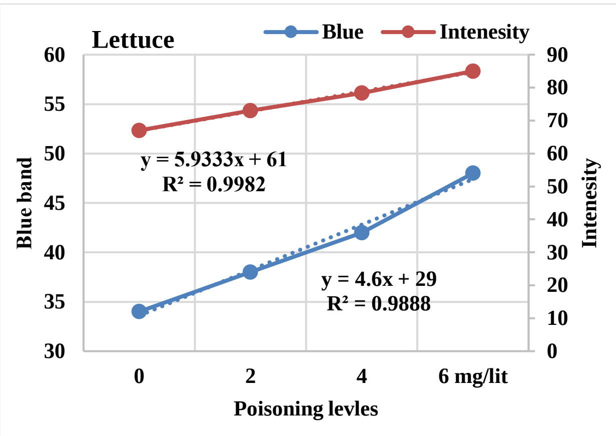

Fig. 9. The blue band and intensity color indices with poisoning levels of lettuce crop
Source: Authors' determination.

Linear regression analysis was performed on the equations to predict the monitoring red band and intensity at different poisoning levels. The following equation represents the relationship.

Blue band: $y = 4.6x + 29$ $R^2 = 0.9888$

Intensity: $y = 5.9333x + 61$ $R^2 = 0.9982$

Figure 10 with the levels of poisoning (0, 2, 4, and 6 mg/lit) showed the maximum value of Hue and vegetative which were 0.71. and 0.027, and also showed the minimum value for the same indices which were 0.41 and 0.024. Linear regression analysis was performed on the equations to predict the monitoring Hue and vegetative at different poisoning levels. The following equation represents the relationship.

Hue: $y = 0.1001x + 0.2937$ $R^2 = 0.9589$

Vegetative: $y = 0.0009x + 0.0244$ $R^2 = 0.9008$

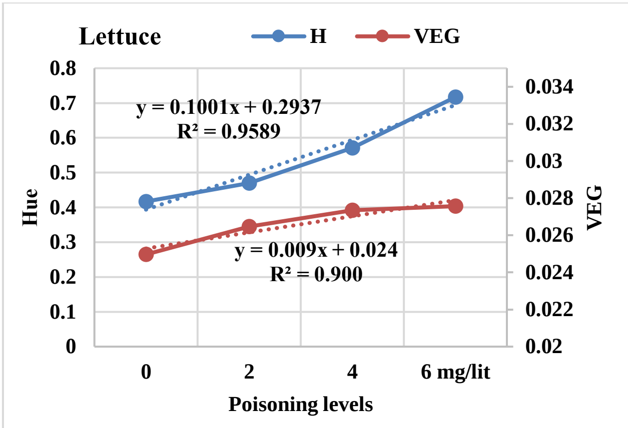

Fig. 10. The Hue and vegetative color indices with poisoning levels of lettuce crop.
Source: Authors' determination.

Figure 11 with the levels of poisoning (0, 2, 4, and 6 mg/lit) showed the maximum value of simple red–green ratio and Green–red vegetation index which were 1.65. and 0.43, and also showed the minimum value for the same indices which were 1.6 and 0.2.

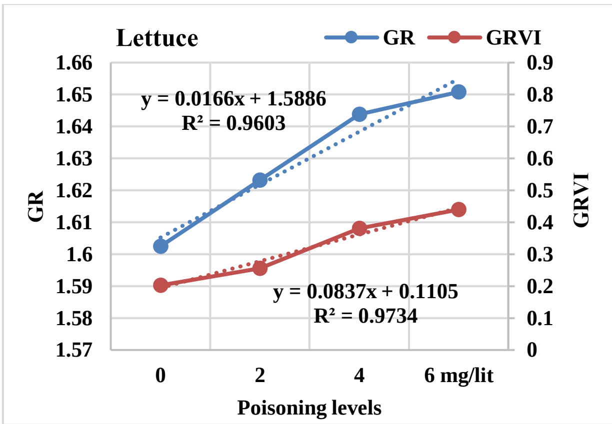

Fig. 11. The simple red–green ratio and Green–red vegetation index with poisoning levels of lettuce crop
Source: Authors' determination.

Linear regression analysis was performed on the equations to predict the monitoring simple red–green ratio and Green–red vegetation index at different poisoning levels. The following equation represents the relationship.
GR: y = 0.0166x +1.5886 R^2 = 0.9603
GRVI: y = 0.0837x +0.1105 R^2 = 0.9734
Figure 12 with the levels of poisoning (0, 2, 4, and 6 mg/lit) showed the maximum value of simple blue–green ratio and visible atmospherically resistant index which were 0.57. and 0.43, and also showed the minimum value for the same indices which were 0.53 and 0.28. Linear regression analysis was performed on the equations to predict the monitoring simple blue–green ratio and visible atmospherically resistant index at different poisoning levels. The following equation represents the relationship.
BGI2: y = 0.0128x +0.5274 R^2 = 0.9447
VARI: y = 0.0536x +0.2064 R^2 = 0.9039
Figure 13 with the levels of poisoning (0, 2, 4, and 6 mg/lit) showed the maximum value of green leaf and normalized green-blue difference index which were 0.05. and 0.52, and also showed the minimum value for the same indices which were 0.02 and 0.2. Linear regression analysis was performed on the equations to predict the monitoring green leaf and normalized green-blue difference index at different poisoning levels. The following equation represents the relationship.
GLI: y = 0.0099x +0.0122 R^2 = 0.9998
NGBDI: y = 0.1107x +0.0651 R^2 = 0.9536
(Fig. 13).

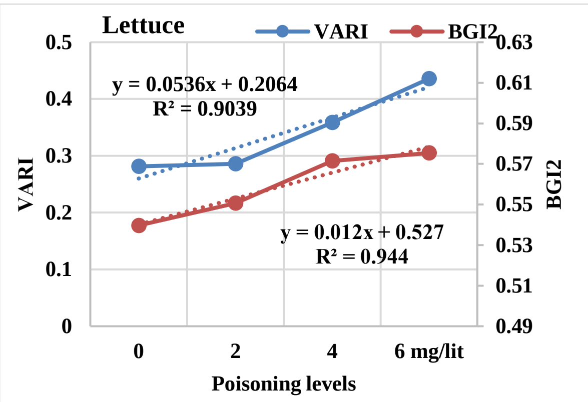

Fig. 12. The simple blue–green ratio and visible atmospherically resistant index with poisoning levels of lettuce crop
Source: Authors' determination.

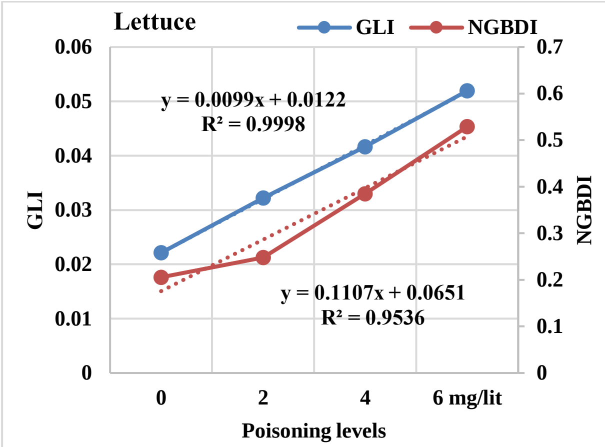

Fig. 13. The simple green leaf and normalized green-blue difference index with poisoning levels of lettuce crop
Source: Authors' determination.

Figure 14 with the levels of poisoning (0, 2, 4, and 6 mg/lit) showed the maximum value of RGB-based vegetation index 2 and RGB-based vegetation index which were 1.36. and 6.7, and also showed the minimum value for the same indices which were 0.46 and 3.1. Linear regression analysis was performed on the equations to predict the monitoring RGB-based vegetation index 2 and RGB-based vegetation index 3 at different poisoning levels.
The following equation represents the relationship.
RGBVI2: y = 0.2859x +0.1765 R^2 = 0.9709
RGBVI3: y = 1.2676x +1.9701 R^2 = 0.9554

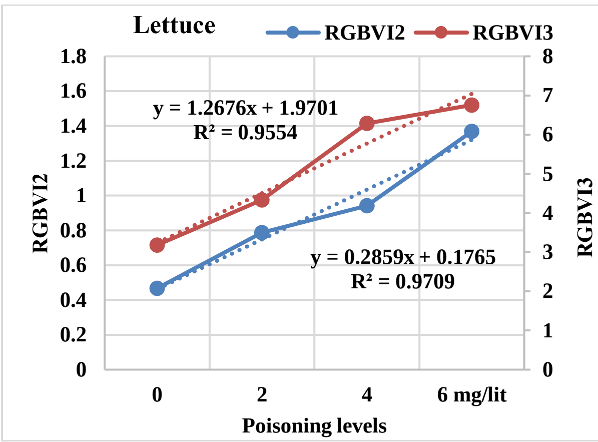

Fig. 14. The RGB-based vegetation index 2 and RGB-based vegetation index 3 with poisoning levels of lettuce crop
Source: Authors' determination.

Figure 15 with the levels of poisoning (0, 2, 4, and 6 mg/lit) showed the maximum value of red and green bands which were 123. and 84, and also showed the minimum value for the same indices which were 104 and63. Linear regression analysis was performed on the equations to predict the monitoring red and green band at different poisoning levels. The following equation represents the relationship.

Red band: $y = 6.5x + 98.5$ $R^2 = 0.9657$

Green band: $y = 6.79x + 55.5$ $R^2 = 0.9561$

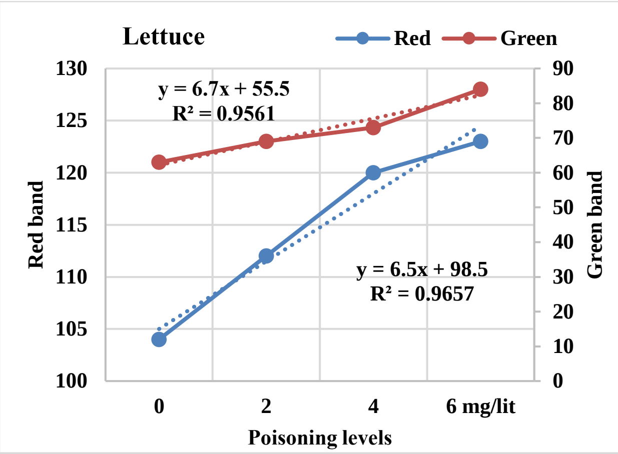

Fig. 15. The red and green band with poisoning levels of lettuce crop
Source: Authors' determination.

Figure 16 and with the levels of poisoning (0,2,4, and 6mg/lit) showed the maximum value of blue band and intensity which were 48. and 85, and also showed the minimum value for the same indices which were 34 and 67. Linear regression analysis was performed on the equations to predict the monitoring red band and intensity at different poisoning levels. The following equation represents the relationship.

Blue band: $y = 4.6x + 29$ $R^2 = 0.9888$

Intensity: $y = 5.9333x + 61$ $R^2 = 0.9982$

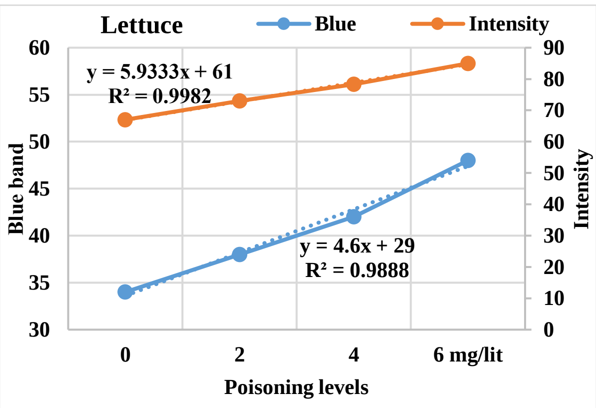

Fig. 16. The blue band and intensity color indices with poisoning levels of lettuce crop
Source: Authors' determination.

Figure 17 with the levels of poisoning (0, 2, 4, and 6 mg/lit) showed the maximum value of Hue and vegetative which were 0.71. and 0.027, and also showed the minimum value for the same indices which were 0.41 and 0.024. Linear regression analysis was performed on the equations to predict the monitoring Hue and vegetative at different poisoning levels. The following equation represents the relationship.

Hue: $y = 0.1001x + 0.2937$ $R^2 = 0.9589$

Vegetative: $y = 0.0009x + 0.0244$ $R^2 = 0.9008$

Figure 18 with the levels of poisoning (0, 2, 4, and 6 mg/lit) showed the maximum value of simple red–green ratio and Green–red vegetation index which were 1.65. and 0.43, and also showed the minimum value for the same indices which were 1.6 and 0. 2.

Linear regression analysis was performed on the equations to predict the monitoring simple red–green ratio and Green–red vegetation index at different poisoning levels (Fig. 18).

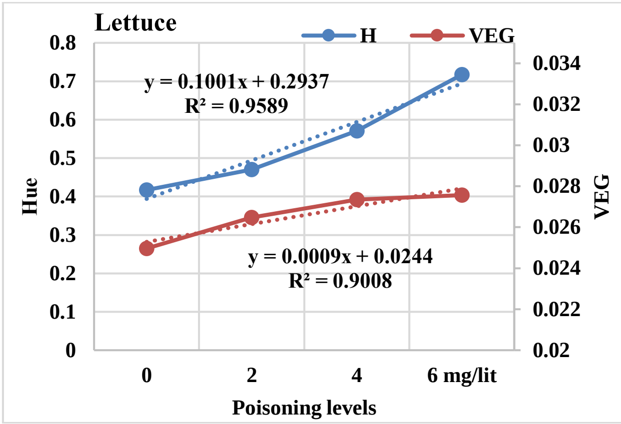

Fig. 17. The Hue and vegetative color indices with poisoning levels of lettuce crop
Source: Authors' determination.

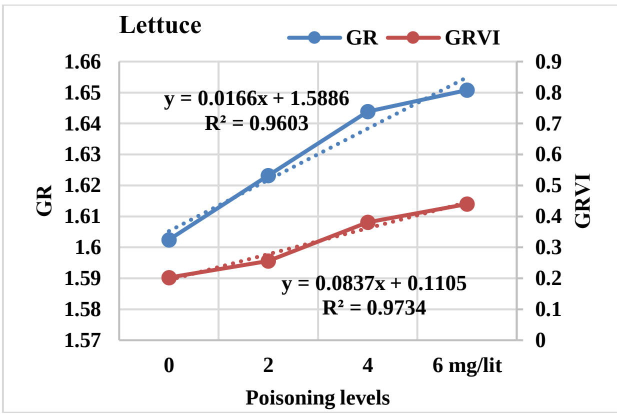

Fig. 18. The simple red–green ratio and Green–red vegetation index with poisoning levels of lettuce crop
Source: Authors' determination.

The following equation represents the relationship.
GR: y = 0.0166x +1.5886 R^2 = 0.9603
GRVI: y = 0.0837x +0.1105 R^2 = 0.9734
(Fig. 18).

Figure 19 with the levels of poisoning (0,2,4, and 6mg/lit) showed the maximum value of simple blue–green ratio and visible atmospherically resistant index which were 0.57. and 0.43, and also showed the minimum value for the same indices which were 0.53 and 0.28.

Linear regression analysis was performed on the equations to predict the monitoring simple blue–green ratio and visible atmospherically resistant index at different poisoning levels.
The following equation represents the relationship.
BGI2: y = 0.0128x +0.5274 R^2 = 0.9447
VARI: y = 0.0536x +0.2064 R^2 = 0.9039

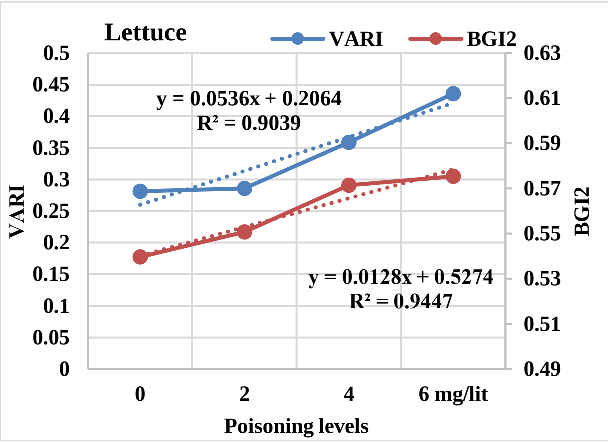

Fig. 19. The simple blue–green ratio and visible atmospherically resistant index with poisoning levels of lettuce crop
Source: Authors' determination.

Figure 20 with the levels of poisoning (0, 2, 4, and 6 mg/lit) showed the maximum value of green leaf and normalized green-blue difference index which were 0.05. and 0.52, and also showed the minimum value for the same indices which were 0.02 and 0.2. Linear regression analysis was performed on the equations to predict the monitoring green leaf and normalized green-blue difference index at different poisoning levels.
The following equation represents the relationship.
GLI: y = 0.0099x +0.0122 R^2 = 0.9998
NGBDI: y = 0.1107x +0.0651 R^2 = 0.9536

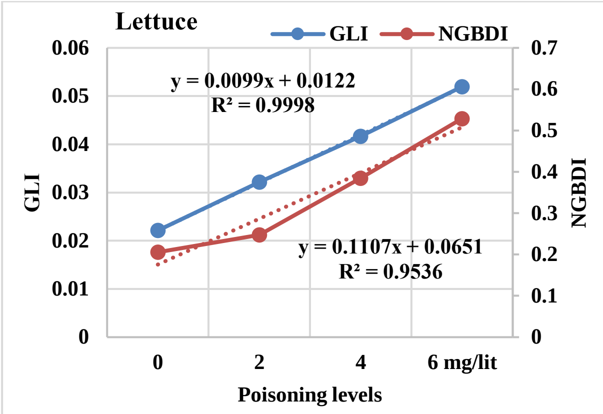

Fig. 20. The simple green leaf and normalized green-blue difference index with poisoning levels of lettuce crop
Source: Authors' determination.

Figure 21 with the levels of poisoning (0, 2, 4, and 6 mg/lit) showed the maximum value of RGB-based vegetation index 2 and RGB-based vegetation index 3 which were 1.36. and 6.7, and also showed the minimum value for the same indices which were 0.46 and 3.1.
Linear regression analysis was performed on the equations to predict the monitoring RGB-based vegetation index 2 and RGB-based vegetation index 3 at different poisoning levels.
The following equation represents the relationship.
RGBVI2: y = 0.2859x +0.1765 R^2 = 0.9709
RGBVI3: y = 1.2676x +1.9701 R^2 = 0.9554

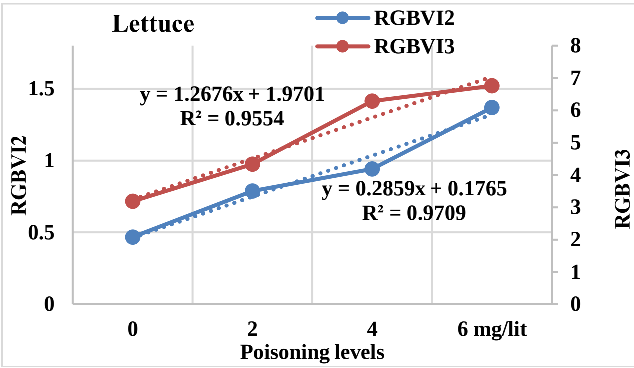

Fig. 21. The RGB-based vegetation index 2 and RGB-based vegetation index 3 with poisoning levels of lettuce crop
Source: Authors' determination.

CONCLUSIONS

The study showed the correlation between RGB color indices and lead concentration in leafy plants. To distinguish heavy metal pollution and its effect on vegetative characteristics, for plants, the results showed that with toxicity levels. Linear regression analysis was performed on the equations to predict the monitoring Hue and vegetative and simple red–green ratio and Green–red vegetation index The red, green, blue band and intensity. The simple blue–green ratio addition to visible atmospherically resistant index simple green leaf and normalized green-blue difference index The RGB-based vegetation index 2 and RGB-based vegetation index 3 at different poisoning levels. The existence of a strong relationship between them and contains a high coefficient of determination

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FINITE ELEMENT ANALYSIS AND TOPOLOGY OPTIMIZATION OF FABA BEAN METERING PLATES

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Abstract

The main objective of this research study is the use of 3D printing to manufacture of a metering plates with different materials and slots shapes for the planting of faba beans. Also, testing the manufactured metering plates by the finite element, fatigue, and topology optimization. Metering plates were designed and tested at department of agriculture engineering, faculty of agriculture, Tanta university, Egypt. through 2022.the maximum values of finite element indices such as von mesies, yield strength, INT (stress intensity), TRI (triaxle stress), ERR (energy norm error), static displacements, RFRES (resultant reaction force), ESTRN (equivalent strain), SEDENS (strain energy density), and ENERGY (total strain energy) were (9.72e+05, 4.04e+06, 8.53e+05, 3.87e+06, 1.00e-16, 1.58e-02, 3.40e-02, 1.52e-4, 8.27e+01, and 4.72e-07) respectively. Also, the minimum values for same indices were (2.54e+04, 7.89e+05, 1.33e+04, 4.71e+03, 1.00e-16, 2.84e-5, 9.19e-03, 1.04e07, 5.06e-07, and 7.88e-08) respectively, with different shapes index of first, second, third, and fourth metering plates were (1.76, 1.78, 3.01, and 1.65) respectively. And for fatigue analysis results, damage, load factor, total cycles, and stress amplitude were (3.36e+05, 5.32e+06, 1.39e+06, and 1.60e+00) respectively. Also, the minimum values for same indices were (2.92e+00, 2.26e-07, 2,21e+04, and 8.26e+00) respectively. And for topology optimization analysis results, the maximum values of topology optimization indices such as best stiffness, and displacement were (4.82e-02, and 3.90e-10) respectively. Also, the minimum values for same indices were (7.97e-2, and 2.61e-06) respectively, and the maximum efficiency of the metering plate was 98% for the first metering plate with TPU material.

Key words*: *Faba Bean, 3D printing, Finite Element Analysis, Fatigue Analysis, Topology Optimization

INTRODUCTION

The faba bean (*Vicia faba* L.) is an important legume crop in North and East Africa, particularly in Arabia. The faba bean plays an important role in Egypt as a low-cost food with great nutritional value, notably in terms of protein content, which ranges from % to 38% [1].

The world population is growing over time, and by 2050 it is expected to reach 13 billion people therefore the request for faba bean as a replacement for animal proteins as well as food and nutritional security has increased over the next 10 years [12].

Machine design is the production of new and improved machinery as well as the improvement of existing ones. A new or improved machine is one that is more cost effective in terms of output and operation. The design process is lengthy and time-consuming. Many topics are required to design a machine component, including mathematics, mechanical engineering, material strength, workshop procedures, and engineering drawing [4].

Alexander Paul Hrennikoff developed the field structural framework method for stress analysis and its application to two fields of elasticity in the 1940s. The method is essentially an arithmetic procedure that can be applied to a problem involving a rectangular plate by the two-dimensional stress and strain situation in a bent plate. The framework method's most essential feature is that it may be utilised to solve a wide range of unsolvable elastic problems. The finite element approach is credited with establishing the framework for this technology [3].

Finite element method (FEM) is a numerical technique used for solving complex engineering and mathematical problems by dividing them into smaller, more manageable subdomains or elements. These elements are interconnected at specific points called nodes, and by applying mathematical equations to each element and their interactions, FEM approximates and solves the behavior of the entire system [2].

the finite element approach is the most stable numerical scheme; it is the most commonly employed method. The computational domain is initially divided into tiny parts for this procedure. For each element, a so-called localized support function is built, which is a function that is specified just within that element [14].

Three-dimensional finite element analysis represents the geometry more realistically. [6].

The advantages of FEM include the broad availability of research codes, as well as the method's ability to provide a physically correct representation of most problem geometries [10].

Topology optimization is a powerful technique used in engineering and design to optimize the shape and distribution of material within a given design space, with the objective of achieving desired performance criteria while minimizing mass and maximizing structural efficiency. By exploring and analyzing various design alternatives, topology optimization allows engineers to push the boundaries of conventional design practices, resulting in lighter and more efficient structures that meet safety requirements. The goal here is to design a lighter and more efficient hanging apparatus [8].

Additive manufacturing techniques create parts by the deposition of successive layers which helps engineers overcome the limits of traditional manufacturing techniques and gives them the freedom to design complex parts. The association of additive manufacturing and topology optimization allows us to take full advantage of these manufacturing techniques. It became the most widely used structural design technique in agriculture to optimize weight and improve the mechanical properties of planting machines. The structures obtained by topology optimization are characterized by complex geometry, which makes their manufacture difficult by conventional manufacturing techniques [5].

If fatigue resistance is chosen as the performance criterion for determining network efficacy, the following criteria The technique and set criteria used to analyze test findings can have a considerable impact on the stiffness reduction criterion [9].

topology optimization is advantageous for manufacturers, as it determines the optimal material distribution in a design space based on required loads. Nowadays, topology optimization extends its applications to simulations in other technical fields [11]

The fundamental purpose of fatigue analysis is to determine how materials and structures decay, crack, or fail when subjected to recurrent loading from variables such as vibration, heat cycling, or fluctuating mechanical forces. Stress Analysis, S-N Curve, Load History, and Fatigue Life Prediction are all important components of fatigue analysis [16].

Digital manufacturing technology, often known as 3D printing or additive manufacturing, uses a continual addition of materials to build actual items from geometric representations. 3D printing is a relatively new technology. 3D printing is now widely utilized all around the world. Also,3D printing technology has transformed the way to think about production and design, allowing to creation of complicated geometries and fine features that would be hard to produce using traditional manufacturing processes. 3D printing is a more environmentally friendly and sustainable method of generating models and prototypes [15].

3D printing has the potential to revolutionize manufacturing and product development by opening up new design, customization, and efficiency opportunities. Its uses are expanding as the technology advances and becomes more widely available [7].

Several sets of metering plates are used in precision planters, each having orifices tailored to the size of the seed to be planted. Several variables contribute to keeping the space between seeds planted in a row

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constant. The spacing between the seeds is supposed to be consistent during the design phase, although this may vary based on the degree of tillage, sowing characteristics, and, most importantly, the physical features of the seeds [13].

In this context, the purpose of the research is to use 3D printing to manufacture metering plates with different materials and slots shapes for the planting of faba beans. Also, to test the manufactured metering plates by the finite element, fatigue, and topology optimization.

MATERIALS AND METHODS

The metering plates were designed and simulated by Solidworks software at the Agricultural Engineering Department, Faculty of Agriculture, Tanta University. The metering plates were manufactured by using 3D printing technology with different materials in Tanta Motors AbouFreikha factory, Tanta, Egypt

Faba bean metering plates

The faba bean metering plates were designed by using Solidworks software with four different shapes and printed with five different materials (ABS+, TPU, NYLON, PTFE, and Ertalon) as shown in Figures 1 and 2.

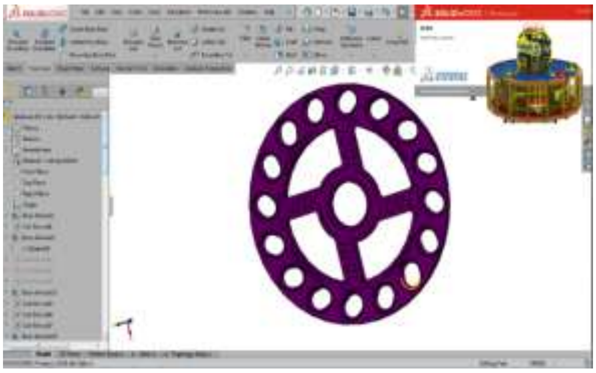

Fig. 1. The Interface of Solidworks Software
Source: Authors' determination.

3D Printer machine

A 3D printer or fused filament fabrication, is an additive manufacturing (AM) technology that involves pushing thermoplastic material through a heated nozzle to build objects layer by layer. The machine was of the type (Creality-CR 10) was used to print metering plates as shown in Figure 3. 3D printer mostly consists of the following components, Printing Bed, Extruder, Moving Parts, Touch Screen, Hot Ends, and Filament.

Fig. 2. Faba Bean Metering Plates
Source: Authors' determination.

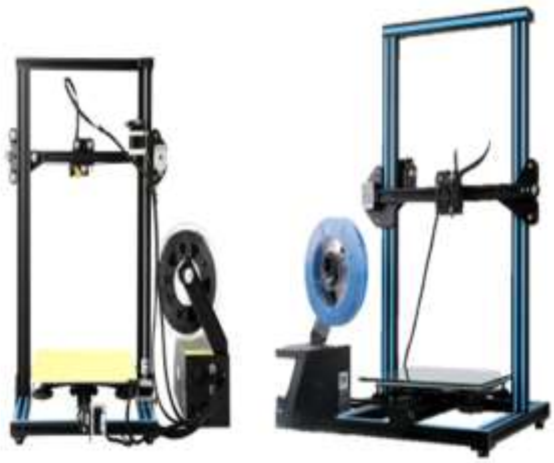

Fig. 3. 3D printer (Creality-CR 10)
Source: Authors' determination.

Finite Element Analysis

Using Solidworks simulation to measure the finite element indicators such as von mises stress, yield strength, INT (stress intensity), TRI (triaxle stress), ERR (energy norm error), static displacements, RFRES (resultant reaction force), ESTRN (equivalent strain), SEDENS (strain energy density), and ENERGY (total strain energy) of faba bean metering plates as shown in Figure 4.

- Von Mises, MPa

$$\text{V.Mises}=\left\{\frac{[(\sigma 1-\sigma 2)^2+(\sigma 2-\sigma 3)^2+(\sigma 1-\sigma 3)^2]}{2}\right\}^{\frac{1}{2}}$$

-Yield Strength, MPa

$$\textbf{Yield Strength}=\frac{\text{Stress at Yield}}{\text{Original Cross}-\text{Sectional Area}}$$

-INT (stress intensity), N/m^2

INT=σ∗sqrt(pi∗a)

- ERR (energy norm error)

ERR=$\sqrt{\frac{\Sigma e \Sigma \Omega e(\nabla uh-\nabla u)^2}{\Sigma e \Sigma \Omega e(\nabla u)^2}}$

-RFRES (resultant reaction force), N

RFRES=$\sum_{i=1}^{n} Ri$

-Equivalent strain

ESTRN=2[$\frac{(\varepsilon 1+\varepsilon 2)}{3}]^{\frac{1}{2}}$

ε1 =0.5[$(EPSX-\varepsilon^*)2+(EPSY-\varepsilon^*)2+(EPSZ-\varepsilon^*)2$

ε2 =$\frac{[(GMXY)2 + (GMXZ)2 + (GMYZ)2]}{4}$

ε* =$\frac{(EPSX + EPSY + EPSZ)}{3}$

-URES

URES=$\sqrt{X^2+Y^2}$

-SEDENS (strain energy density), Nm/m^3

SEDENS =0.5$\sigma * \epsilon$

-ENERGY (total strain energy), N.m

ENERGY=$\int V * 0.5\sigma ij * \epsilon ij \; dV$

where:

- ε 1, ε 2, and ε 3 =Normal strain in the first, second, and third principal direction.

-EPSX, EPSY, and EPSZ= Normal strain in the X.Y.Z -direction of the selected reference geometry.

-GMXY, GMXZ, and GMYZ= Shear strain in the Y, Z direction in the YZ- XZ plane of the selected reference geometry.

- $\sigma 1 \backslash \sigma 2 \backslash \sigma 3$=principal stresses. X=is the first direction that the object is traveling. Y=the second direction that the object is traveling.

-σ = the applied stress

- a = the length of the crack or the distance from the center of the crack to the point of interest.

- $e =$ represents each element in the computational domain.

-Ωe= is the domain of each element.

- ∇uh = represents the numerical solution (approximation) obtained by the finite element method.

-u= represents the exact or reference solution.

- Ri = represents the reaction forces at each support point or node in the direction of interest.

-n= is the total number of support points or nodes that provide reactions in that direction.

- σ =is the applied stress.

-ϵ =is the corresponding strain (deformation) that results from the applied stress.

-σij =represents the components of the stress tensor.

- ϵij= represents the components of the strain tensor.

-V = is the volume of the deformable body.

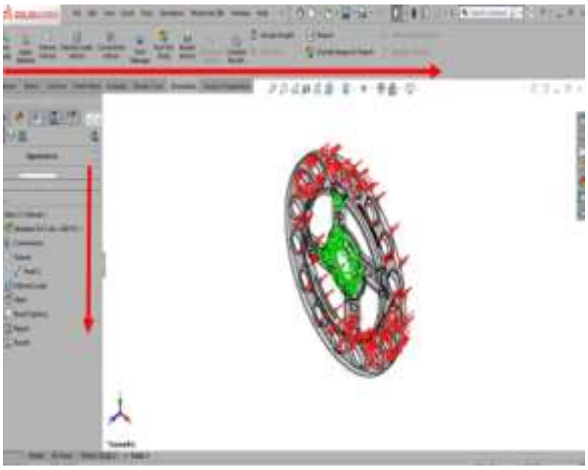

Fig. 4. Finite Element Analysis of Faba Bean Metering Plate
Source: Authors' determination.

Fatigue Analysis

Using Solidworks simulation to measure the fatigue indicators such as damage, total life cycles, loaf factor, and stress amplitude. as shown in Figure 5.

-Damage

Damage=$\frac{n1}{N1}+\frac{n1}{N1}+\frac{n1}{N1}+\frac{n1}{N1} \dots \dots \frac{ni}{Ni}$

-Total life cycles

Total life cycles =$(\frac{Se}{\sigma a})^b$

-Load factor

Load factor=$\frac{\text{Load Design Value}}{\text{Load Calculation Value}}$

-Stress amplitude, Mpa

Stress amplitude=σa=$\frac{\sigma \; max-\sigma \; min}{2}$

where:

-n1,n2,n3,…,ni = the number of cycles experienced at various stress levels or load amplitudes during the life of the component.

-N1,N2,N3,…,Ni = the fatigue life or endurance limits corresponding to those stress levels or load amplitudes.

-Se = the endurance limit (also known as the fatigue strength or fatigue limit) of the material, representing the stress level below which the material can endure an infinite number of cycles without failure.

-σa = the stress amplitude, which is the difference between the maximum and minimum stress levels in a loading cycle.
-b=the fatigue exponent, which is a material property determined from experimental data.
- σmax = the maximum stress experienced during a loading cycle.
- σmin = the minimum stress experienced during the same loading cycle.

Fig. 5. Fatigue Analysis of Faba Bean Metering Plate
Source: Authors' determination.

Topology Optimization Analysis

Using Solidworks simulation to measure the best stiffness, and displacement as shown in Figure 6.

-Best stiffness

-Best stiffness = E·ϵ
where:
E=Young's Modulus or Elastic Modulus, and
ϵ =represents the strain experienced by the material

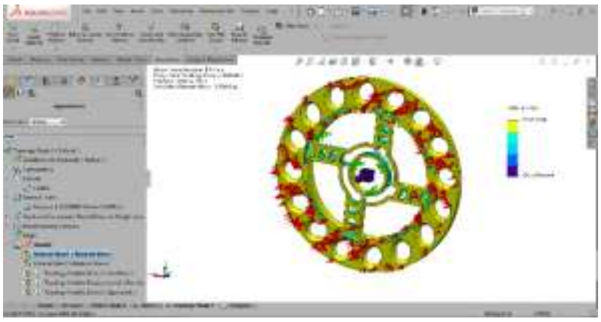

Fig. 6. Topology Optimization Analysis of Faba Bean Metering Plate
Source: Authors' determination.

Metering plates efficiency

$$\text{Metering plate efficiency, \%} = \frac{Number\ of\ output\ seeds}{Number\ of\ total\ seeds} x100$$

$$\text{Seed damage , \%} = \frac{Number\ of\ \ damaged\ seeds}{Number\ of\ total\ seeds} x100$$

RESULTS AND DISCUSSIONS

Finite Element Analysis

Figure 7 to Figure 11 showed the maximum values of finite element indices such as von mesies, yield strength, INT (stress intensity), TRI (triaxle stress), ERR (energy norm error), static displacements, RFRES (resultant reaction force), ESTRN (equivalent strain), SEDENS (strain energy density), and ENERGY (total strain energy) were ($9.72e^{+05}$, $4.04e^{+06}$, $8.53e^{+05}$, $3.87e^{+06}$, $1.00e^{-16}$, $1.58e^{-02}$, $3.40e^{-02}$, $1.52e^{-4}$, $8.27e^{+01}$, and $4.72e^{-07}$) respectively. Also, the minimum values for same indices were ($2.54e^{+04}$, $7.89e^{+05}$, $1.33e^{+04}$, $4.71e^{+03}$, $1.00e^{-16}$, $2.84e^{-5}$, $9.19e^{-03}$, $1.04e^{-07}$, $5.06e^{-07}$, and $7.88e^{-08}$) respectively, with different shapes index of first, second, third, and fourth metering plates were (1.76, 1.78, 3.01, and 1.65) respectively.

Fatigue Analysis

indices such as damage, load factor, total cycles, and stress amplitude were ($3.36e^{+05}$, $5.32e^{+06}$, $1.39e^{+06}$, and $1.60e^{+00}$) respectively. Also, the minimum values for same indices were ($2.92e^{+00}$, $2.26e^{-07}$, $2,21e^{+04}$, and $8.26e^{+00}$) respectively, with different shapes index of first, second, third, and fourth metering plates were (1.76, 1.78, 3.01, and 1.65) respectively as shown in Figure (12) and Figure (13).

Fatigue Analysis

indices such as damage, load factor, total cycles, and stress amplitude were ($3.36e^{+05}$, $5.32e^{+06}$, $1.39e^{+06}$, and $1.60e^{+00}$) respectively. Also, the minimum values for same indices were ($2.92e^{+00}$, $2.26e^{-07}$, $2,21e^{+04}$, and $8.26e^{+00}$) respectively, with different shapes index of first, second, third, and fourth metering plates were (1.76, 1.78, 3.01, and 1.65) respectively as shown in Figure 12 and Figure 13.

Topology Optimization Analysis

Figure 14 showed the maximum values of topology optimization indices such as best stiffness, and displacement were ($4.82e^{-02}$, and $3.90e^{-10}$) respectively. Also, the minimum values for same indices were ($7.97e^{-2}$, and $2.61e^{-06}$) respectively, with different shapes index of first, second, third, and fourth metering plates were (1.76, 1.78, 3.01, and 1.65) respectively.

Metering plates efficiency

Figure 15 showed the maximum value of the metering plate efficiency was 98% for the first metering plate with TPU material and a shape index of 1.76 while the minimum value of seed damage was 1% for the same metering plate and shape index with Nylon material.

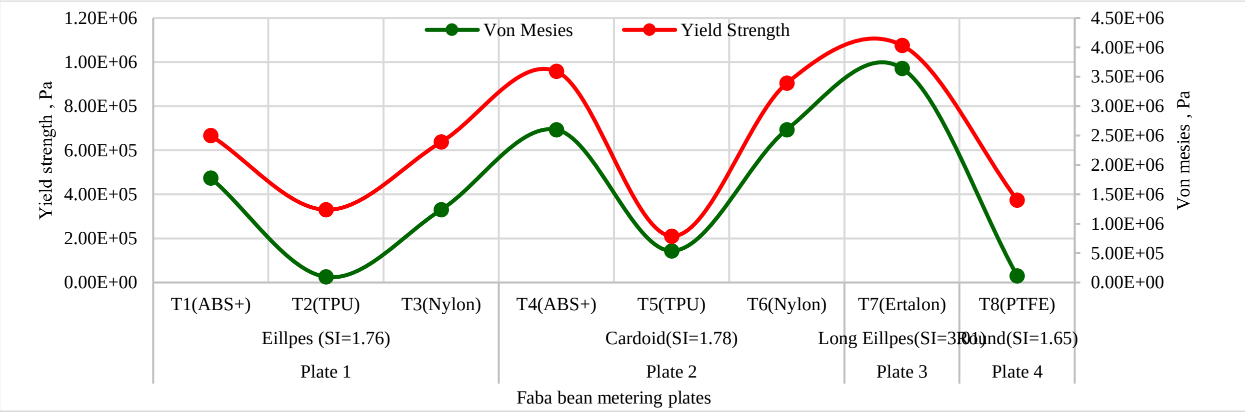

Fig. 7. Von Mesies and Yield Strength at Different Parameters of Faba Bean Metering Plates
Source: Authors' determination.

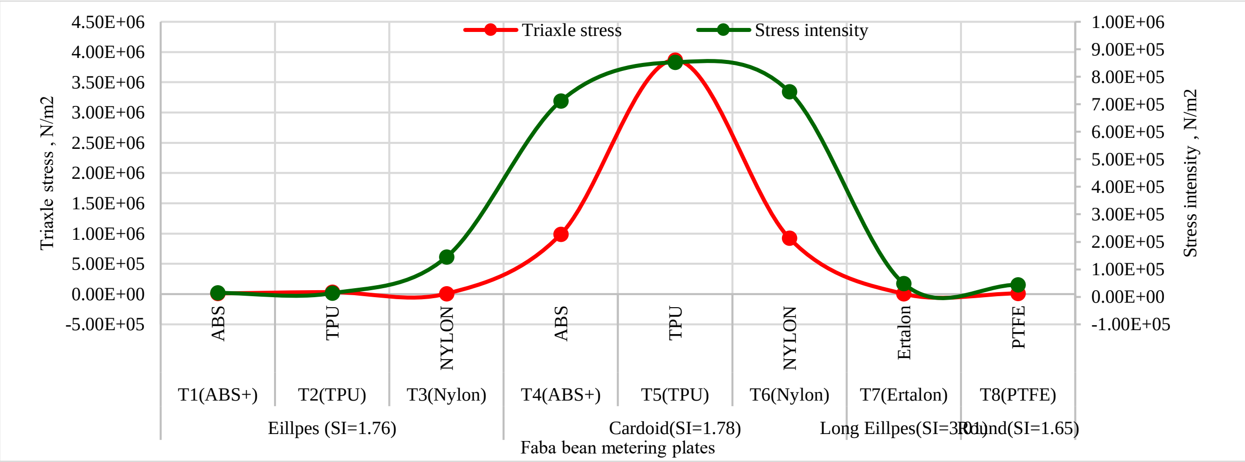

Fig. 8. Triaxle Stress and Stress Intensity at Different Parameters of Faba Bean Metering Plates
Source: Authors' determination.

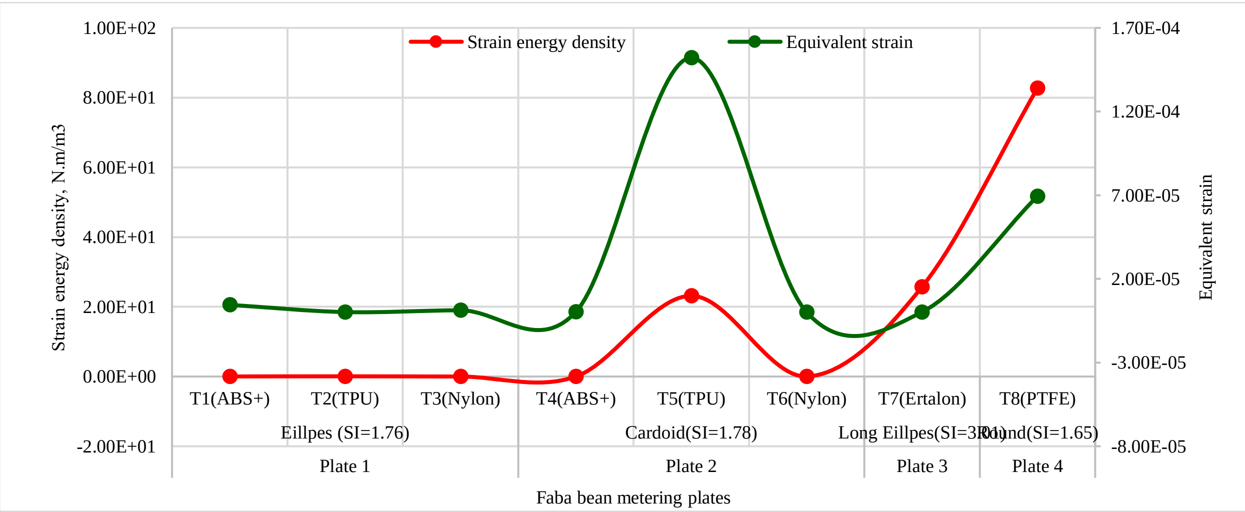

Fig. 9. Strain Energy Density and Equivalent Strain at Different Parameters of Faba Bean Metering Plates
Source: Authors' determination.

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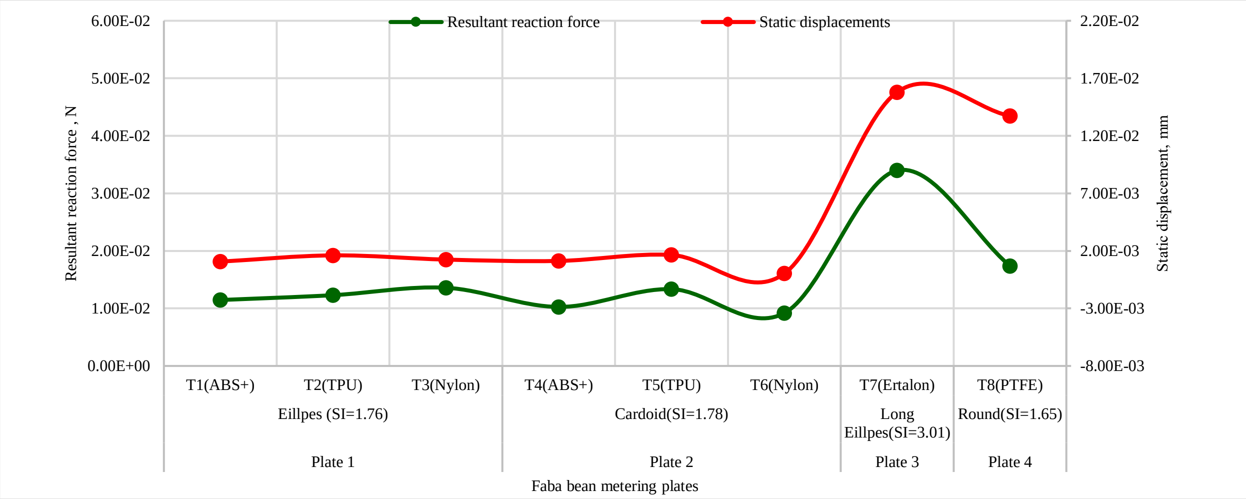

Fig. 10. Resultant Reaction Force and Static Displacement at Different Parameters of Faba Bean Metering Plates
Source: Authors' determination.

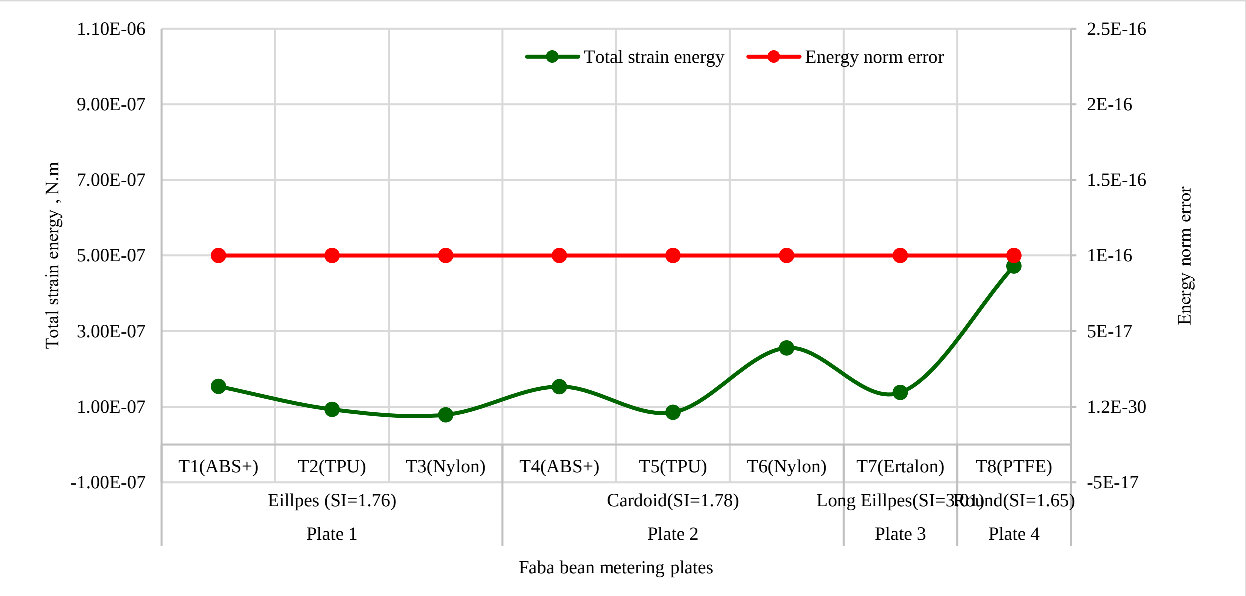

Fig. 11. Total Strain Energy and Energy Norm Error at Different Parameters of Faba Bean Metering Plates
Source: Authors' determination.

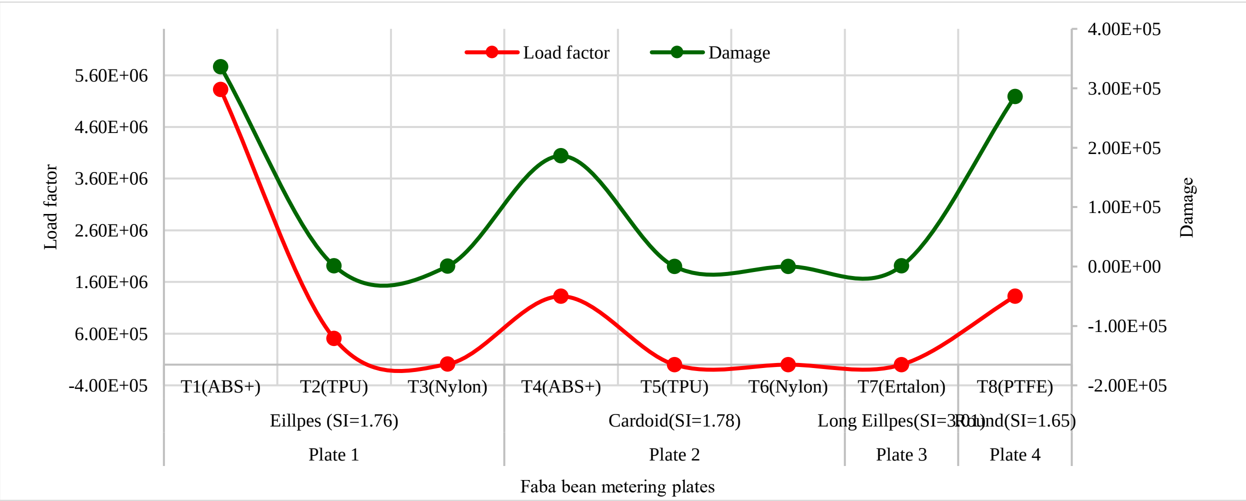

Fig. 12. Load Factor and Damage at Different Parameters of Faba Bean Metering Plates
Source: Authors' determination.

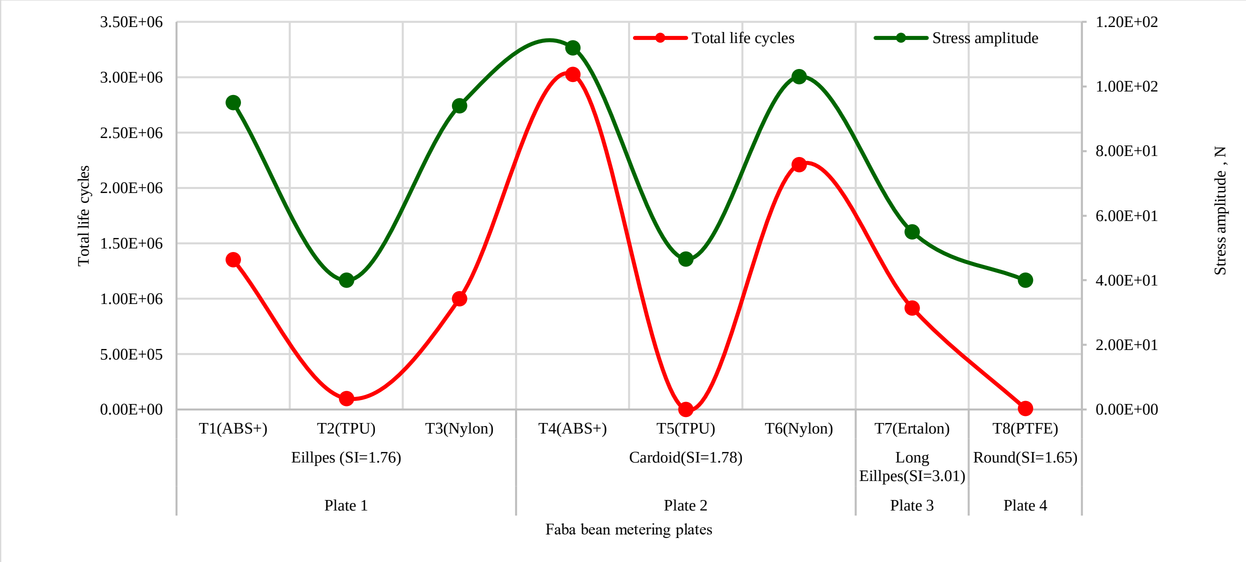

Fig. 13. Total Life Cycles and Stress Amplitude at Different Parameters of Faba Bean Metering Plates
Source: Authors' determination.

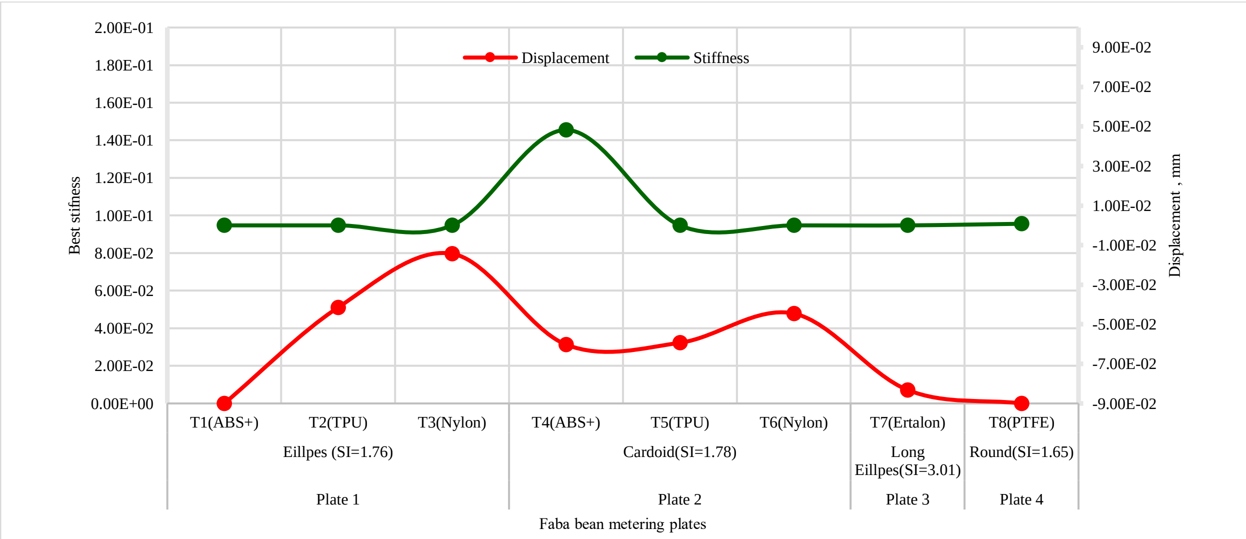

Fig. 14. Best Stiffness and Displacement at Different parameters of Faba Bean Metering Plates
Source: Authors' determination.

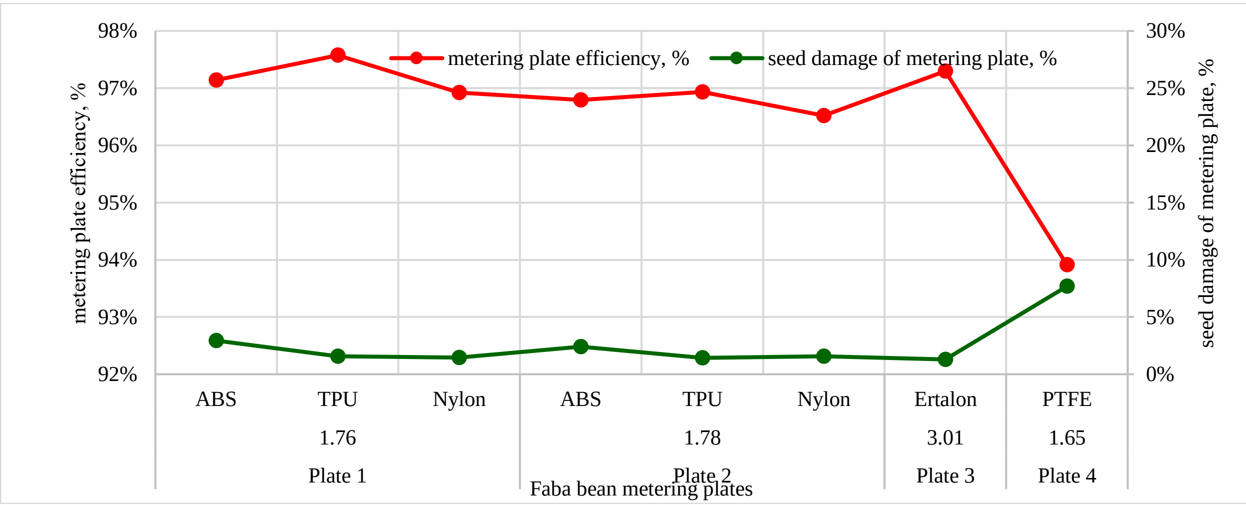

Fig. 15. Metering plate efficiency and seed damage of metering plate at different metering plates
Source: Authors' determination.

CONCLUSIONS

The study showed the plate with "TPU" material will not fail under the given stresses as the maximum stresses are much lower than the yield strength of the plate material will not carry out any significant deformations according to the loading conditions applied. Also give the maximum value of the metering plate efficiency for the same plate.

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USING HEATING AND VACUUM AS A NEW SYSTEM TO ACHIEVE SHORT COOKING TIME FOR PRODUCING BLACK HONEY

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Abstract

The experiments were conducted at Agricultural Engineering Department Laboratory, Faculty of Agriculture Al-Azhar University, Assiut Governorate during 29th of July to 15th of November 2022, in order to develop and manufacture a small unit for producing high quality black honey depends on heating and vacuum system. Also, to determine the optimum treatment forsafe method taken into consideration the environmental impact and evaluate changes in black honeyquality during cooking. This unit consisting of pan vessel, heater, compressor, condenser, rectifier, vessel receiver oil and smart control system.The experimental treatments for black honey cooking unit were tested on three heating temperatures different at 200, 350 and 500 °C and four vacuum levels at 150, 300, 450 and 600 mbar and atmospheric pressure.The results shows a decreasing of cooking time at vacuum pressure less than from atmospheric pressure. At vacuum pressure samples, cooking time ranged from 30 to 172 minutes. The highest cooking time was (177, 77and 40 minutes) recorded with atmospheric pressure at different heating temperatures (200, 350 and 500ºC), respectively. The lowest cooking time was (155, 64and 30 minutes) recorded with vacuum pressure (-600 mbar) with different heating temperature (200, 350 and 500ºC), respectively. The data shows an increasing of evaporation rate of water from sugar cane juice at vacuum pressure more than from atmospheric pressure. At vacuum pressure samples, evaporation rate ranged from 4.53to 26 gH_2O/min. The lowest evaporation rate was (4.41, 10.13 and 19.50 gH_2O/min) recorded with atmospheric pressure at different heating temperatures (200, 350 and 500ºC), respectively. The highest evaporation rate was (5.03, 12.19 and 26 gH_2O/min) recorded with vacuum pressure (-600 mbar) with different heating temperature (200, 350 and 500ºC), respectively.

Key words: *black honey, cooking, heating and vacuum system*.

INTRODUCTION

Black honey or sugarcane honey is one of the healthy natural sweeteners, unlike sugar and artificial sweeteners such as saccharin and aspartame, which do not contain any useful substances and may cause some problems for people with sensitive bodies. Sugarcane honey is in great demand in the natural food market because it retains nutrients from cane juice, such as iron, phosphorus, magnesium, calcium, potassium, and chlorine [12].
reported thatsugarcane is the cheapest source of energy because it contains fructose and glucose. and an excellent source of iron, as filtered sugarcane juice contains [8].
Honey is a carbohydrate which is constituted mainly of inverted sugars and sucrose and light brown color, it is due to the concentration of sweet substances of sugar cane juice. Sucrose hydrolysis in inverted sugar is gotten by the action of an acid to high temperatures or by enzymes. The sucrose inversion of sugar cane juice starts at 80°C. It is evident at 100°C and it depends on factors such as pH, temperature, and boiling duration. The final concentration gets hydrolyzed honey, it influences the yield and consequently the productivity and profit. The lower time it takes, the better results, the more productive is the process. In order to obtain honey cane or molasses is necessary to incorporate citric acid from 100 to 110 °C and from 103 to 106 °C (65 to 75 °brix) in this way is possible to obtain the final concentration [5].
To produce honey, sugar cane juice extraction, cleaning and clarification, hydrolysis and evaporation, final concentration and bottled. All stages in the

process are important for the quality of the final product. Natural clarification stages, concentration and juices concentration, pH factors, temperature and time of the process have an impact in the production, since quality characteristics, as well as viscosity, turbidity, brightness, color, flavor and odor, stability andabsence of crystals in the product are demonstrated. Alsostated that cane honey until its final concentration gets temperatures higher than 105°C, it is rich in inverted sugar and minerals, easy to use and especially harmless (healthy and safe food) since it is bottled in hot and due to its nature, air-tight containers are used [11].

Therow black honey is obtained by crushing, squeezing and sieving sugar cane. Juice is then clarified evaporated and concentrated by heating and then cooled to be a black honey. Solids remained after crushing, squeezing and sieving sugar cane are bagasse. In a black honey processing units solid raw bagasse is sun dried and usually used as a fuel for combustion process. Juice concentration process is performed in black honey ovens is longitudinal oven of length, width and height of about 13 x 5 x 4 m built of bricks 40 cm thickness of thermal conductivity 0.2 W/m.^{o}K, has one or two production lines, each line has three or four pans for molasses concentration process [8].

Sugarcane honey is the syrupy liquid obtained by evaporation of the sugarcane juice, concentrated until it reaches solids content between 65 and 75%. The necessary temperature to achieve the solids content is 105-110°C [1].

Concentration at normal atmospheric pressure, so it is better concentration under vacuum pressure. Non good peeling sugar cane sticks, resulting in a dark color of honey. Finding some foaming material and impurities,so good filtering must be done to remove it. Use of red copper in the concentrate metal causes darkening of the color, so it is better use stainless steel or aluminium [3].

Some honey producers used raw bagasse as fuel in private manufacturing plants of moisture content ranged between 12 to 35 % wet basis, bulk density ranged between 70 to 100 kg/m^3 and particle size ranged between 10 to 50 cm [7].

The combination of microwave heating and a vacuum system allows a quicker mass and energy transfer at low temperature over a short time. More water vapor is separated from the product using a vacuum microwave evaporation (VME) system, working at suitable power and vacuum levels, due to the rapid heating of the product [2].

Compared the vacuum microwave evaporator (VME), rotary evaporator (RE) and rising film evaporator (RFE). The results show that the evaporation rate of (VME) was three times higher than that of (RE) and was two times higher than that of (RFE) [4].

Ohmic vacuum concentration treatment enabled rapid heating to the concentration temperature because heat loss was minimized under the vacuum. In addition, the OVC treatment required less energy input for moisture evaporation at lower boiling temperatures. The required amount of heat energy to boil the liquid decreases, and subsequently, the heating time a decreases when the boiling point of the liquid decreases under vacuum [6].

The higher voltage gradients in the ohmic vacuum concentration (OVC) will save the concentration time with more internal energy generation. Moisture was evaporated at a lower temperature of 66^{o}C during OVC compared to 100^{o}C during ohmic atmospheric concentration (OAC) because the boiling point of water decreases under a vacuum. OVC treatment reduced the concentration time compared to OAC treatment [10].

The potential of ohmic vacuum concentration to produce value-added fruit juice concentrates. Efficacy of ohmic vacuum concentration (OVC) was evaluated for the production of value-added orange juice concentrate under different voltage gradients. OVC enables the evaporation of moisture in fruit juice at low temperatures under a vacuum. During OVC treatment, orange juice extract was ohmically heated to 66^{o}C using different voltage gradients (15, 20, 25, and 30 V/cm) under 27 kPa vacuum. The highest concentration of OVC was 22 min, producing 2 kg water/kg dry solid orange concentrate.

However, it took 40 min to produce the same concentration using ohmic atmospheric concentration (OAC) treatment. OVC also enabled a slower concentration time in which the orange concentrate was exposed to less thermal abuse [9].

The industry of extracting black honey in Upper Egypt is primitive, polluting the environment, consuming energy, high costs and long time, in addition to classical black honey industry have a lot of many risks which causes a polluting effect on the environment

The main objectives of this study is to use heating and vacuum as a new system to achieve short cooking time.

MATERIALS AND METHODS

Experiments were carried out through 29th of July to 15th of November 2022 at Agricultural Engineering Laboratory, Faculty of Agricultural Engineering Al-Azhar University, Assiut Governorate order to develop and manufacture a small unit for producing high quality black honey. In this study using heating and vacuum system to suitable for black honey cooking. This unit consisting of pan vessel (evaporator), heater, vacuum pump (compressor), vacuum pressure gauge, condenser, rectifier, Oil receiver and smart control system as showing in Figure 1.

The experimental treatments for black honey cooking unit were tested on three different levels of temperature at 200, 350 and 500°C, four vacuum levels at -150, -300, -450 and -600 mbar and atmospheric pressure. The measurement indices were thermal energy consumed, useful heat energy, evaporation efficiency, heat exchange efficiency, thermal loss percentage, cooking time.

A small unit for producing black honey and homogeneous cane juice were used.

The cane juice was obtained from the El Roddavillage, Malawi city, EL Minya Governorate, Upper Egypt. (45 liters for all experiments and replications).

The percentage of total solids was 20.2% and the pH value is 5.25. The quantity was mixed to be homogeneous.

NO	NAME
1	Condenser
2	Laptop
3	Pan Vessel
4	Table
5	Electric Heater
6	Arduino System
7	Compressor
8	Oil Receiver
9	Rectifier
10	Vacuum pressure gauge.
11	Platform Weighing Scale

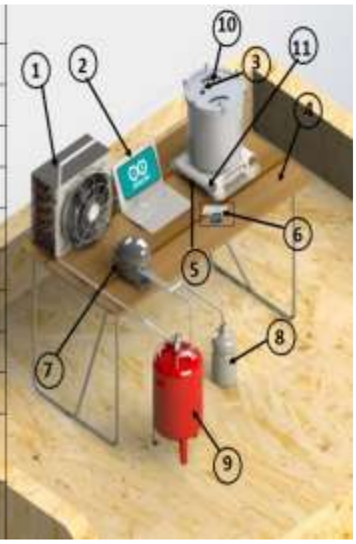

Fig. 1. Sketch of the unit producing black honey
Source: Authors' drawing.

A sample of one liter of cane juice (with a weight of 1,090 g) was taken in each replicate. Sugar cane juice was providing the best heat transfer properties, it was limited by its temperature range since can be evaporated and boils at 110-120°C at atmospheric pressure.

Unit for producing black honey (UPBH)

The heating processes were carried out by mechanisms and devices of periodic and continuous action. The system consisting of:

-Electric heater - vacuum pump
- Pan vessel (evaporator) - Oil receiver
-Condenser and fan -Smart control system
Rectifier - vacuum pressure gauge

Heating system used for heating, evaporating and concentrating sugarcane juice. The system consists of an evaporator and electric heater (Fig. 2).

Fig. 2. Photo of heating system
Source: Authors' drawing.

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Evaporator

Evaporator was used to cooking honey at different temperaturesmade from Stainless steel have thermal conductivity of 80 W/m.K, thickness was 2 mm, diameter out was 289 mm. and diameter in was 285 mm. Pan vessel volume was 19.1 liters and insulated by glass wool 0.05 m thick asshown Fig. (3), specifications of pan vessel as shown

Fig. 3. Photo of evaporator
Source: Authors' drawing.

Electric heater

The electric heater is source that supplies the evaporating vessel with latent heat to evaporate the amount of water to be removed from the sugarcane juice.

Vacuum system

Vacuum system used to remove air and water vapor from evaporator It consists of vacuum pump, condenser, rectifier, pressure gauge, tubes and oil receiver as shown in Figure 4.

Vacuum pump

Compressor: the specifications of compressor ACC Cubigel Huayi Electrolux ZEM GL90TB, HMBP 220 - 240V/1/50Hz, 1/5 HP, discharge 7.9 cm^3, motor type CSIR, oil charge 300 cm^3 and weight 8.8 kg. The vacuum pump is a device for removing non-condensable gases, so as to obtain the required vacuum in the evaporation vessel. Figure 5 shows the description of vacuum pump.

Fig. 4. Photo of vacuum system
Source: Authors' drawing.

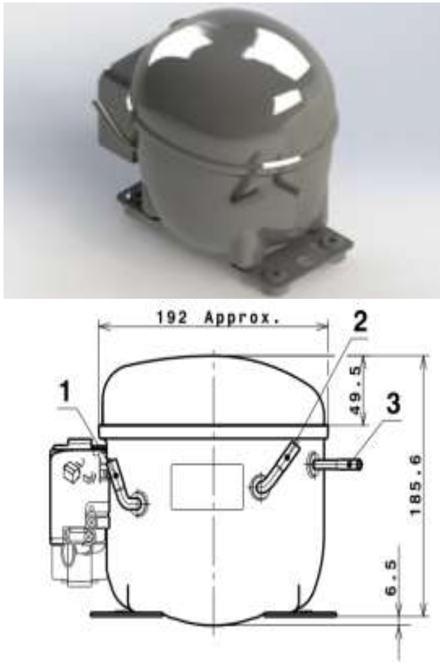

Fig. 5. Photo of vacuum pump
Source: Authors' drawing.

Fan and condenser

Condenser of type GTB 1000 air cooled condenser. Condenser used to condense vapor coming from evaporation vessel while cooking process to come out in the form of water droplets. Condenser consists of 22 tubes with 69 fins; each fin has a dimension of 250* 80*1 mm, capacity 1,000 W, with fan of 5 vane.

Water vapor in the condenser is condensed by ambient cooled air. The liquid water leaving condenser flows under gravity and vacuum pump pull to the rectifier. The condenser can be used to do such as compressors. as shown in Figure 6.

Rectifier

Iron local manufacture container use as rectifier to receipt water droplets from condenser during the honey manufacturing process. Rectifier dimensions were diameter 250 mm, height 350 mm, and volume 17.2 liters as shown in Figure 7. It contains a pressure gauge, two valves to adjust the operating pressure, and two connections in the form of the letter T for entry and exit. The rectifier was connected to the condenser outlet vacuum pump inlet.

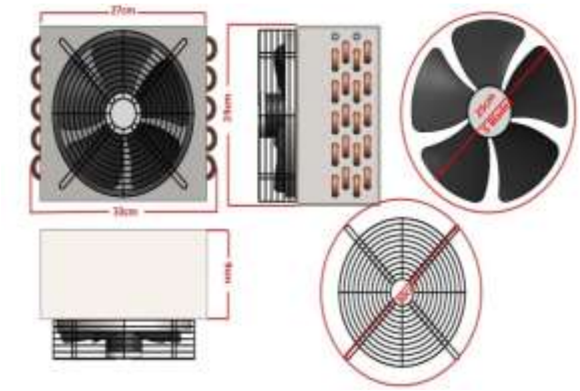

Fig. 6. Photo of fan and condenser
Source: Authors' drawing

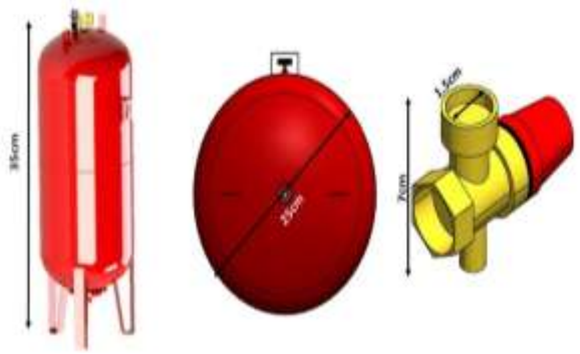

Fig. 7. Photo of rectifier
Source: Authors' drawing

Vacuum pressure gauge

Vacuum pressure gauge (mechanical pressure measuring instruments) for gauge, absolute and differential pressure have been proven millions of times over. For the optimal solution for the widest range of applications, there is a choice of measuring systems in Bourdon tube, diaphragm element and capsule element technologies. The pressure gauges cover scale ranges from 0-0.1 MPa (0-1,000 mbar) and indication accuracies of up to 0.1 %. For the various requirements in industrial and process instrumentation there are pressure elements from copper alloys, stainless steel or special materials. pressure gauges were used as showing in Figure 8.

Fig. 8. Photo of vacuum pressure gauge
Source: Authors' owns.

Oil receiver

Oil receivers presented by models from 0.5 to 2.5 liters is designed for temporary storage of unused refrigeration system oil. as showing in Figure 9.

Fig. 9. Photo of oil receiver
Source: Authors' owns.

Smart control system

Smart control system, which consists of laptop, control unit (Arduino Uno R3, two converters, two Thermocouples, relay, load cell and Amplifier

Temperature sensor

Temperature sensor connection of two thermocouples, two converters and Arduino Uno R3. as shown in Figure 10 to measure and storage the temperature for sugarcane juice every one minute during the experiment.

Fig. 10. Connection between two thermocouples with converters
Source: Authors' owns.

Weight sensor

Weight sensor connection of load cell, Amplifier and Arduino Uno R3. as shown Figure 11 to measure and storage weight of the sugarcane juice every one minute during the experiment.

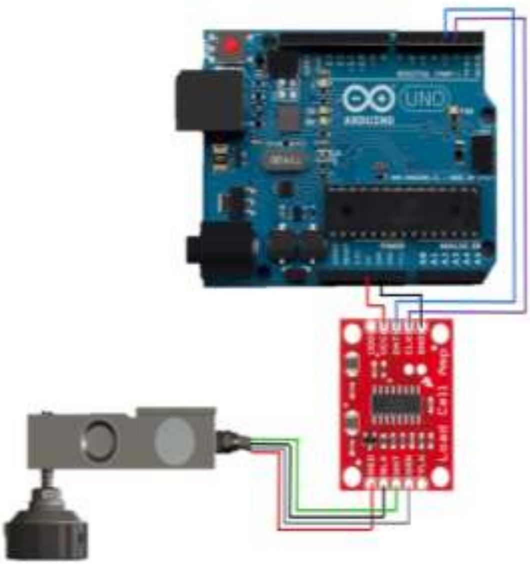

Fig. 11. Connection between load cell and amplifier
Source: Authors' owns.

Turn on/turn off the heater sensor

Turn on/turn off the heater sensor connection using a relay of one channel and Arduino Uno R3. as shown Figure 12. For turn on/turn off the heater at end of experiment.A relay was used to turn on heater when weight from sensor is greater than (14.02 kg), A relay was used to turn off heater when weight from sensor is less than (13.24 kg).

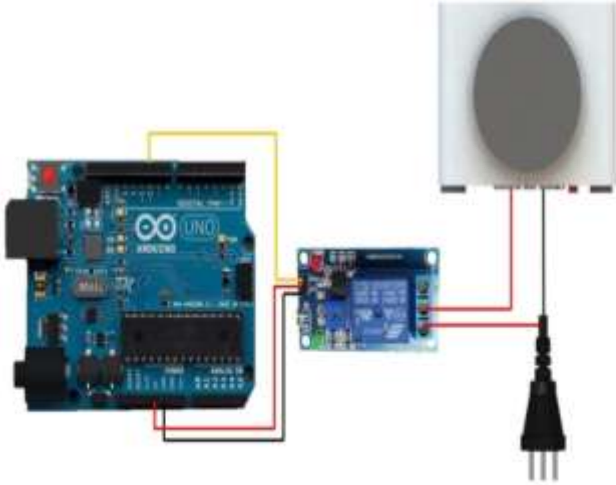

Fig. 12. Connection between relay one channel with heater
Source: Authors' owns.

RESULTS AND DISCUSSIONS

The cooking process affected by cooking time, evaporation rate, total soluble solids, mass of juice and temperature of juice.

Effect of pressures and temperature levels on cooking time

Figure 13 showed the effect of atmospheric pressure and different four levels vacuum pressures (-150, -300, -450 and -600 mbar), with three levels of heating temperature (200, 350 and 500°C) on black honey cooking time. The data shows a decreasing of cooking time at vacuum pressure less than from atmospheric pressure. At vacuum pressure samples, cooking time ranged from 30 to 172 minutes. The highest cooking time was (177, 77and 40 minutes) recorded with atmospheric pressure at different heating temperatures (200, 350 and 500°C), respectively. The lowest cooking time was (155, 64 and 30 minutes) recorded with vacuum pressure (-600 mbar) with different heating temperature (200, 350 and 500°C), respectively. The study finds a direct relationship between decrease in cooking time as a result of pressure decreasing, and inverse relationship was found between cooking time and heating temperature. At any pressure, heating temperature increasing leads to decreasing cooking time, at any heating temperature, decrease in pressure leads to decrease cooking time.

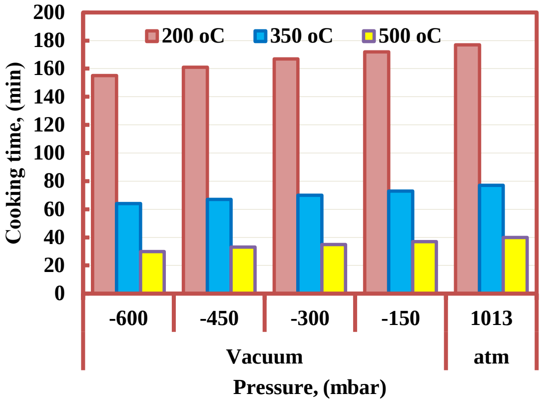

Fig. 13. Effect of pressures and temperature levels on cooking time
Source: Authors' determination.

Effect of pressures and temperature levels on evaporation rate

Figure 14 presented the effect of atmospheric pressure and different four level vacuum pressures (-150, -300, -450 and -600 mbar), with three level heating temperatures (200, 350 and 500°C) on evaporation rate of water from sugar cane juice.

The data shows an increasing of evaporation rate of water from sugar cane juice at vacuum pressure more than from atmospheric pressure. At vacuum pressure samples, evaporation rate ranged from 4.53 to 26 gH_2O/min. The lowest evaporation rate was (4.41, 10.13 and 19.50 gH_2O/min) recorded with atmospheric pressure at different heating temperature (200, 350 and 500°C), respectively. The highest evaporation rate was (5.03, 12.19 and 26 gH_2O/min) recorded with vacuum pressure (-600 mbar) with different heating temperatures (200, 350 and 500°C), respectively.

The study finds an inverse relationship between increase in evaporation rate as a result of pressure decreasing, and direct relationship was found between evaporation rate and heating temperature. At any pressure, heating temperature increasing leads to increasing evaporation rate at any heating temperature, decrease in pressure leads to increase evaporation rate.

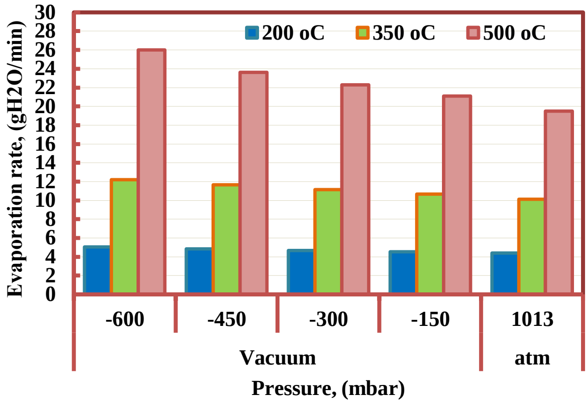

Fig. 14. Effect of pressures and temperature levels on evaporation rate.
Source: Authors' determination.

Effect of pressures and temperature levels on mass of juice

Mass of juice affected by heating temperature at 200, 350 and 500°C. with atmospheric pressure and different four levels of vacuum pressure.

Effect at a heating temperature 500°*C*

Figure 15 depicted the relationship between the mass of sugar cane juice as affected by cooking time of sugar cane juice at temperature of heating 500°C at pressures: -600, -450, -300, -150 mbar and atmospheric.

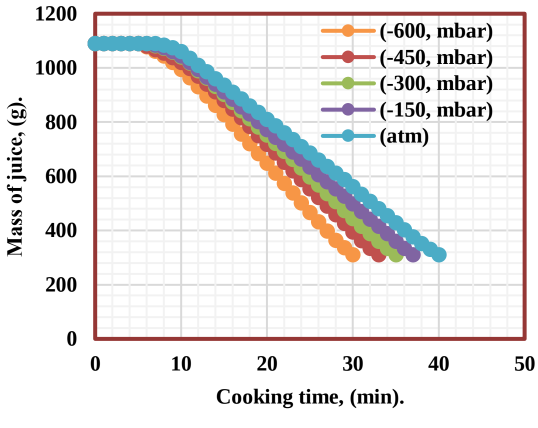

Fig. 15. Mass of juice as affected by cooking time at heating temperature 500°C with deferent pressures
Source: Authors' determination.

It is clear that as the time of cooking sugar cane juice increased, mass of juice decreased. The maximummass of sugar cane juice was 1,090g at zero time with all pressures. Minimum mass of sugar cane juice was 310g at times 30, 33, 35, 37 and 40 minutes at pressures -600, -450, -300, -150 mbar and atmospheric respectively. After 30 minutes, the mass of juice was 310, 394, 444, 498 and 562g at pressures -600, -450, -300, -150 mbar and atmospheric respectively. At the same time, a decrease in pressure leads to a decrease in the mass of juice.

Effectat a heating temperature 350°C

Figure 16 depicted the relationship between the mass of sugar cane juice as affected by cooking time of sugar cane juice at temperature of heating 350°C at pressures: -600, -450, -300, -150 mbar and atmospheric. It is clear that as the time of cooking sugar cane juice increased, mass of juice decreased. The maximummass of sugar cane juice was 1,090g at zero time with all pressures. Minimum mass of sugar cane juice was 310g at times 64, 67, 70, 73 and 77 minutes at pressures -600, -450, -300, -150 mbar and atmospheric respectively. After 64 minutes, the mass of juice was 310, 342, 376, 412 and 458g at pressures -600, -450, -300, -150 mbar and atmospheric respectively. At the same time, a decrease in pressure leads to a decrease in the mass of juice.

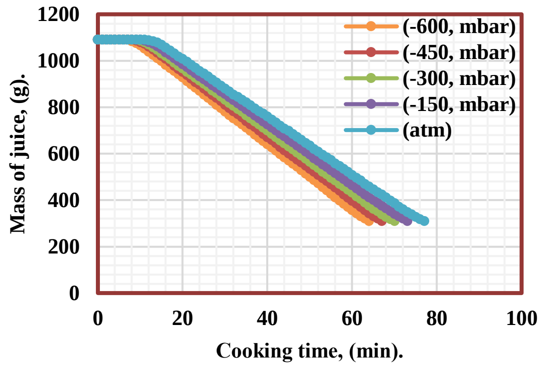

Fig. 16. Mass of juice as affected by cooking time at heating temperature 350°C with deferent pressures
Source: Authors' determination.

Effect at a heating temperature 200°C

Figure 17 depicted the relationship between the mass of sugar cane juice as affected by cooking time of sugar cane juice at temperature of heating 200°C at pressures: -600, -450, -300, -150 mbar and atmospheric. It is clear that as the time of cooking sugar cane juice increased, mass of juice decreased. The maximummass of sugar cane juice was 1,090g at zero time with all pressures. The minimum mass of sugar cane juice was 310g at times 155, 161, 167, 172 and 177 minutes at pressures -600, -450, -300, -150 mbar and atmospheric respectively. After 155 minutes, the mass of juice was 310, 334, 366, 384 and 412g at pressures -600, -450, -300, -150 mbar and atmospheric respectively. At the same time, a decrease in pressure leads to a decrease in the mass of juice.

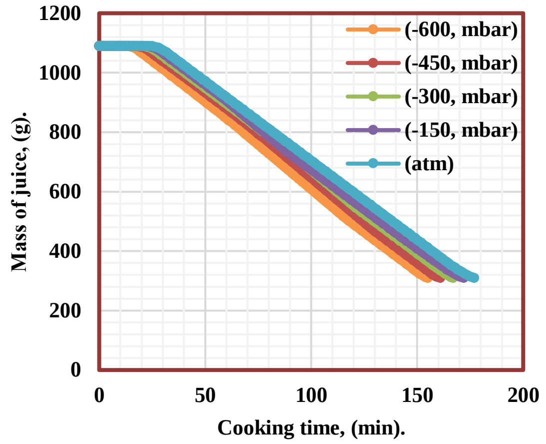

Fig. 17. Mass of juice as affected by cooking time at heating temperature 200°C with deferent pressures
Source: Authors' determination.

CONCLUSIONS

A small unit were developed and manufactured for producing high quality black honey depends on heating and vacuum system. This unit consisting of pan vessel, heater, compressor, condenser, rectifier, vessel receiver oil and smart control system. The experimental treatments for black honey cooking unit were tested on three heating temperatures different at 200, 350 and 500 °C and four vacuum levels at 150, 300, 450 and 600 mbar and atmospheric pressure. The data showed that the stability of the samples produced under vacuum pressure was better, as the highest values for all studied quality traits were recorded compared to their counterparts at atmospheric pressure.

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DEVELOPMENT AND EVALUATION OF RAISED BED MACHINE TO SUIT FABA BEAN PLANTING

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Abstract

The research aimed to develop and evaluate the raised bed machine to suit faba bean planting with local materials. Metering plates were designed with different shapes index and slots shapes suitable for faba bean planting and tested at the Department of Agriculture Engineering, Faculty of Agriculture, Tanta University, Egypt. The raised bed machine was tested and evaluated under three different forward speeds (2, 3.5, and 4.5 km/h), and three different planting distances (D1, D2, and D3 were 15, 20, and 25 cm). The results indicated that the lowest percentage of missing hills, seed damage, germination ratio, and dispersion ratio were 1.4%,1.2%, 97.57%, and 8.5% at a forward speed of 2km/h and planting distance of 15 cm. The highest value of the actual field capacity, the lowest value of specific energy, and the lowest value of operating costs were 1.25 fed/h, 11. 66kW.h/fed, and 280 L.E./faddan (4,200 m^2), respectively for first metering plate (TPU Materials, Hole Length 19mm, Hole Width15mm, Slot Shape Ellipse and Shape Index1.76. Linear regression analysis were performed to predict the operating parameters for the raised bed machine the machine at different forward speeds during different planting distances.

Key words: *faba bean, local manufacture, raised bed machine, forward speeds, planting distances*

INTRODUCTION

Agriculture has an important role in the global economy and food security since it contributes significantly to the Gross domestic product [4].
The main leguminous crop in the world is the faba bean (*Vicia faba* L.). With the expansion of specialized areas. The faba bean is the most important cool season food and feed legume crop grown in various places across the world. The crop may grow in a variety of soil types and environmental conditions. Over 4.1 million households reported farming the crop on approximately 0.5 million hectares of land, yielding more than a million tonnes of grain [6, 1].
Beans (*Vicia faba* l.) are Egypt's most frequently grown as legume crop, accounting for the majority of cultivated area, total production, and consumption. Humans use beans (*Vicia faba* l.) as processed food because they provide a high-quality percentage of carbs (58%) and protein (28%), as well as several vitamins and minerals. With an average farmed area of 86.1 hectares per year and an average output of 4.47 tonnes per hectare, Egypt has the greatest bean production in the Mediterranean region [12].
Plowing the field to produce a series of linear incisions known as furrows is a traditional planting method. The seeds are subsequently dispersed across the field. This approach has severe disadvantages; such as seeds not being buried at the right depth or with sufficient space between them. The seeds that fall into the furrows are protected from the weather, and raking or natural soil erosion gradually covers them up [11].
Manual approaches' poor seed placement, low efficiency, late planting, and significant stiffness difficulties for farmers limit the size of the field that may be sown. The timeliness of operation is one of the most significant things that can be efficiently achieved via the right deployment of agricultural machinery [9].
The agricultural industry has various obstacles, including a lack of qualified labor to carry out agricultural activities and long

processing periods. Because the world's population is always growing, agricultural commodities are becoming more focused, as are industrial demands. Raised bed farming methods integrate the majority of conservation agriculture principles and have generated promising outcomes in a range of environmental circumstances. RBM has the ability to minimize field compaction and physically damaged soil structure, as well as save water and boost crop output while lowering the danger of water logging [16].

With a growing population and rising per capita food consumption, food demand is expected to soon outpace our ability to supply it. Combating this issue needs not just new agricultural areas, but also optimizing crop yields from existing agricultural land. Over the previous four decades, the world's expansion in this business has been considerable, with increased agricultural land use contributing to lower productivity. As a result, the agricultural sector has been able to increase output in response to increased food demand [10].

On three seed-metering systems, the influence of levels of factors such as forward speed, cell shape, and seed metering performance characteristics was studied. Mean seed spacing, miss index, and seed damage rose as forward speed increased for all metering plates tested, although multiple index decreased. The average seed spacing was 140.8 mm, which was near to the theoretical maximum of 150 mm. The best quality feed index was 1%, the worst miss index was 6.1%, and seed damage was 0.38 percent [15].

The main frame, seed hopper, seed metering mechanism, driving wheels, seed tube, furrow opener, furrow closer and push handle were all designed and tested for a manually row planter for field crop seeds. The designed machine had a high field capacity of 7.6 and 10.2 times for maize sowing at 1.89 and 2.61 km/h forward speeds, respectively, and 8.9 and 11.9 times for faba bean sowing at 1.83 and 2.58 km/h forward speeds, respectively, and the amount of seeds per hectare was reduced by 40 and 11.5 percent, respectively, when compared to manual planting. The overall cost of planted hectare by the single row planter was 95.92 & 96.63 % and 89.35 & 89.84 % less than manual planting at the two possible speeds [14].

Experiments were conducted in the laboratory as a function of metering device speed and cell size (1 seed/cell and 2 seed/cell). Experiments in the field were carried out to optimize machine forward speed and planting depth. Seed damage, plant dispersion, emergence, crop yield, specific energy, and planting cost were all investigated. According to the trial results, the created faba bean planter should be utilised under the following conditions: forward speed of 3.5 km/h, cell size of 2 seeds/cell, and planting depth of 50 mm. At ideal circumstances, the following results were obtained: plant emergence of 97.70%, seed yield of 3.99 ton/ha, ground wheel slip of 3.9%, necessary power of 4.04 kW, specific energy of 8.66 kW h/ha [5].

In this context, the research aimed to develop and evaluate the raised bed machine to suit faba bean planting with local materials. Metering plates were designed with different shapes index and slots shapes suitable for faba bean planting and tested at the Department of Agriculture Engineering, Faculty of Agriculture, Tanta University, Egypt.

MATERIALS AND METHODS

The raised bed machine (Photo 1 and Fig. 1) was designed and simulated at the Agricultural Engineering Department, Faculty of Agriculture then manufactured at Tanta Motors Abou Freikha Factory and tested at a privet farm in Kafer Essam, Tanta, Egypt.

Faba bean metering plates

The faba bean metering plates were designed by using Solidworks software with four different shapes and printed with five different materials (ABS+, TPU, NYLON, PTFE, and Ertalon) as shown in Fig. 2 and Table 1 showed the parameters of metering plates.

Measurements

The measurements made in this research regard: Fuel consumption, Energy requirements, Specific energy consumption, Slippage, Theoretical field capacity, Effective field capacity, Field efficiency, Dispersion Ratio, Missing Hill and Operational costs, whose formulas of calculation are presented in Table 2.

Photo 1. The Raised Bed Machine
Source: Authors' determination.

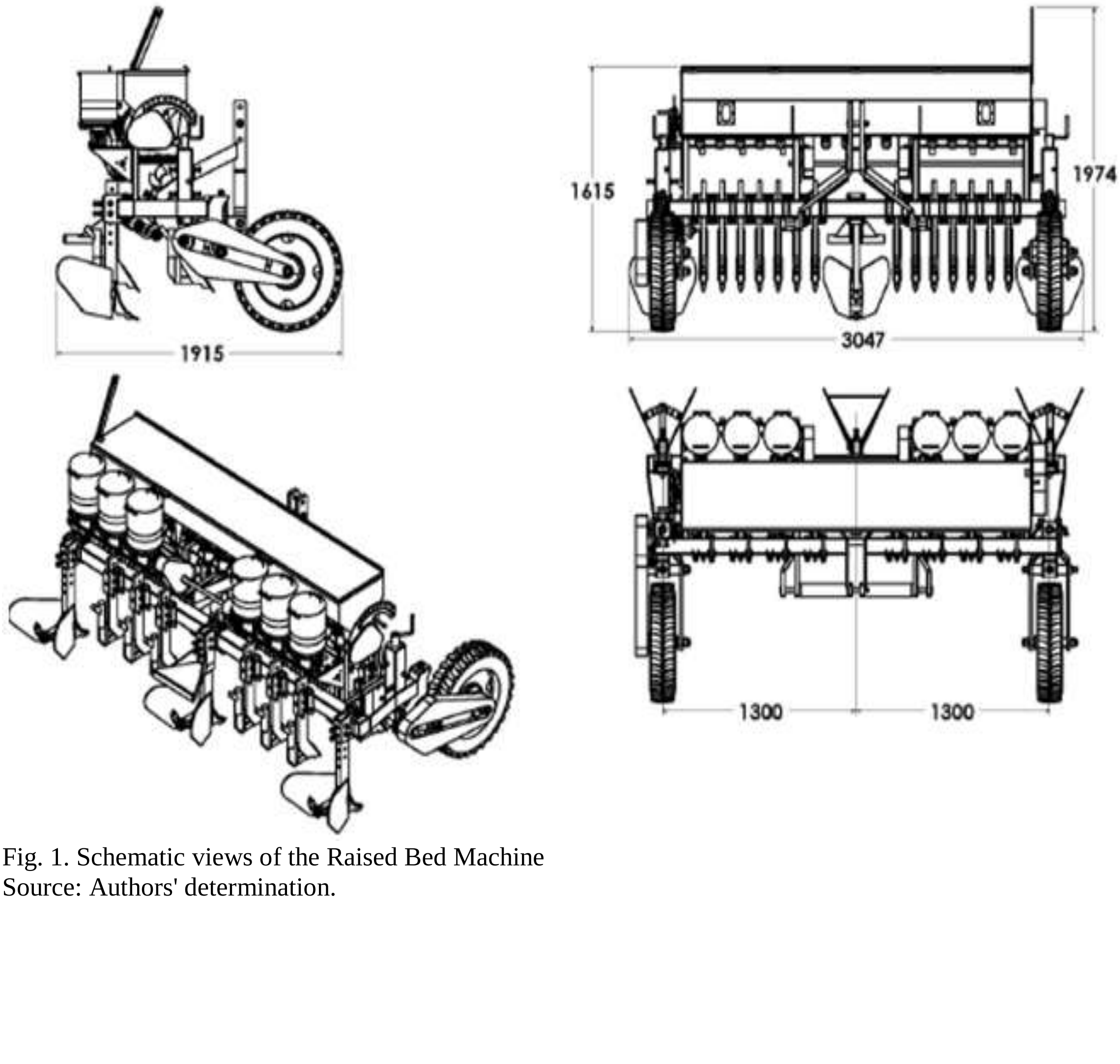

Fig. 1. Schematic views of the Raised Bed Machine
Source: Authors' determination.

Fig. 2. Faba Bean Metering Plates
Source: Authors' determination.

Table 1. Faba bean metering plates parameters

Items	Plate 1	Plate 2	Plate 3	Plate 4	Plate 5	Plate 6	Plate 7	Plate 8
Materials	ABS TPU NYLON			ABS TPU NYLON			Ertalon	PTFE
Hole Length	19mm			21mm			25mm	$\emptyset = 20mm$
Hole Width	15mm			17mm			19mm	
Slot Shape	Ellipse			Cardioid			long Ellipse	Round
Shape Index	1.76			1.78			3.01	1.65

Source: Authors' determination.

Table 2. Measurements regarding the Raised Bed Machine

Equations	Authors
Fuel Consumption= $\frac{fuelconsumption\,,ml}{Time,sec}\, x\, 3.6\ L\backslash h$	**El Shal, and Awny (2019) [7]**
Energy Requirements= $\frac{RequiredPower,kw}{EffictiveFieldCapacity,fed\backslash h}\ \mathrm{kw.h\backslash fed}$	**Hoque, and Miah (2015) [8]**
Specific Energy Consumption = $\frac{Powerrequirements}{EFC}\ \mathrm{kW.h/fed}$	**El Shal, and Awny (2019) [7]**
Slippage = $\frac{Actualdistance-theoreticaldistance}{Etheoreticaldistance}$ *100,%	**Al-Gezawe et al (2022) [5]**
Theoretical Field Capacity = $\frac{VxW}{4.2}\ fed\backslash h$	**Wang et al. (2002) [17]**
Effective Field Capacity = $\frac{1}{T}\ fed\backslash h$	**Oduma et al (2014) [13]**
Field Efficiency= $\frac{EFC}{TFC}\, x100\%$	**Adisa et al (2012) [3]**
Dispersion Ratio= $\frac{dispersedseeds}{totalseed} * 100$	**Wang et al. (2002) [17]**
Missing Hill= $\frac{Numberofmissingplants}{totalplants} * 100$	**Abu El-Maaty et al (2020) [2]**
Operational Cost = $\frac{MachineCost\ (L.E\backslash h)}{EffectiveFieldCapacity(fed\backslash h)}\ LE\backslash fed$	**Al-Gezawe et al (2022) [5]**
Note: V=Average Implement forward speed, km\h, W=The Working Width of Implement, m., T=Total Planting Time, h	

Source: Authors' determination.

RESULTS AND DISCUSSIONS

Effect of the Operational Parameter On The Fuel Consumption, l/fed

Forward speed is one of the most important elements influencing machine fuel consumption. Figure 3 depicts the relationship between forward speed and fuel consumption under various distances. it is obvious that the use of the first distance led to an increase in fuel consumption from 6.42 liters/hour to 9.36 liters/hour by increasing the forward speed from 2 km / h to 4.5 km / h. While the use of the second distance led to an increase in fuel consumption from 5.16 liters/hour to 9 liters/hour by increasing the front speed from 2 km / h to 4.5 km / h. And from 4.2 liters/hour to 8.28 liters/hour when using the third distance with the same forward speeds. Thus, the results showed a convergence of consumption levels. Linear regression analysis was performed on the equations of the raised bed machine to predict the fuel consumption at different forward speeds during different planting distances. The following equation represents the relationship:

D1: $y = 1.1417x + 3.9907$ $R^2 = 0.9479$
D2: $y = 1.5184x + 2.0351$ $R^2 = 0.99$
D3: $y = 1.6339x + 0.9417$ $R^2 = 0.9999$

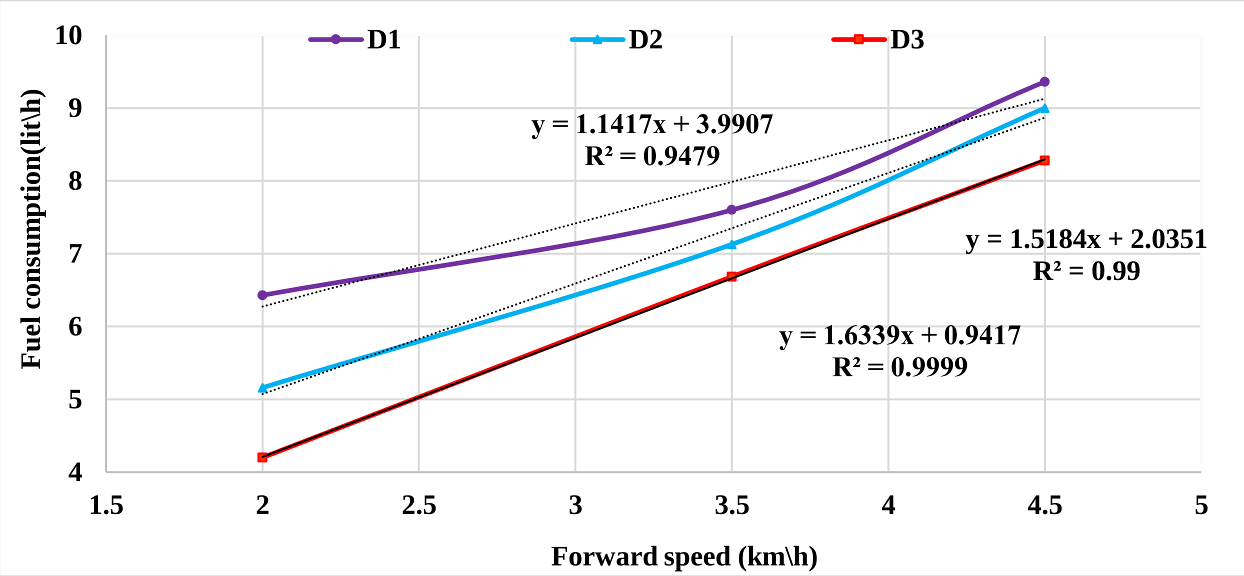

Fig. 3. Relationship between forward speed and fuel consumption under the different planting distances
Source: Authors' determination.

Effect of the Operational Parameter On the Power Requirements

Figure 4 shows the relationship between forward speed and engine power required under different planting distances. It was observed that using the first distance (15 cm), the total engine power was recorded as 17.85 kW / h at a front speed of 2 km / h. It increased to 21.11 and 26 kW/ h when the forward speed was increased to 3.5 and 4.5 km/h respectively. While using the second distance (20 cm), the power was 14.33 kW/ h with a forward speed of 2 km/h, and 19.80 kW with a forward speed of 3.5 km/h, and increased to 25 kW/ h with a forward speed of 4.5 km/h. The engine power recorded the maximum value of 23 kW/ h with a forward speed of 4.5 km/h and 11.66 and 18.56 kW/ h with a forward speed of 2 and 3.5 km/h. Linear regression analysis was performed on the equations of the raised bed machine to predict the engine power at different forward speeds during different planting distances. The following equation represents the relationship.

D1: $y = 3.1715x + 11.086$ $R^2 = 0.94$
D2: $y = 4.2179x + 5.6533$ $R^2 = 0.99$
D3: $y = 4.539x + 2.6161$ $R^2 = 0.99$

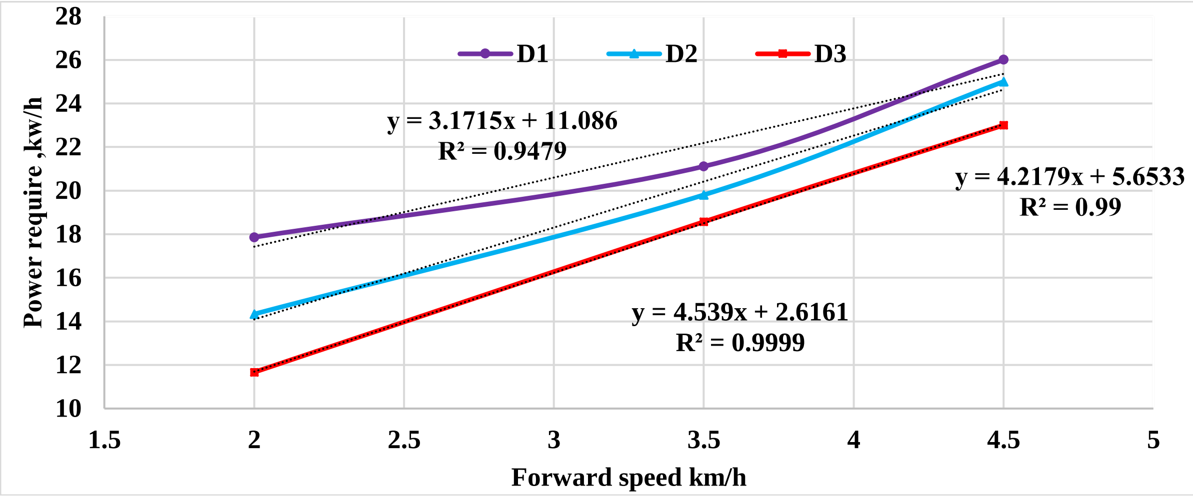

Fig. 4. Relationship between forward speed and required power under the different planting distances
Source: Authors' determination.

Effect of the Operational Parameter On the Specific Energy Consumption

Figure 5 shows the effect of forward speed on energy consumed and planting distances. It was found that increasing the forward speed tends to increase the energy consumed with planting distances. However, increasing the forward speed from 2 to 4.5 km/h tends to increase the energy consumed from 13.73 to 20 kw.h/fed at a planting distance of 15 cm. The maximum energy consumed of 21.25 kWh/fed was recorded at a forward speed of 4.5 km/h, and a planting distance of 20 cm, and the minimum energy consumed of 15.52 Kw.h/fed was recorded at a forward speed of 2 km/h at same planting distance. The minimum energy consumed of 17.94 Kw.h/fed was recorded at a forward speed of 2 km/h, and a planting distance of 25 cm, and the maximum energy consumed of 24.15 kWh/fed was recorded at a forward speed of 4.5 km/h. Linear regression analysis was performed on the equations of the raised bed machine to predict the engine power at different forward speeds during different planting distances. The following equation represents the relationship.

D1: $y = 2.5108x + 8.7414$ $R^2 = 0.997$

D2: $y = 2.2986x + 10.979$ $R^2 = 0.9987$

D3: $y = 2.4314x + 12.841$ $R^2 = 0.9702$

Effect of the Operational Parameter On The Theoretical Field Capacity

Figure 6 shows the relationship between forward speed and theoretical field capacity. It was clear that the theoretical field capacity increased with increasing forward speed, the theoretical field capacity was 1.23 fed/h with a forward speed of 2 km/h and reached 2.16 fed/h with a forward speed of 3.5 km. / h and recorded the highest value of 2.78 fed/h with a forward speed of 4.5 km / h. Linear regression analysis was performed on the equations of the raised bed machine to predict the theoretical field capacity at different forward speeds during different planting distances. The following equation represents the relationship.

$y = 0.7738x + 0.5159$ $R^2 = 0.9868$

Effect of the Operational Parameter On The Effective Field Capacity

Effective field capacity is an important indicator to evaluate a raised bed machine which is affected by many factors such as effective machine width, machine forward speed, and time lost in the field. The data in Figure 7 show the effect of forward speed, and planting spacing on effective field capacity. The results show an increase in effective field capacity with an increase in forward speed.

The effective field capacity was increased from 1 to 1.25 fed/h when the forward speed increased from 2 to 4.5 km/h while using the first planting distance (15 cm), the effective field capacity was increased from 0.92 to 1.76 fed/h when the forward speed increased from 2 to 4.5 km/h while using the second planting distance (20 cm) (Fig. 7).

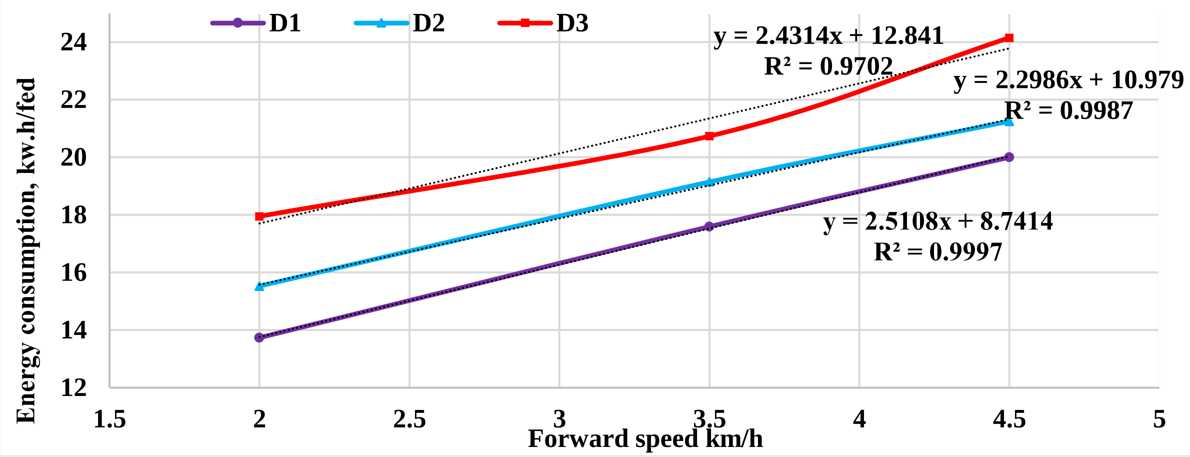

Fig. 5. Relationship between forward speed and required power under the different planting distances
Source: Authors' determination.

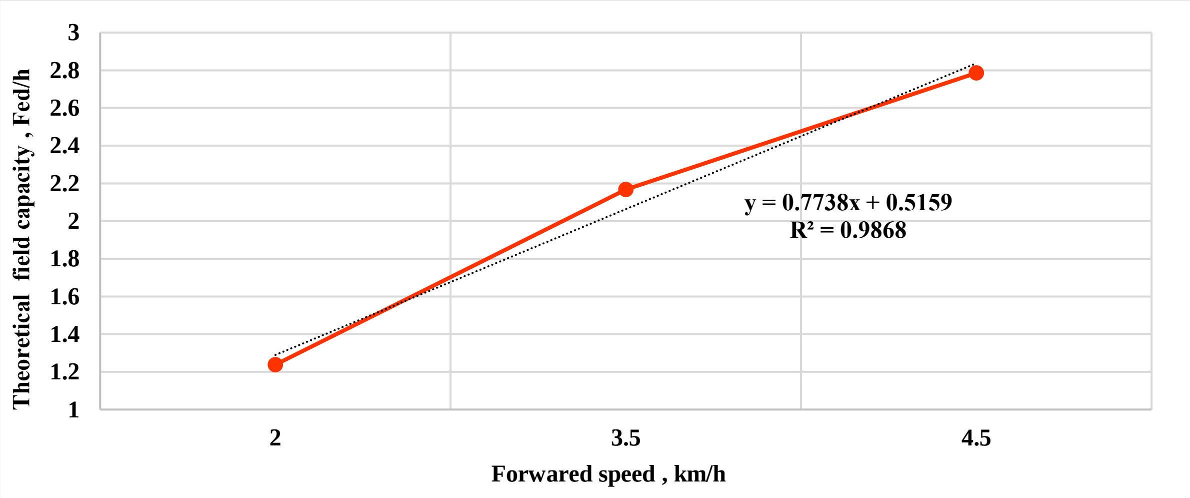

Fig. 6. Relationship between forward speed and theoretical field capacity.
Source: Authors' determination.

Also, with forward speeds 2 and 4.5 km/h the effective field capacity was 0.85, and 0.95 respectively. Linear regression analysis was conducted on the raised bed machine equations to estimate the effective field capacity at different forward speeds and planting distances. The estimated equation for this diagram is:

D1: $y = 0.0644x + 0.9658$ $R^2 = 0.9908$
D2: $y = 0.0992x + 0.7139$ $R^2 = 0.9663$
D3: $y = 0.0371x + 0.778$ $R^2 = 0.9496$
(Fig. 8).

Effect of the Operational Parameter On The Field Efficiency

The effect of forward speed on field efficiency under the different planting distances methods were shown in Figure 8. The results show a decrease in field efficiency as the forward speed increased. By using the first planting distance the field efficiency decreased from 88.1% to 44.87% with a forward speed from 2 up to 4.5 Km / h, and by using the second, and third planting distances field efficiency decreased from 74.55% to 42.23%, and from 69.23% to 34.18 % with same forward speeds. Linear regression analysis was performed on the equations of the raised bed machine to predict the field efficiency at different forward speeds during different planting distances. The following equation represents the relationship.

D1: $y = -17.653x + 121.63$ $R^2 = 0.9702$
D2: $y = -13.32x + 99.244$ $R^2 = 0.9395$
D3: $y = -14.379x + 96.18$ $R^2 = 0.9547$

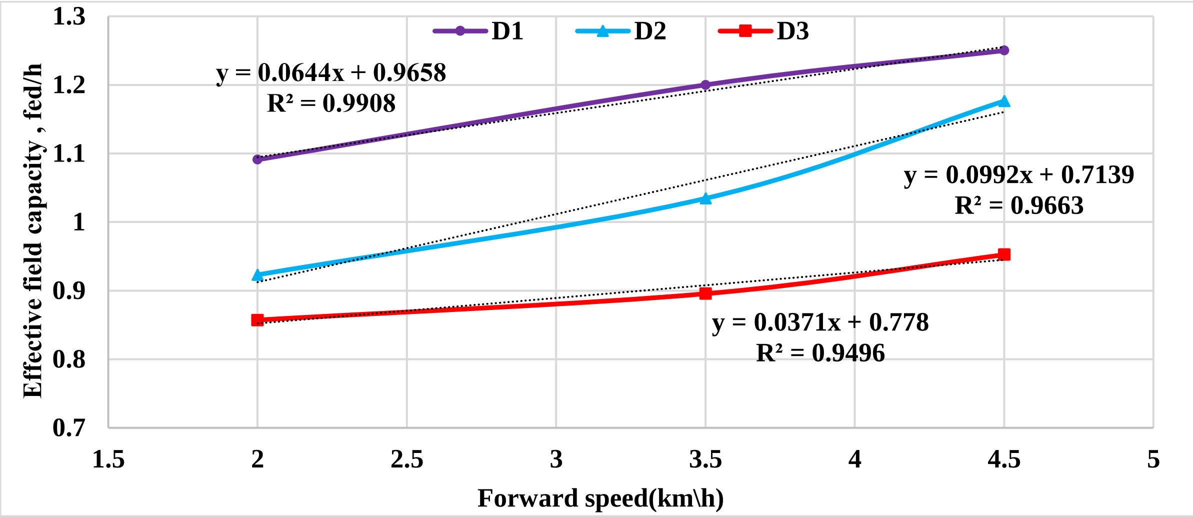

Fig. 7. Relationship between forward speed and effective field capacity under the different planting distances
Source: Authors' determination.

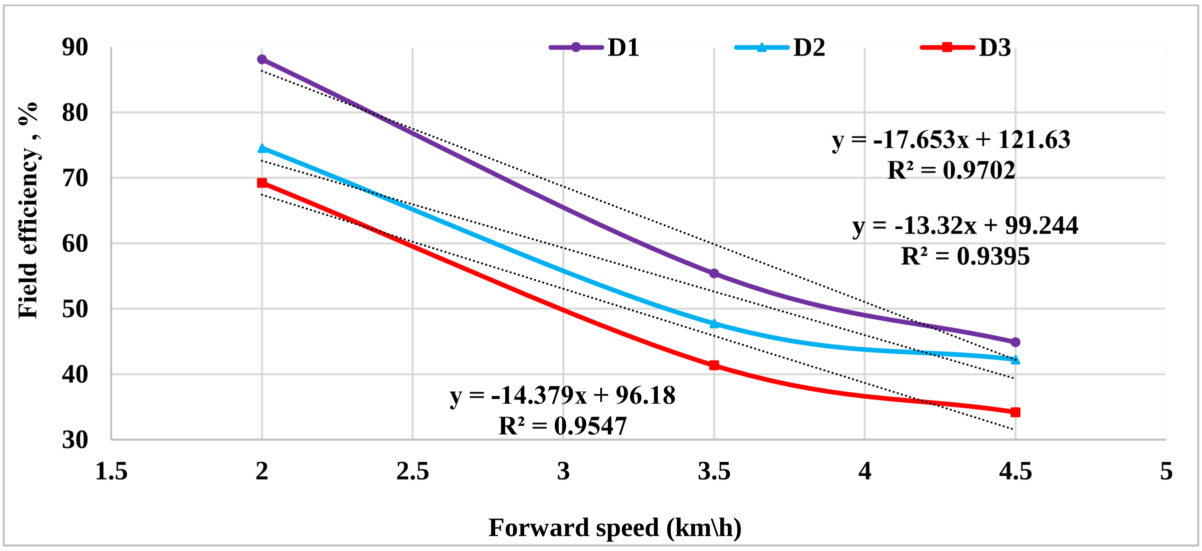

Fig. 8. Relationship between forward speed and field efficiency under the different planting distances
Source: Authors' determination.

Effect of the Operational Parameter On The Dispersion Ratio

The effect of forward speeds on the dispersion rate of seeds during the use of four types of metering plates is shown in Figures 9, 10, 11 and 12, and it was clear that there was an increase in the dispersion ratio when using the first metering plate and three different planting distances. The dispersion rate increased from 8.57% to 18.57% at forward speeds from 2km/h to 4.5km/h for the first planting distance and from 10% to 20%, and from 12.5% to 25%, respectively, for the second and third planting distances, and at similar forward speeds for the first planting distance. As for the second metering plate, the dispersion rate for the three planting distances was 10% to 21.41%,12% to 32%, and 15% to 37.5%, respectively, with forward speeds from 2km/h to 4.5km/h. At the same time, the results were with the third metering plate for the same planting distances from 7.14% to 24.28%. 14% to 36%, and from 22.5% to 52.5%, respectively, with forward speeds of 2 and 4.5km/h. The fourth metering plate was increased from 14.28% to 34.28%, 38% to 64%, and 42.5%. to 70% with forward speeds from 2km/h to 4.5km/h. Linear regression analysis was performed on the equations of the raised bed machine to predict the dispersion ratio at different forward speeds during different planting distances. The following equation represents the relationship.

Plate1

D1: $y = 3.985x + 0.5263$ $R^2 = 0.9989$

D2: $y = 4x + 2$ $R^2 = 0.9934$

D3: $y = 5x + 2.5$ $R^2 = 0.9821$

Plate 2

D1: $y = 4.5865x + 0.9023$ $R^2 = 0.9992$

D2: $y = 8.1053x - 3.6842$ $R^2 = 0.9875$

D3: $y = 9.0789x - 2.7632$ $R^2 = 0.9944$

Plate 3

D1: $y = 6.9173x - 6.391$ $R^2 = 0.9944$

D2: $y = 8.6316x - 4.1053$ $R^2 = 0.9722$

D3: $y = 11.842x - 1.9737$ $R^2 = 0.9868$

Plate 4

D1: $y = 7.8947x - 2.0301$ $R^2 = 0.9868$

D2: $y = 10.526x + 17.579$ $R^2 = 0.9893$

D3: $y = 11.184x + 21.053$ $R^2 = 0.9801$

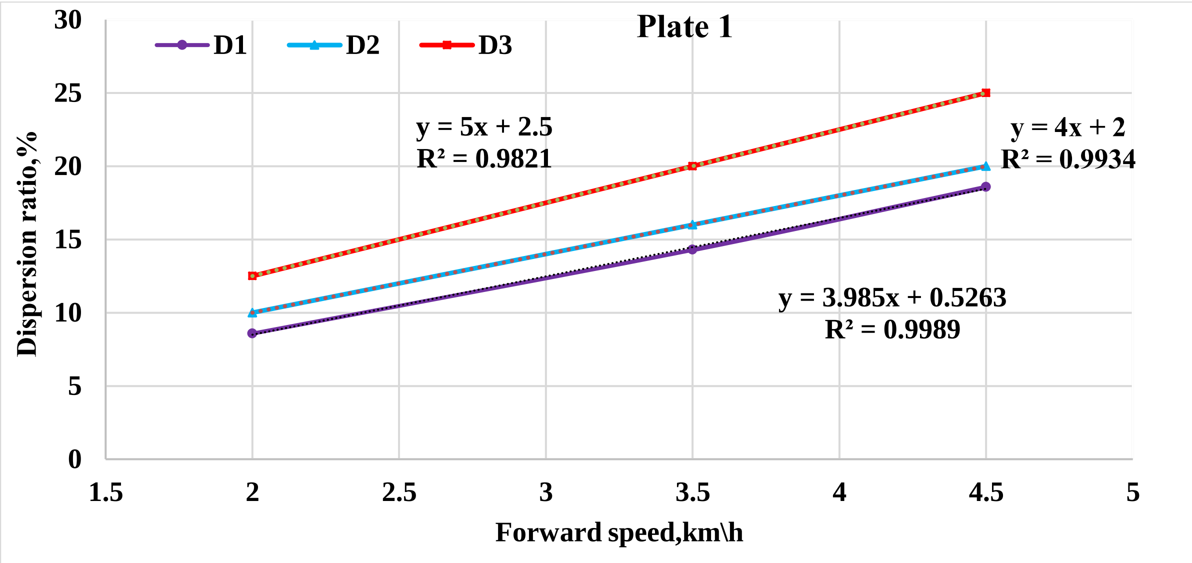

Fig. 9. The effect of forward speeds on the dispersion ratio of the first metering plate under different planting distances

Source: Authors' determination.

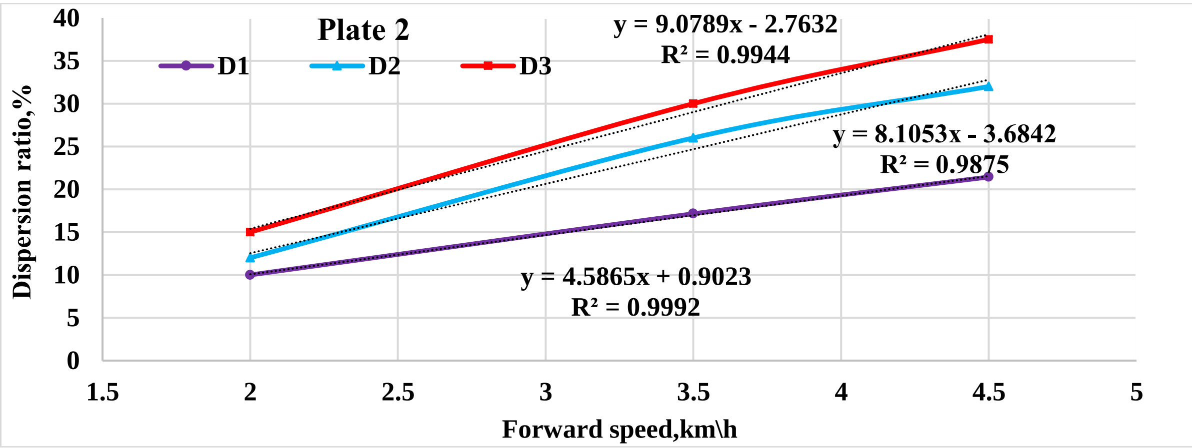

Fig. 10. The effect of forward speeds on the dispersion ratio of the second metering plate under different planting distances

Source: Authors' determination.

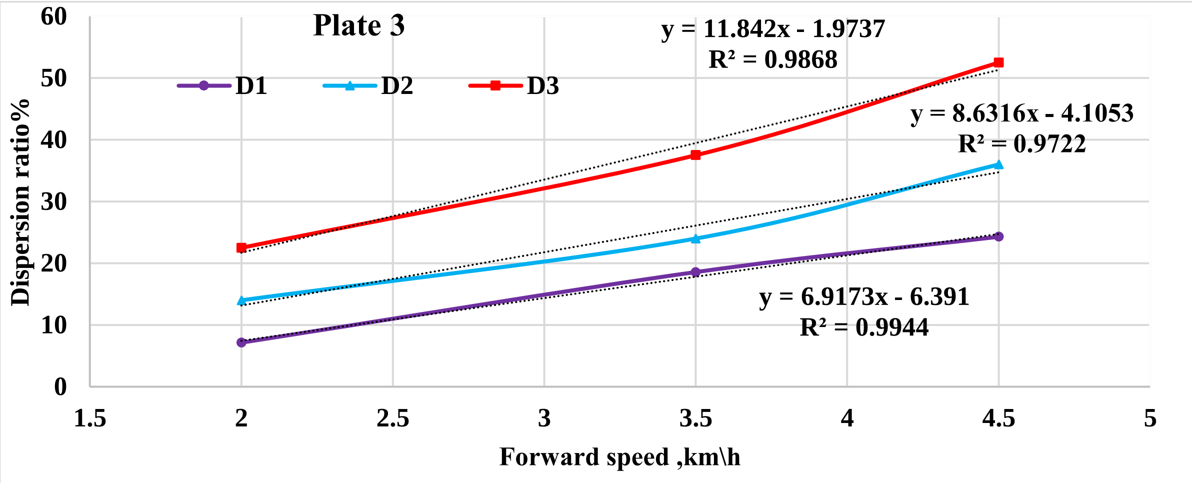

Fig. 11. The effect of forward speeds on the dispersion ratio of the third metering plate under different planting distances
Source: Authors' determination.

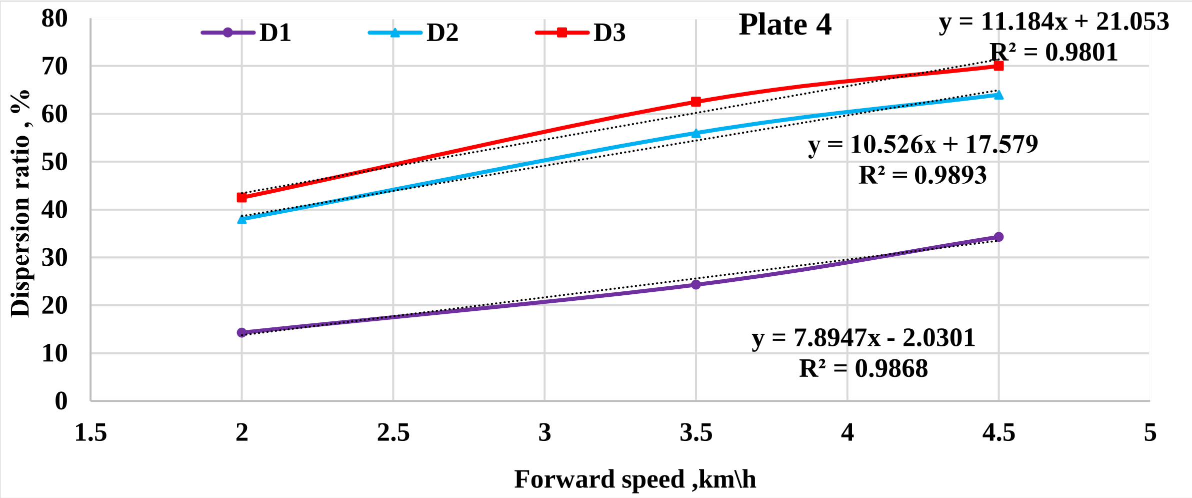

Fig. 12. The effect of forward speeds on the dispersion ratio of the fourth metering plate under different planting distances
Source: Authors' determination.

Effect of the Operational Parameter On The Missing Hill, %

The effect of forward speeds on the missing hill of seeds during the use of four types of metering plates is shown in Figures 13, 14, 15, and 16, and it was obvious that there was an increase in the missing hill when using the first plate with three different planting distances. The missing hill increased from 1.4% to 4.2% during forward speeds from 2km/h to 4.5km/h for the first distance and from 2% to 6% and from 2.5% to 7.5%, respectively, for the second and third distances, and at similar forward speeds for the first distance. As for the second plate, the missing hill for the three planting distances was 2.85% to 7.14%,4% to 10%, and 5% to 15%, respectively, with forward speeds from 2km/h to 4.5km/h. At the same time, the results were with the third plate for planting distances (15, 20, and 25 cm) from 7.14% to 15.71%. 12% to 34%, and from 17.5% to 40%, respectively, with forward speeds of 2 and 4.5km/h. These results were also different from the measurements of the fourth plate, as they increased from 11.42% to 31.42%, 34% to 64%, and 50%. to 87% with forward speeds from 2km/h to 4.5km/h respectively. Linear regression analysis was performed on the equations of the raised bed machine to predict the missing hill at different forward speeds during different planting distances. The following equation represents the relationship.

Plate1

D1: $y = 1.1278x - 0.9023$ $R^2 = 0.9868$
D2: $y = 1.1278x - 0.9023$ $R^2 = 0.9868$
D3: $y = 1.9737x - 1.5789$ $R^2 = 0.9868$

Plate 2

D1: $y = 1.6541x - 0.7519$ $R^2 = 0.9098$
D2: $y = 2.3158x - 1.0526$ $R^2 = 0.9098$
D3: $y = 3.8158x - 3.5526$ $R^2 = 0.8512$

Plate 3

D1: $y = 3.3083x - 0.0752$ $R^2 = 0.9098$
D2: $y = 8.5263x - 6.4211$ $R^2 = 0.9283$
D3: $y = 8.8158x - 1.0526$ $R^2 = 0.9683$

Plate 4

D1: $y = 8.0451x - 4.4361$ $R^2 = 0.9976$
D2: $y = 12.211x + 10.632$ $R^2 = 0.9782$
D3:$y = 14.868x + 19.605$ $R^2 = 0.9942$

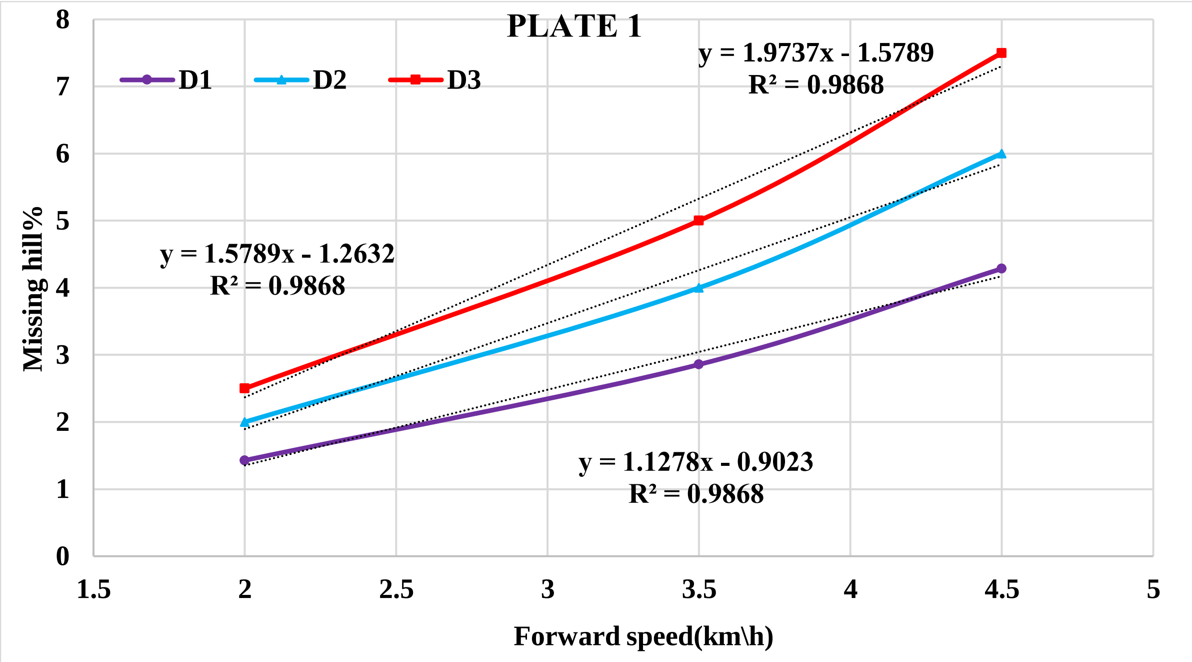

Fig. 13. The effect of forward speeds on the missing hill of the first metering plate under different planting distances
Source: Authors' determination.

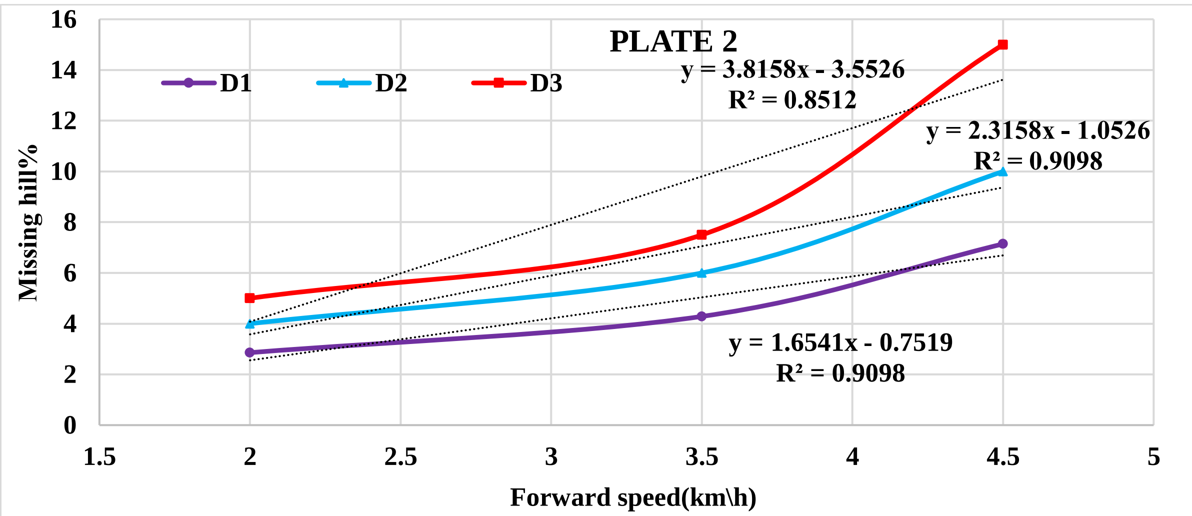

Fig. 14. The effect of forward speeds on the missing hill of the second metering plate under different planting distance
Source: Authors' determination.

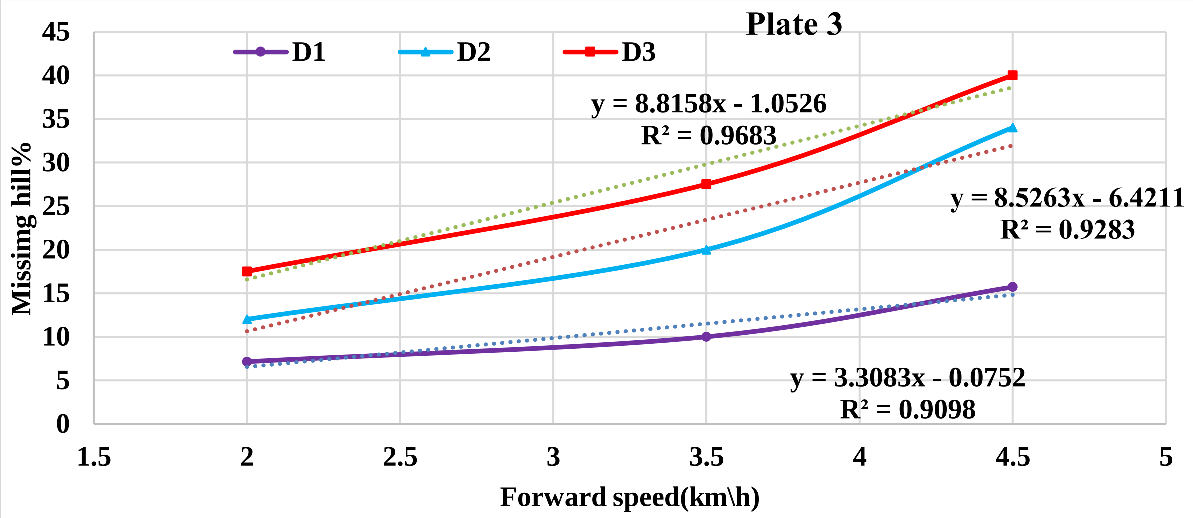

Fig. 15. The effect of forward speeds on the missing hill of the third metering plate under different planting distances
Source: Authors' determination.

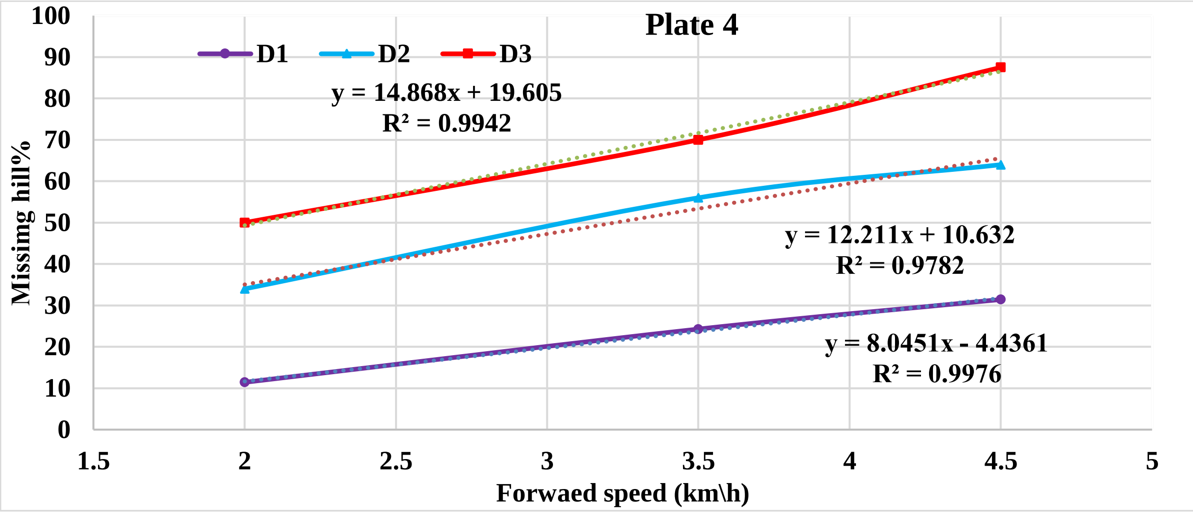

Fig. 16. The effect of forward speeds on the missing hill of the fourth metering plate under different planting distances
Source: Authors' determination.

Effect of the Operational Parameter On The Seeds Damage, %

Figure 17 shows the effect of metering device speed and metering plates on seed damage percent. Results showed that seed damage decreased by increasing cell size and increased by increasing metering device speed. The maximum seed damages of 3.12%, 4.26%, 6.34%, and 10.23% were obtained at a metering device speed of 47 rpm for metering plate 1, plate 2, plate 3, and plate 4 respectively. Meanwhile, the minimum seed damages of 1.2%,2%, 3.73% and 6.6% were obtained at a metering device speed of 45 rpm for the same metering plates respectively. Linear regression analysis was performed on the equations of the raised bed machine to predict the seed damage at different rpm speeds during different metering plates. The following equation represents the relationship.

y=1.002x+0.2173 R^2=0.9714 (Plate 1)

y=1.132x+0.865 R^2=0.9997 (Plate 2)

y=1.3062x+2.5216 R^2=0.9845 (Plate 3)

y=1.8155x+4.7984 R^2=0.9998 (Plate4)

Effect of The Operational Parameters on The Total Operating Costs, L.E/fed

The results show that the operational cost decreased as the forward speed increased as shown in Figure 18. The operational cost decreased from 320.83 to 280 L.E / Fed as the forward speed increased from 2 to 4.5 Km / h for the first planting distance, and decreased from 379.16 to 297.5 LE / fed, and from 408 to 367.5 LE / fed for the second, and third planting distances with forward speed from 2 to 4.5 Km /. Linear regression analysis was run to derive equations to predict operational costs at different forward speeds during planting faba bean seeds, and the following equation represents the relationship.

D1: $y = -15.965x + 442.11$ $R^2 = 0.9616$

D2: $y = -32.237x + 445.79$ $R^2 = 0.9868$

D3: $y = -16.579x + 352.76$ $R^2 = 0.9838$

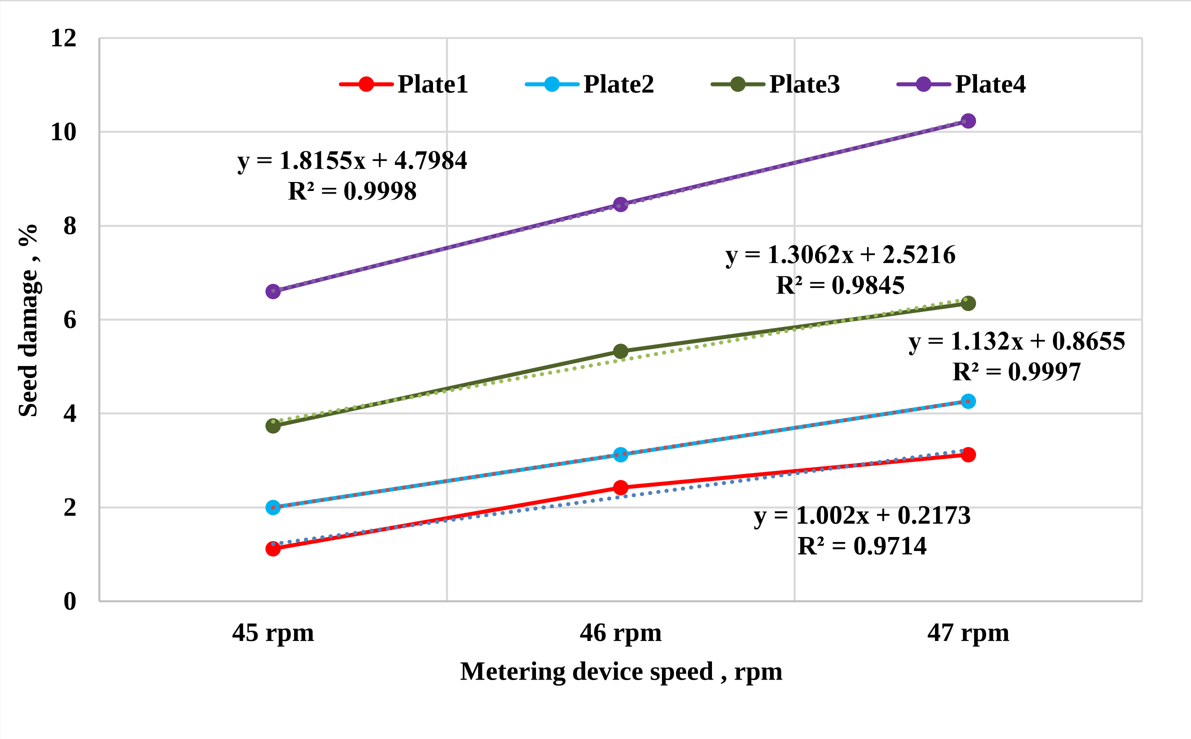

Fig. 17. Effect of metering device speed, and metering plates on seed damage percent
Source: Authors' determination.

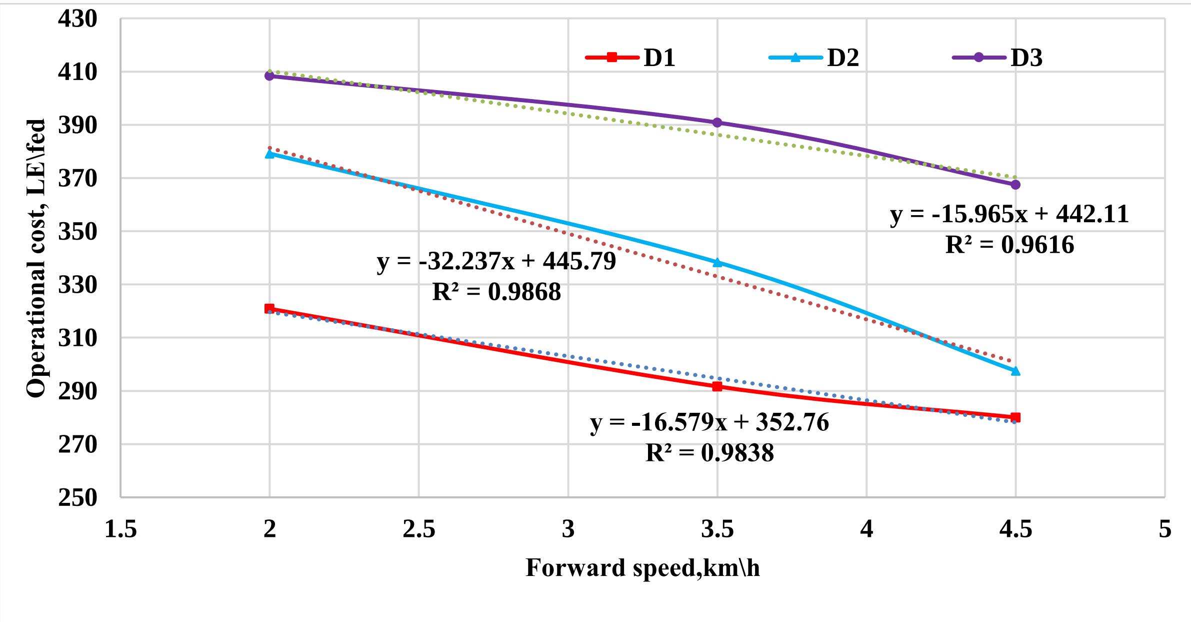

Fig. 18. Effect of machine forward speed and planting distances on the total operating costs
Source: Authors' determination.

Effect of The Operational Parameters on The Slippage, %

For the tractor as shown in Figure 19, the results showed that when the wheel was rotated for 10 revolutions, the slippage increased from 4.35% to 9.3% when the forward speed increased from 2 km/h to 4 km/h. When the tractor was connected to the raised bed machine, the results showed that with the first planting distance (15cm), the slip increased from 2.4% to 5.73. Also increased when using the second and third planting distances (20, and 25 cm) from 2.7% to 6.8%, and from 3.36% to 7.12% respectively in the same increased forward speed as shown in Figure 20. Linear regression analysis was run to derive equations to predict slippage at different forward speeds and planting distances, and the following equation represents the relationship.

D1: $y = -15.965x + 442.11$ $R^2 = 0.9616$
D2: $y = -32.237x + 445.79$ $R^2 = 0.9868$
D3: $y = -16.579x + 352.76$ $R^2 = 0.9838$

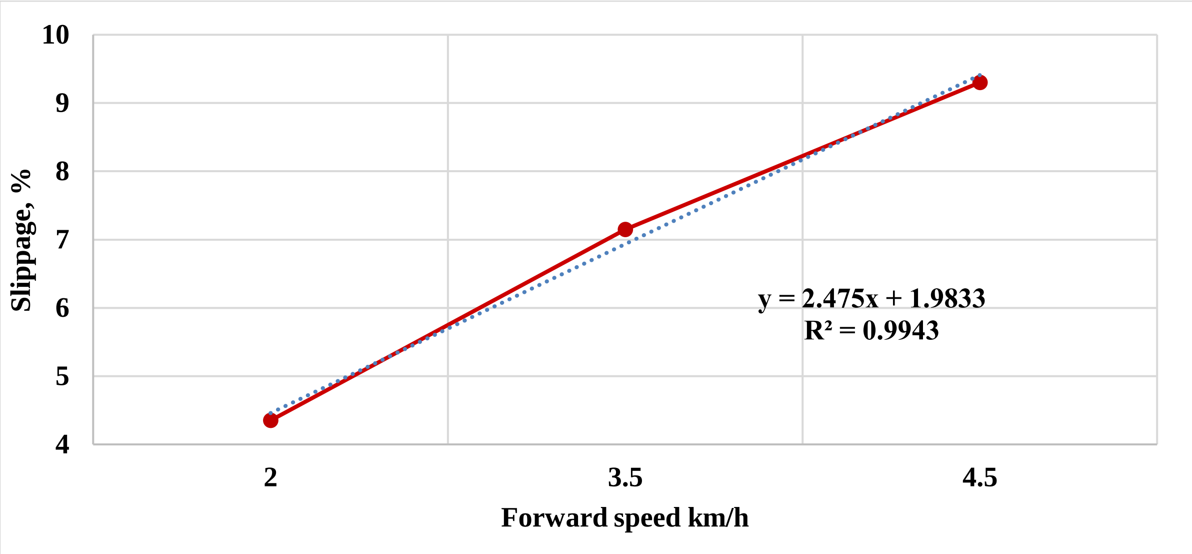

Fig. 19. Effect of machine forward speed on the slippage of tractor
Source: Authors' determination.

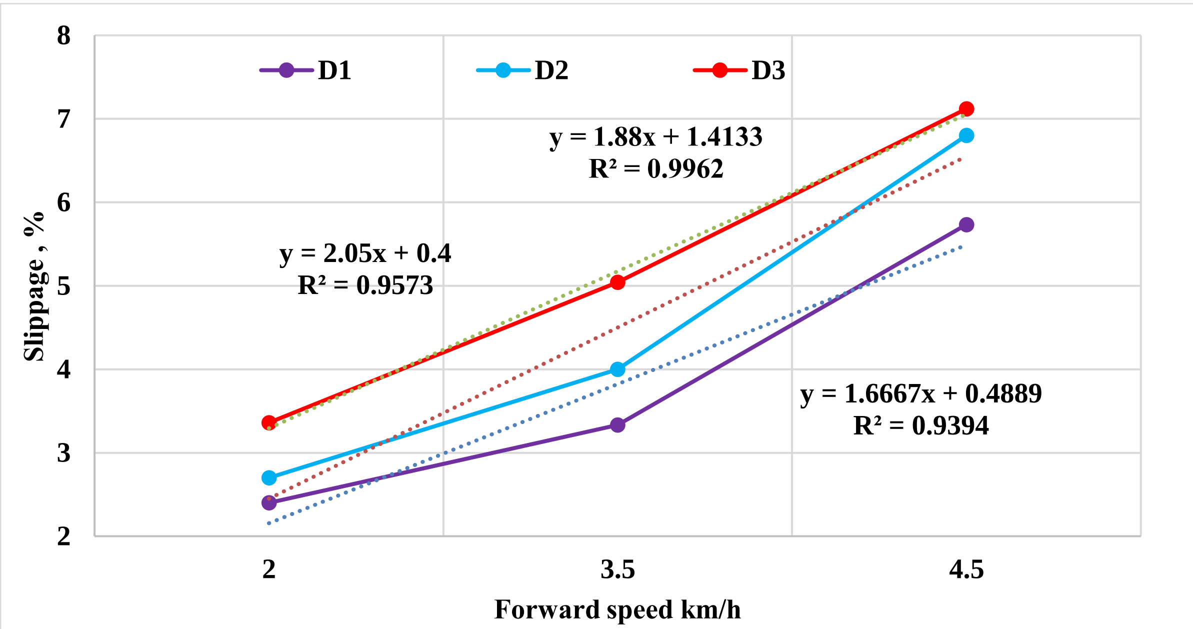

Fig. 20. Effect of machine forward speed and planting distances on the slippage of tractor with raised bed machine
Source: Authors' determination.

Effect of the Operational Parameter On the Germination ratio, %

The effect of planting distances on the germination ratio under different forward speeds is shown in Figure 21**.** The obtained results show a significant increase in the germination ratio with a decrease in the forward speed. By using the first planting distance the germination ratio was from 97.57% to 92.85% with the forward speed from 2 to 4.5 km/h respectively. By using the second and third planting distances, the germination ratio was 97.14%, and 92.85% for a forward speed of 2km/h, and for a forward speed of 4.5 km/s the germination ratio was 92%, and 88% respectively. Linear regression analysis was performed on the equations of the raised bed machine to predict the germination ratio at different forward speeds during different planting distances. The following equation represents the relationship.

D1: $y = -2.3571x + 100.1$ $R^2 = 0.9852$
D2: $y = -2.5714x + 99.524$ $R^2 = 0.9838$
D3: $y = -2.4286x + 95.143$ $R^2 = 0.9897$

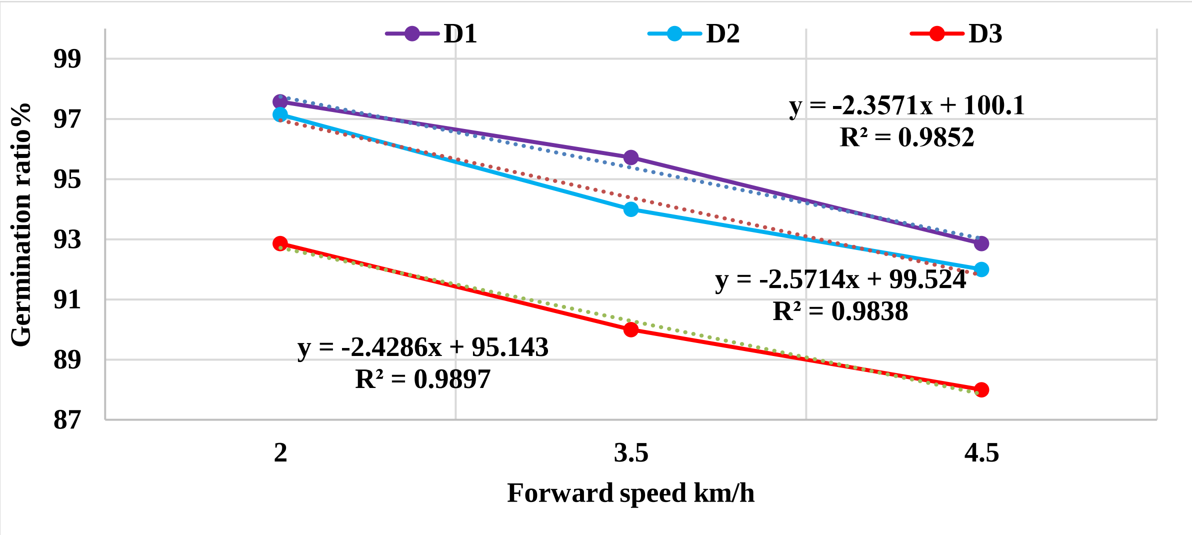

Fig. 21. Relationship between the germination ratio of faba bean seeds and the forward speeds under different planting distances
Source: Authors' determination.

CONCLUSIONS

The development of the equipment showed the first metering plate with TPU material and Shape Index1.76. gave a satisfactory performance with a missing hill, seed damage, and dispersion ratio where 1.4%,1.2%,97.57%, and 8.5%.

Also the results of the performance of raised bed machine such as the maximum value of actual field capacity, minimum values of specific energy, and operating costs where1.25 fed/h, 11. 66kW.h/fed, and 280 L.E./fed with forward speed of 2km/h and planning distance 15cm

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USING FINITE ELEMENT METHOD AND FATIGUE ASSESSMENT OF SINGLE - SCREW FISH OIL EXTRUDER

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Abstract

Modelling by Finite Element Method (FEM) and fatigue assessment of the single-screw of a press for obtaining fish oil through Solidworks software. Fish oil is a dietary supplement resulting from the tissues of fatty fish, such as salmon, mackerel, herring, and other different types of fish. It is rich in omega-3 fatty acids, and this oil is extracted using an extrusion machine. The objective of this study is to design and analyze extruder parts by finite element analysis at the Department of Agricultural Engineering - Faculty of Agriculture, Egypt. The functional parts of the machine include a feeder, nozzle (barrel), filter mesh, pressure chambers 1 and 2, screw axis, and finally a waste outlet. As for finite element analysis, 9 indicators were studied such as Von Mises, yield strength, INT (stress intensity), TRI (triaxle stress), static displacements, RFRES (resultant reaction), ESTRN (equivalent strain), SEDENS (strain energy density, and ENERGY (total strain energy), and the results for screw axle were (3.12e+07 N/m^2, 1.72e+08 N/m^2, 3.60e+07 N/m^2, 3.71e+07 N/m^2, 3.17e-02 mm, 1.91e+02N, 1.08e-04,1.41e+03 N.m/m^3, 4.41e-15 N.m) when applied 100 N as a torque load, this axle can press 5 times the added weight of fish waste. Also, for screw axis, the results of fatigue indices such as load factor and biaxiality were (7.72e+08, and 9.34e-01) respectively.

Key words: *Extruder Machine, solid works, Finite Element Analysis, Fatigue analysis*

INTRODUCTION

The expansion and development of science and technology, together with the current economic condition, has increased the challenges for the creation of various machines and gadgets to suit people's needs. The synergy between technological advancements and economic factors underscores the necessity for sustainable and resource-efficient solutions, encouraging a shift towards eco-friendly technologies [2].
According to a widely acknowledged hierarchy of waste management options, the main solution to be adopted is waste avoidance. Alternative activities to be done include the exploitation of trash for the recovery of added-value goods, which is an incredibly appealing option both environmentally and economically. The acts fall under the umbrella term "bio refinery," which refers to the sustainable conversion of biomass into energy and other bio based products [8].
The valorization of fish by-products, through innovative and sustainable practices, plays a pivotal role in minimizing fish waste and maximizing the utility of resources in the fishing industry. By extracting valuable components from fish processing waste, such as proteins, oils, and collagen, and transforming them into products. This approach embodies the principles of a circular economy, promoting a sustainable and responsible use of marine resources while simultaneously contributing to economic growth and environmental conservation [11].
Fish processing on an enormous scale generates a considerable quantity of by-products such as skins, heads, viscera, bones, and fins. In general, these fish leftovers, which make up 20-80% of the original fish, contribute significantly to worldwide garbage build-up. Fish waste, like other sources of omega-3 fatty acids, has high nutritional quality and potential for human consumption [10].
The lipid fraction derived from fish and fish by-products is known as fish oil. Fish oil is distinguished from other oils by the wide range of fatty acids it contains, including significant quantities of unsaturated fatty

acids. The market for liquid fish oil for human consumption may be classified into three categories: pharmaceutical components, healthy food components, and food sector commodities. The main free fatty acids (FFAs) found in fish oil are eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA).There is evidence that EPA and DHA improve human health by promoting correct cerebral development, the capacity to perceive and learn, and by modulating eicosanoid production, lowering the risk of cardiovascular disease. A mathematical model explaining the process of extracting fish oil utilizing mechanical screw press equipment would be ideal. Such a model may be used to define the extraction system's limitations as well as assess all variables involved, resulting in the optimization of system parameters. In industrial presses, the shafts feature discontinuous, non-continuous flights known as worm sections [3].

Traditional sources of 3-FAs include wild and aquaculture fish, however, due to rising demand, there is an urgent need for alternate and appropriate sources. Fish oil for human use is expected to reach 771,000 tonnes by 2025, according to projections [1].

Each oil extraction process, such as the screw press, hydraulic press, and solvent extraction, has its own set of benefits, design variants, operating size, technical implications, cost, personnel safety, and throughput dependability. There are various methods for converting fish to oil. The following processing stages are shared by all approaches of practical importance:

1-Heating coagulates proteins, destroys fat deposits and releases oil and physically and chemically bound water. 2- Press (or occasionally centrifuge) to remove most of the liquid from the mass 3-The liquid separates into oil and water (sticky water). If the oil content of the fish is less than 3%, you can skip this step.4-Concentration of the stick water (fish solubles) by evaporation [4].

Fish oil is typically extracted using a variety of methods, including solvent extraction, wet rendering, dry (steam) rendering, and wet pressing procedures. Extraction and purification of lipids using conventional methods, such as hexane extraction, vacuum distillation, or conventional crystallization, have the disadvantage of requiring high-temperature processing, which results in decomposition or degradation of the thermally labile compounds, and/or using toxic solvents with negative health effects [12].

Cold pressing is popular because of its wide range of applications, ease of use, lack of labor, cheap cost, environmental friendliness, lack of toxic organic solvents, and high-quality manufacturing capabilities. Also, cold presses are typically mechanically operated, with a screw mechanism tightened on the paste to remove the oils. Cold pressing often yields a lesser yield but a higher quality of oil [6].

Mechanical pressing is simpler and safer than other extraction methods. 'Cold-pressing' is one sort of pressing. Cold-pressed oils are extracted without the use of chemicals or heat, and they are nutritious, safe, pure, and organoleptically acceptable. Also, the oils from the cold press have high economic and nutritional significance [5].

SolidWorks is the industry standard for any complexity and purpose of solid modelling, automated design, engineering analysis, and product preparation. There are three primary system configurations available depending on the type of job to be solved: SolidWorks comes in three editions: Standard, Professional, and Premium [7].

FEA stands for Finite Element Analysis. It is a numerical technique used in engineering and physics to analyze the behaviour of structures, components, and systems under various conditions. FEA breaks down a complex physical system into smaller, simpler parts called finite elements. The behaviour of each element is then analyzed using mathematical equations to predict the overall response of the entire structure [9].

The finite element approach is the most often used method. For this method to work, the computational domain is initially divided into small pieces. A so-called localized support function is created for each element, which is a function that is specified just within that element [13].

The primary goal of fatigue analysis is to discover how materials and structures degrade, crack, or fail when subjected to repeated loading from factors such as vibration, heat cycling, or fluctuating mechanical forces. Fatigue analysis includes stress analysis, S-N curve, load history, and fatigue life prediction [14].

This study designed and evaluated an oil extruder machine by finite element and fatigue analysis. The primary goal of this study is to analyze the extruder machine by applying different loads for each part to extract the oil from fish wastes by using cold-pressing and extracting omega-3.

MATERIALS AND METHODS

The extruder was designed and simulated by Solidworks software at the Agricultural Engineering Department, Faculty of Agriculture, Tanta University.

Fish oil extrude machine

The fish oil extruder machine was designed by using Solidworks software as shown in Photo 1 and 2.

Photo 1. Fish oil extruder machine
Source: Author's' determination.

Photo 2. Parts of extruder machine
Source: Author's' determination.

The parts of the extruder were manufactured from different materials as shown in Table 1.

Table 1.Parts of extruder and material used

No	Name of part	Material
1	Feeder	Stainless Steel (ferritic)
2	Nozzle (barrel)	
3	Filter mesh	
4	Pressure chamber 1	Alloy Steel
5	Screw axis	Stainless Steel (ferritic)
6	Pressure chamber 2	
7	Die	Alloy Steel

Source: Author's determination.

Material properties are presented in Table 2.

Table 2. Material properties

Items	Value
Stainless Steel (ferritic)	
Yield strength	$1.7233e^{+08}$ N/m^2
Tensile strength	$5.1363e^{+08}$ N/m^2
Elastic modulus	$2e^{+11}$ N/m^2
Poisson's ratio	0.28
Mass density	7800 kg/m^3
Shear modulus	$7.7e^{+10}$ N/m^2
Alloy Steel	
Yield strength	$6.20422e^{+08}$ N/m^2
Tensile strength	$7.23826e^{+08}$ N/m^2
Elastic modulus	$2.1e^{+11N}$/m^2
Poisson's ratio	0.28
Mass density	7700 kg/m^3
Shear modulus	$7.9e^{+10}$ N/m^2

Source: Author's determination.

Volumetric properties are shown in Table 3.

Table 3. Volumetric properties of feeder, nozzle(barrel), pressure chamber 1, screw axis, pressure cage 2

Items	Value
Feeder	
Mass	1.28796 kg
Volume	0.000165123 m^3
Weight	12.622 N
Nozzle (barrel)	
Mass	1.85008 kg
Volume	0.00023719 m^3
Weight	18.1308 N
Pressure chamber 1	
Mass	4.70347 kg
Volume	0.000610828 m^3
Weight	46.094 N
Screw axis	
Mass	2.95656 kg
Volume	85. 91 m^3
Weight	29 N
Pressure cage 2	
Mass	0.6311 kg
Volume	$8.08991e^{-05}$ m^3
Weight	6.184 N

Source: Author's determination.

Applied loads and Meshing

A pressure load was applied to the feeder, nozzle, pressure chamber 1and 2 were 3 Mpa for each one respectively. For the screw barrel, the load was 100 N.m. Also, meshing in FEA is the process of dividing a complex geometry into a finite number of simple, interconnected elements. The purpose of meshing is to discretize the physical structure or component under analysis so that numerical methods can be applied to solve engineering problems (Photo 3 and 4).

Load Name	Part Image	Part Details
Pressure		Value:3 Mpa Total Nodes:8657
		Value:3 Mpa Total Nodes:49468
		Value:3 Mpa Total Nodes:12598
		Value: 3 Mpa Total Nodes10175
Torque		Value: 100 N Total Nodes:6914

Photo 3. Applied loads of extruder parts
Source: Author's determination.

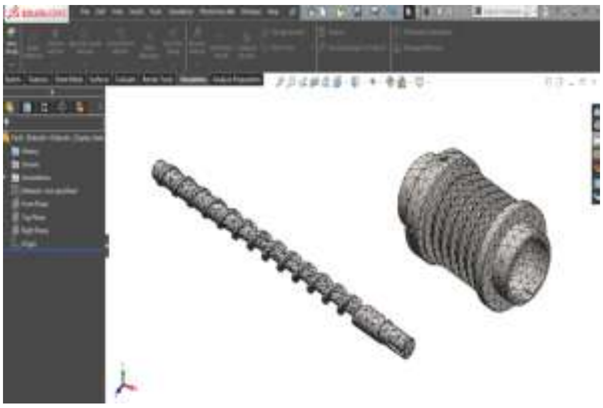

Photo 4. The meshing process of extruder parts
Source: Author's determination.

Finite Element Analysis

Using Solidworks software to measure the finite element indicators such as von mises stress (is a critical measure used to assess the potential for yielding or failure in a material under complex loading conditions), yield strength (is a critical mechanical property that indicates the stress at which the material undergoes plastic deformation or yielding), INT (stress intensity is a measure used to evaluate the severity of stress concentrations or singularities in a structure), TRI (triaxle stress refers to a stress state in which three principal stresses are acting on a material or structure in three mutually perpendicular directions), static displacements (refer to the calculated or predicted movements or deformations of a structure or component under applied loads when the system is in static equilibrium), RFRES (resultant reaction refers to the total force exerted by a structure or component at a particular boundary or support point in response to applied loads force), ESTRN (equivalent strain is a single scalar value used to represent the overall deformation or strain experienced by a material or structure), SEDENS (strain energy density refers to the amount of energy stored per unit volume in a material due to deformation), and ENERGY (total strain energy refers to the cumulative amount of energy stored in a structure or component due to deformation under applied loads.) of oil extruder parts.

- Von Mesies, MPa

$$\text{V.Mises}=\{\frac{[(\sigma1-\sigma2)^2+(\sigma2-\sigma3)^2+(\sigma1-\sigma3)^2]}{2}\}^{\frac{1}{2}}\ldots(1)$$

-Yield Strength, MPa

$$\text{Yield Strength}=\frac{\text{Stress at Yield}}{\text{Original Cross}-\text{Sectional Area}}\ .(2)$$

-INT (stress intensity), N/m^2

INT= σ∗sqrt(pi∗a)……………………..….(3)

-RFRES (resultant reaction force), N

$$\text{RFRES}=\sum_{i=1}^{n} Ri\ldots\ldots\ldots\ldots(4)$$

-Equivalent strain

$$\text{ESTRN}=2[\frac{(\varepsilon1+\varepsilon2)}{3}]^{\frac{1}{2}}\ldots\ldots\ldots\ldots(5)$$

$$\varepsilon_1=0.5[\quad(\text{EPSX}-\varepsilon^*)2+(\text{EPSY}-\varepsilon^*)2+(\text{EPSZ}-\varepsilon^*)2\ ]\ldots\ldots\ldots\ldots(5\text{-}1)$$

$$\varepsilon_2=\frac{[(\text{GMXY})2+(\text{GMXZ})2+(\text{GMYZ})2]}{4}\ldots\ldots\ldots(5\text{-}2)$$

$$\varepsilon_*=\frac{(\text{EPSX}+\text{EPSY}+\text{EPSZ})}{3}\ldots\ldots\ldots\ldots(5\text{-}3)$$

-URES

URES=$\sqrt{X^2+Y^2}$…………………………(6)

-SEDENS (strain energy density), Nm/m^3
SEDENS =$0.5\sigma * \epsilon$………………………..(7)

-ENERGY (total strain energy), N.m
ENERGY=$\int V * 0.5\sigma ij * \epsilon ij\, dV$ ………..(8)

where:
-EPSX, EPSY, and EPSZ= Normal strain in the X.Y.Z -direction of the selected reference geometry.
-GMXY, GMXZ, and GMYZ= Shear strain in the Y, Z direction in the YZ- XZ plane of the selected reference geometry.
- ε 1, ε 2, and ε 3 =Normal strain in the first, second, and third principal direction.
- $\sigma 1\backslash\sigma 2\backslash\sigma 3$= principal stresses. X= is the first direction that the object is traveling. Y= the second direction that the object is traveling.
-σ = the applied stress
- a = the length of the crack or the distance from the centre of the crack to the point of interest.
- $e =$ represents each element in the computational domain.
(approximation) obtained by the finite element method.
-u= represents the exact or reference solution.
- Ri = represents the reaction forces at each support point or node in the direction of interest.
-n= is the total number of support points or nodes that provide reactions in that direction.
- σ =is the applied stress.
-ϵ = is the corresponding strain (deformation) that results from the applied stress
- Ωe= is the domain of each element.
-∇uh = represents the numerical solution.
- σij =represents the components of the stress tensor.
- ϵij = represents the components of the strain tensor.
-V = is the volume of the deformable body.

Fatigue Analysis

Solidworks simulation was used to measure the fatigue indicators such as damage, total life cycles, load factor, biaxiality, and stress amplitude.

-Biaxiality Indicator

Biaxiality is defined as the smallest principal stress divided by the largest principal stress, neglecting the principal stress closest to zero. A value of zero corresponds to uniaxial stress, a value of -1 to pure shear, and a value of 1 to pure biaxial stress. In this example, the majority of the model is subjected to purely uniaxial loading, with parts exhibiting both pure shear and near-pure biaxiality. Using the biaxial map in conjunction with the factor of safety plot, it is clear that the most damaged point occurs where primarily uniaxial stresses occur. If the most damaged area was exposed to pure shear, it would be preferable to use S-N data gathered by torsional loading.

-Damage

To calculate the fatigue damage, the ratio of the nominal service life to the available service life is used. The default duration can be set explicitly. Values greater than one for fatigue damage indicate failure before reaching nominal life Damage=$\frac{n1}{N1}+\frac{n1}{N1}+\frac{n1}{N1}+\frac{n1}{N1}\dots\dots\frac{ni}{Ni}$………(9)

-Total life cycles

Total life cycles refer to the number of loading cycles that a material or structure can undergo before fatigue failure occurs. Fatigue failure is a type of structural failure that occurs due to repeated cyclic loading, even if the applied loads are below the material's static strength limit.

Total life cycles =$(\frac{Se}{\sigma a})^b$…………………(10)

-Load factor

In fatigue analysis, the load factor is a multiplier applied to the loads experienced by a structure to account for uncertainties or variations in the actual loading conditions. It is used to estimate the effect of potential load fluctuations, dynamic effects, and other uncertainties that may impact the structure's fatigue life.
The load factor is typically denoted by the symbol "γ" (gamma) and is applied to the nominal or expected loads. The formula for calculating the factored load is:
Load factor=$\frac{\text{Load Design Value}}{\text{Load Calculation Value}}$………..(11)

-Stress amplitude, Mpa

In fatigue analysis, stress amplitude refers to the range of stress values experienced by a material during a single loading cycle. It is a key parameter in understanding how cyclic loading affects the fatigue life of a material or structure. The stress amplitude is often denoted as "Δσ" is calculated as the difference between the minimum and maximum stress values during a loading cycle.

Stress amplitude=$\sigma a=\frac{\sigma\ max-\sigma\ min}{2}$……….(12)

where:

-n1,n2,n3,…,ni = the number of cycles experienced at various stress levels or load amplitudes during the life of the component.

-N1,N2,N3,…,Ni = the fatigue life or endurance limits corresponding to those stress levels or load amplitudes.

-Se = the endurance limit (also known as the fatigue strength or fatigue limit) of the material, representing the stress level below which the material can endure an infinite number of cycles without failure.

-σa = the stress amplitude, which is the difference between the maximum and minimum stress levels in a loading cycle.

-b=the fatigue exponent, which is a material property determined from experimental data.

- σmax = the maximum stress experienced during a loading cycle.

- σmin = the minimum stress experienced during the same loading cycle.

RESULTS AND DISCUSSIONS

The values of finite element indices such as Von Mesies, yield strength, INT, TRI, displacements, RFRES, ESTRN, SEDENS, and ENERGY were ($1.049e^{+07}$ N/m^2, $1.723e^{+08}$ N/m^2, $1.175e^{+07}$ N/m^2, $6.679e^{+06}$ N/m^2, $5.519e^{-03}$mm, $1.30e^{+02}$N,$4.11e^{-05}$, $2.76e^{+2}$ N.m/m^3, and $1.35e^{-5}$ N.m) respectively as shown in Photo 5.

Also, for the nozzle part, the results for the same indices were ($4.90e^{+05}$ N/m^2, $1.73e^{+08}$ N/m^2, 5.10^{+05} N/m^2, 5.93^{+05} N/m^2, $3.74e^{-05}$mm, $4.13e^{+00}$N,$1.75e^{-06}$, $4.44e^{-1}$ N.m/m^3, and $4.45e^{-09}$ N.m) respectively as shown in Photo 6.

In Photo 7, the pressure chamber 1 showed the values of the same indices were ($2.47e^{+05}$ N/m^2, $6.20e^{+08}$ N/m^2, $2.65e^{+05}$ N/m^2, $3.78e^{+05}$ N/m^2, $3.35e^{-05}$mm, $6.59e^{+00}$N, $9.35e^{-07}$,$1.40e^{-01}$N.m/m^3, and $1.49e^{-08}$ N.m) respectively.

Photos 8 and 9 showed the results of pressure camber 2 and screw axis for previous indices were ($6.26e^{+01}$,$7.503e^{+07}$ N/m^2), ($1.72e^{+08}$,$1.723e^{+08}$N/m^2), ($6.50e^{+1}$,$7.82e^{+07}$ N/m^2), ($1.052e^{+02}$,$6.13e^{+07}$ N/m^2), ($6.09e^{-09}$,$4.32e^{-0}$ mm), ($6.516e^{-04}$,$4.71e^{+02}$N), ($2.16e^{-10}$,$2.79e^{-04}$), ($6.376e^{-09}$,1.18e+04 N.m/m^3), and ($5.486e^{-16}$,$1.52e^{-03}$ N.m) respectively.

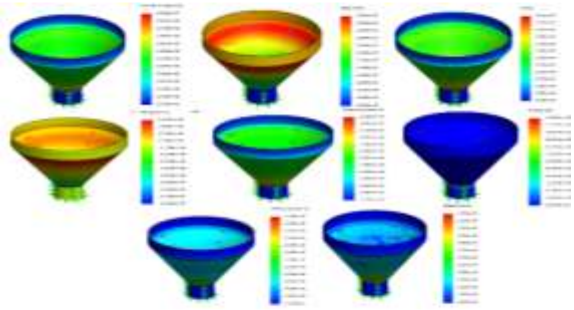

Photo 5. Finite element indices of feeder
Source: Author's determination.

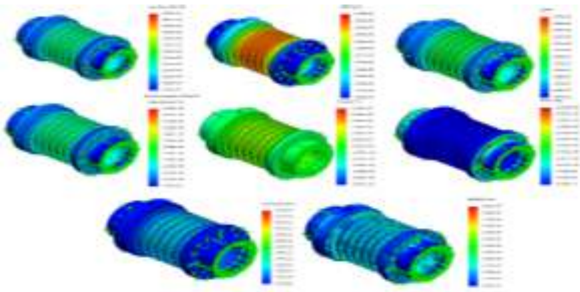

Photo 6. Finite element indices of nozzle (barrel)
Source: Author's determination.

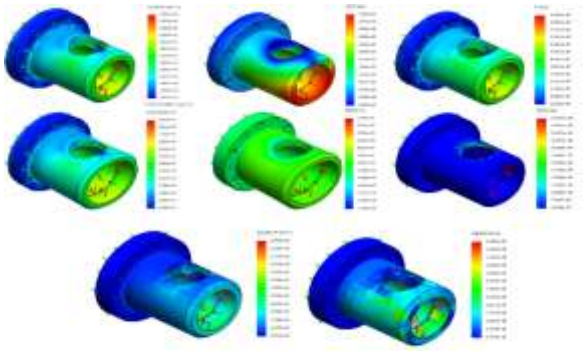

Photo 7. Finite element indices of pressure chamber 1
Source: Author's determination.

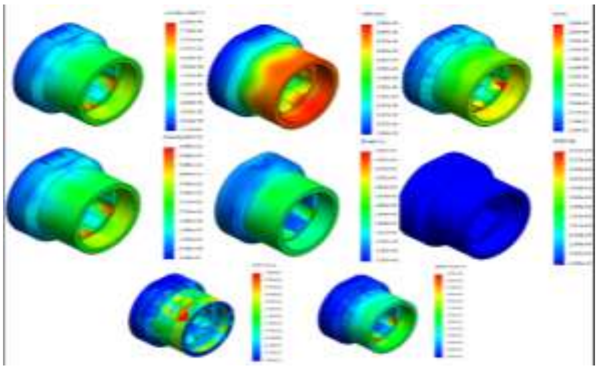

Photo 8. Finite element indices of pressure chamber 2
Source: Authors' determination.

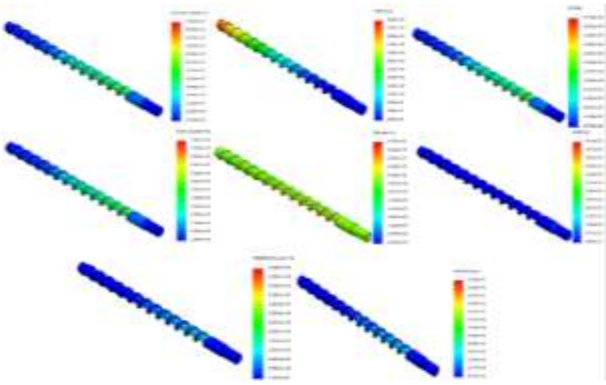

Photo 9. Finite element indices of screw axis
Source: Author's' determination.

Based on fully reversed (LR=-1) loading type, the values of fatigue indices such as damage, load factor, biaxiality, and stress amplitude when applied number of cycles= 10^6 of screw axle were (1.00^{e+00}, $7.72e^{+08}$, $9.34e^{-01,}$ and 87.09 Mpa) respectively as shown in Photo 10 and Fig. 1. Also, the same indices for pressure chamber 2 were ($1.01e^{+00}$, $7.13e^{+08}$, $1.001e^{+06}$, and 95.2 Mpa) respectively as shown in Photo 11 and Fig. 2. For nozzle (barrel) part, the results were (97.5 Mpa, $9.94e^{-01}$, $1.32e^{+09}$, and $1.001e^{+00}$) for stress amplitude, load factor, biaxiality, and damage indices respectively as shown in Photo 12 and Fig. 3. Also, as shown in Photos 13 and Fig. 4, the results of previous indices of hopper were (93.7 Mpa, $2.26e^{+05}$, $9.77e^{-01}$, $1.00e^{+05}$, and $1.01e^{+01}$) respectively. The values of fatigue indices such as damage, load factor, biaxiality, and stress amplitude when applied number of cycles= 10^6 of screw axle were (1.001^{e+00} ,$1.38e^{+05}$,$8.75e^{-01}$,$1.001e^{+06}$, and 83.09 Mpa) respectively as shown in Photo 14 and Fig. 5.

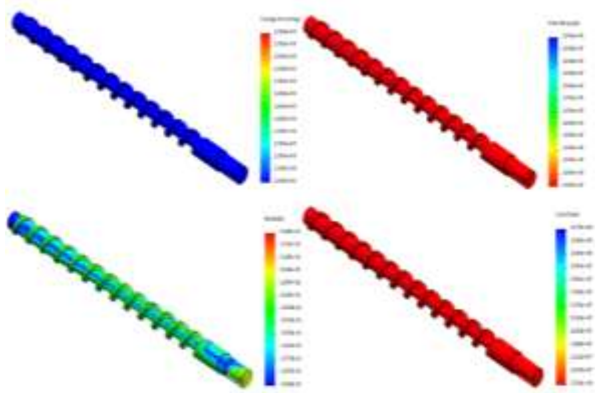

Photo 10. Fatigue indices of screw axis
Source: Author's determination.

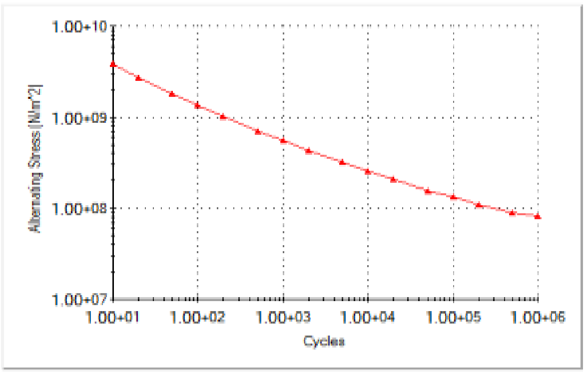

Fig. 1. Relationship between alternating stress and cycles of screw axis
Source: Author's determination.

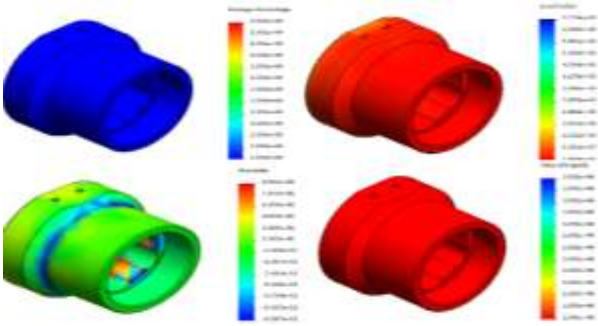

Photo 11. Fatigue indices of pressure chamber 2
Source: Author's determination.

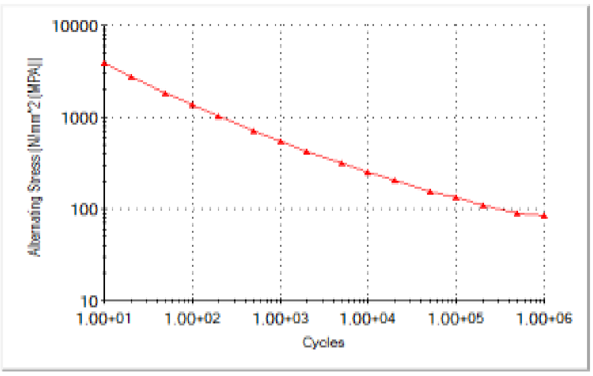

Fig. 2 Relationship between alternating stress and cycles of pressure chamber 2
Source: Author's determination.

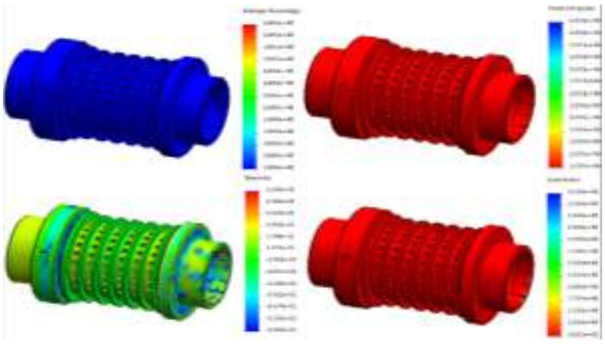

Photo 12. Fatigue indices of nozzle (barrel
Source: Authors' determination.

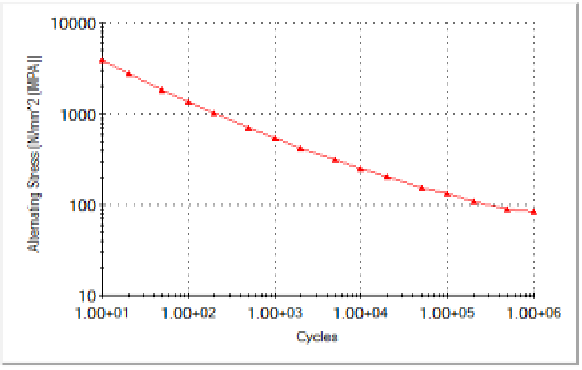

Fig. 3. Relationship between alternating stress and cycles of nozzle (barrel)
Source: Author's determination.

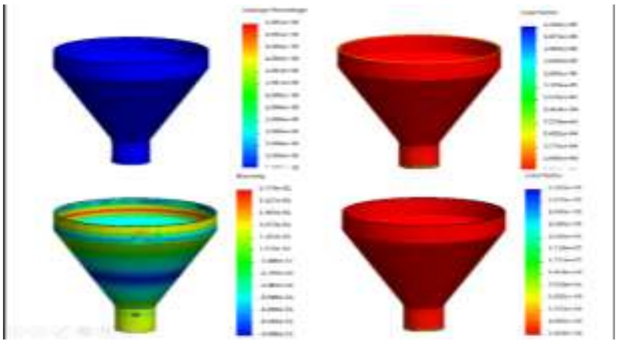

Photo 13. Fatigue indices of feeder
Source: Author's determination.

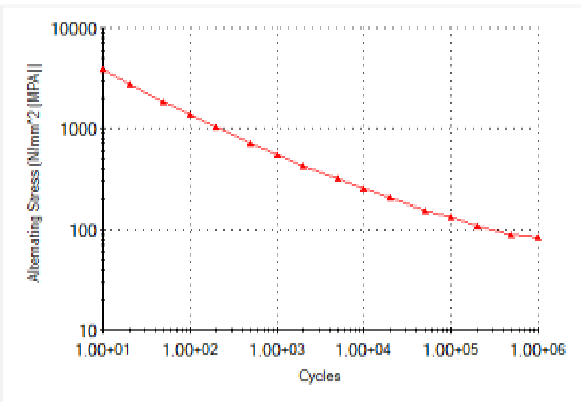

Fig. 4. Relationship between alternating stress and cycles of feeder
Source: Author's determination.

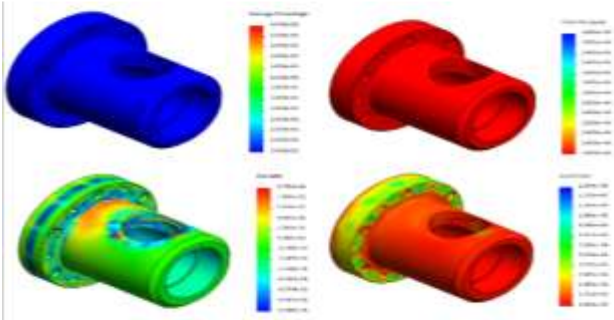

Photo 14. Fatigue indices of pressure chamber 1
Source: Author's determination.

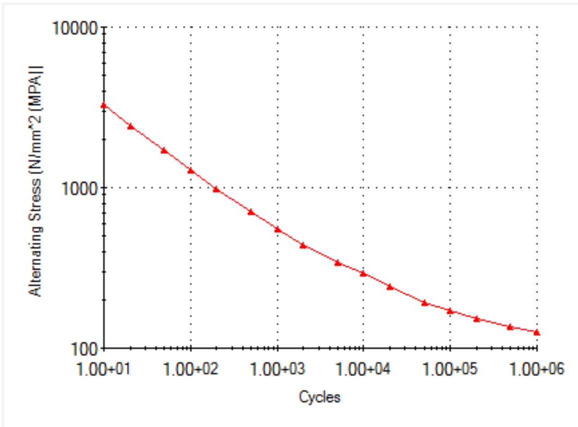

Fig. 5. Relationship between alternating stress and cycles of pressure chamber 1
Source: Author's determination.

CONCLUSIONS

The finite element method was used to examine the strength and deformation of solid materials with complex geometric shapes. The extruder was divided into a finite large number of small, simple-shaped parts, their physical behavior can be well calculated due to its simple geometry with familiar approach functions. The physical behavior of the entire body is reproduced by how these elements react to forces, loads and constraints, how they react to loads and in the transition from one element to the next deployment through specific continuity conditions that depend on the problems and which must fulfill the functions of the approach. The study showed the extruder parts will not fail according to the applied loads, the screw axle can press 5 times the added weight of fish waste.

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USING HYPERSPECTRAL DATA FORMONITORING AND OBSERVATION OF FABA BEAN CROP GROWTH

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Abstract

The optical imagery at high spatial resolution to monitoring and observation of faba bean crop growth obtained from The Sentinel-2 sensor during November 2021 to February 2022 (daytime) were used. Thirteen bands of multispectral data covering the visible, near-infrared, and short wave infrared portions of the spectrum using to monitor land cover change for environmental monitoring. A surface emissivity calculation is the first step of land surface temperature observation and finding the agricultural indices of faba bean crop.The emissivity per pixel was obtained directly from Sentinel-2 sensor data. Natural surfaces at the resolution of 30 m are heterogeneous and they differ from each other in their emissivity. In the present study, surface emissivity was evaluated by analysis of NDVI, NDMI, SWIR, NDWI, Agriculture Composite, and SAVI of vegetation cover per pixel, and the maximum values of climatic indices such as sunshine duration, relative humidity, long, short wave radiation, ultraviolet radiation direct, diffuse radiation, soil temperature, FAO reference evapotranspiration (Eto.The results showed the monthly composite pictures which produced using to generate correct crop growth findings by comparing band reflectance values, vegetation indices, and environmental indicators.

Key words: *Faba bean, Sentinel-2, Monitoring, NDVI, NDMI, SWIR, NDWI*

INTRODUCTION

Faba bean (*Viciafaba* L.) was one of the first crops cultivated around 10,000 years ago. It is cultivated on every inhabited continent, with around 4 million tonnes produced per year. Of the starch-containing legumes, it has the greatest protein content, with a global average of 29% dry matter and a global average yield of 2.0 t/ha, indicating a high potential protein output per hectare in favourable conditions [1].

In the Mediterranean Basin, faba beans are often seeded in October to take advantage of the rainy winter months [9].

Its cultivation throughout the globe has undergone a fall since the middle of the twentieth century, with the area declining from more than 830,000 hectares in the early 1960s to only 109,000 ha in 2021 [3].

Viciafaba L. is a multi-purpose crop that is highly appreciated throughout North and East Africa; yet, output is still below demand, and productivity is low in many countries. This is mostly due to several issues, including the prevalence of low-yielding cultivars, a poor seed system in many areas, vulnerability to abiotic and biotic challenges, a lack of better cultivars, and a lack of expansion [2].

Furthermore, it ranks top among the cold season food legumes produced in North and East Africa, with output averaging 1.6 and 0.7 million tonnes collected from 0.76 and 0.07 million hectares for dry and green faba beans, respectively [5].

Faba bean green pods and grains are gaining popularity in North African countries such as Egypt (190,937 tonnes), in addition to their traditional use as dry seeds (39,629 tonnes) [12].

Satellite remote sensing has already helped researchers improve and map minerals, rock kinds, crop growth, and other geological and agricultural properties. Since the introduction of Landsat-1 in 1972, the use of satellite pictures for agricultural research, particularly mapping agricultural units, has progressed significantly and successfully by employing multispectral data from the Advanced Space borne Thermal Emission and Reflection Radiometer Sentinel-2 [8].

Image processing technologies was utilized to automatically evaluate the size and shape of faba bean during growth periods. Shape measurement methods are mostly based on these models and are necessary for an accurate description, enabling comparison between polymorphisms or developmental periods [6].

Different ways that combine these methodologies with machine learning techniques have also been presented for observing agricultural growth. Spectral indices are only used to extract vegetation characteristics if the approaches are simple and effective enough. These include the false color composite index, normalized difference vegetation index (NDVI), enhanced vegetation index (EVI), barren soil visualization index, moisture stress NDMI, agriculture composite index, and normalized difference moisture index (NDMI) [13].

To develop reliable crop classification maps, multitemporal techniques must be used, as cultivations vary their spectral and textural appearance depending on the crop type growth cycle. Sentinel 2 data, which provides dense Time Series (TSs) of multispectral pictures with great spatial resolution, is a valuable information source [11].

The utilization of multi-temporal remote sensing data for enhanced spectral feature recognition and change detection is critical to crop-growth mapping, and optical Sentinel-2 multi-temporal imaging gives more accurate information and an improvement in classification accuracy in this way [7].

Temperature, sunshine duration, solar radiation, longwave radiation, UV radiation, direct radiation, diffuse radiation, soil temperature, and evapotranspiration are some of the climatic factors that affect faba bean cultivation.

Temperature influences the germination, growth, flowering, and pod formation of beans.

The optimal temperature range for beans is 15-25°C.

Sunshine duration and solar radiation determine the amount of photosynthesis and biomass production of fab beans.

The optimal sunshine duration for beans is 8-10 hours per day. Solar radiation consists of different components, such as direct radiation from the sun, diffuse radiation from the sky, and longwave radiation from the atmosphere. Direct radiation is more intense and beneficial for beans than diffuse radiation, but it can also cause heat stress and water loss. Diffuse radiation can penetrate deeper into the canopy and enhance the photosynthesis of lower leaves. Longwave radiation is the main source of heat loss for faba beans at night. UV radiation can damage the DNA and proteins of beans, reducing their yield and quality. Soil temperature affects the root growth and nutrient uptake of beans. The optimal soil temperature for beans is 16-24°C. Evapotranspiration is the combined loss of water from the soil and the plant surface. It influences the water balance and irrigation requirements of faba bean. The optimal evapotranspiration rate for beans is 4-6 mm/day [15].

The objective of this study was the possibility of using the satelliteimages to monitoring and observation of faba bean crop growth starting from agriculture to harvesting and measuring agricultural and climatic indicators during that period based multispectral imager bands of sentinel-2.

MATERIALS AND METHODS

A field experiment was conducted to grow faba bean in the village of KafrEssam - Gharbia - Egypt, studying the vegetative and environmental indicators from planting in November 2021 until harvesting in February 2022, and monitoring and analysing developments in the Department of Agricultural Engineering - Faculty of Agriculture - Tanta University. As shown in Photo 1 and scientific classification of faba bean crops was shown in Table 1.

Photo 1. Faba bean crops
Source: Authors' determination.

Table1. Scientific Classification of Faba Bean Crops

Kingdom	**Plantae**
Family	Fabaceae
Genus	Vicia
Order	Fabales
Tribe	Fabeae
Subfamily	Faboideae

Source: Wikipedia, Viciafaba, https://en.wikipedia.org/wiki/Vicia_faba [14].

Satellite Data

is an Earth observation mission from the Copernicus and sentinel hub (EO)programme that provides high-resolution images in the visible and infrared wavelengths, to monitor vegetation, soil and water cover, and inland waterways as shown in Photo 2 and the specification of the satellite was shown in Table 2. Also, the Spatial resolutions were 10m, 20m, and 60m, depending on the wavelength as shown in Table 3.

Photo 2. Model of a Sentinel-2 satellite
Source: https://earth.esa.int/web/sentinel/technical [4].

Table 2. Specification of Sentinel-2 satellite

Manufacturer	**Astrium/Airbus**
	Thales Alenia Space
	Boostec
	Jena-Optronik
Operator	European Space Agency
Applications	Land and sea monitoring, natural disasters mapping, sea ice observations, ships detection

Source: https://earth.esa.int/web/sentinel/technical [4].

Table 3. Spectral bands for the SENTINEL-2 sensors

Sentinel-2 bands	**Central wavelength, µm**	**Resolution, m**
Band 1-coastal aerosol	0.443	60
Band 2-blue	0.490	10
Band 3-green	0.560	10
Band 4-red	0.665	10
Band 5-vegetation red edge	0.705	20
Band 6- vegetation red edge	0.740	20
Band 7- vegetation red edge	0.783	20
Band 8-NIR	0.842	10
Band 8A- vegetation red edge	0.865	20
Band 9-water vapour	0.945	60
Band 10-SWRI-cirrus	1.375	60
Band 11- SWRI	1.610	20
Band 12- SWRI	2.190	20

Source: https://www.numerade.com [10].

Copernicus browser

The Copernicus program is a European Union initiative that aims to provide reliable and up-to-date Earth observation data for a variety of applications, including environmental monitoring, and climate change analysis. The Sentinel satellites are a key component of the Copernicus program, providing high-quality and frequent Earth observation data as shown in Photo 3.

Sentinel hubbrowser

Sentinel Hub is a platform that provides access to Earth observation (EO) data, specifically satellite imagery. Sentinel Hub is known for its integration with the European Space Agency's (ESA) Copernicus program, which includes the Sentinel satellites.

Sentinel Hub simplifies the process of accessing and analysing satellite imagery by offering a cloud-based infrastructure and an application programming interface (API) as shown in Photo 4.

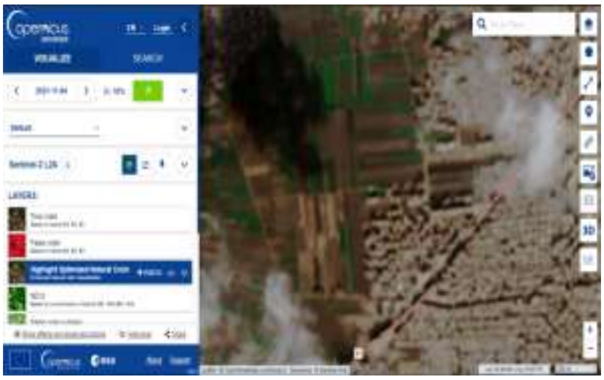

Photo 3. Copernicus browser interface
Source: Authors' determination.

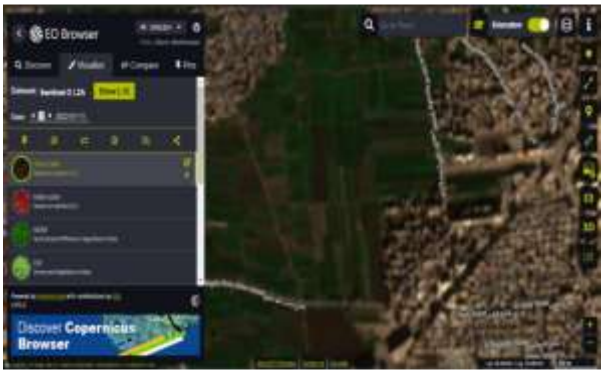

Photo 4. Sentinel hub browser interface
Source: Authors' determination.

Experimental Field

The experimental field was located in KafrEssam, Tanta Governorate. between 30°48'15.9"N 30°58'56.2"E. The experimental field was plowed to a depth of 15 cm and leveled by a leveler machine. Also, the experimental field was irrigated abundantly once before planting for weed resistance. Also, after planting, the crop was fertilized using 45 kg of ammonium sulphate + 2 kg of potassium sulphate + 35 kg of superphosphate. Two weeks after planting, the crop was sprayed with 60 g of iron - 60 g of zinc - 60 g of manganese - 0 2 g of iron - 60 g of copper - 2 kg of urea. Photo 5 shows the true color of the farmland (based on B4, B3, and B2) before planting faba bean seeds.

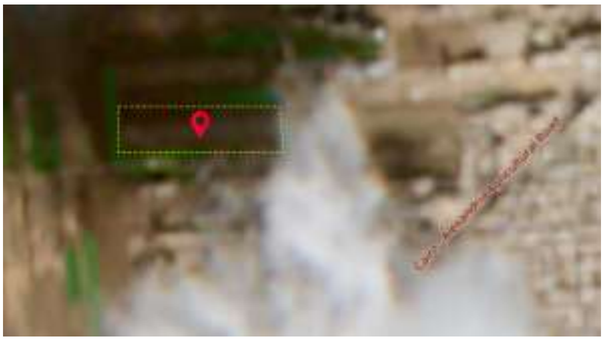

Photo 5. Farmland bySENTINEL-2
Source: Authors' determination.

-Visualization Of Agricultural Indices

False Color Composite Index

A false color compositebased on B8, B4, and B3)uses at least one non-visible wavelength to image Earth. The false color composite using near-infrared, red, and green bands is very popular (a band is a region of the electromagnetic spectrum; a satellite sensor can image Earth in different bands). The false colour composite is most commonly used to assess plant density and health, since plants reflect near infrared and green light, while they absorb red. Cities and exposed ground are grey or tan, and water appears blue or black.

Normalized Difference Vegetation Index (NDVI)

NDVI built on a combination of bands (B8 and B4)is a simple, but effective index for quantifying green vegetation. It is a measure of the state of vegetation health based on how plants reflect light at certain wavelengths. The NDVI has a value range of -1 to 1. Water is represented by NDVI values that are negative (numbers that are close to -1). Arid patches of rock, sand, or snow are typically represented by values near zero (-0.1 to 0.1). Shrub and grassland are represented by low, positive values (between 0.2 and 0.4), while temperate and tropical rainforests are represented by high values (values close to 1) as shown in Photo 6.

$$NDVI=\frac{B8-B4}{B8+B4} \quad (1)$$

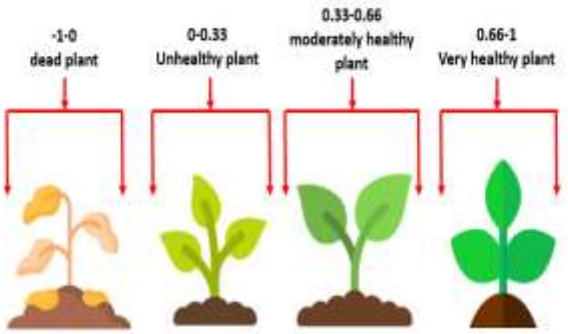

Photo 6. Normalized Difference Vegetation Indexof plants
Source: Authors' drawing.

Normalized Difference Moisture Index (NDMI)
The normalized difference moisture Index (NDMI)based on (B8 and B11) is used to determine vegetation water content and monitor droughts. The value range of the NDMI is -1 to 1. Negative values of NDMI (values approaching -1) correspond to barren soil. Values around zero (-0.2 to 0.4) generally correspond to water stress. High, positive values represent high canopy without water stress (approximately 0.4 to 1).

NDMI=$\frac{B8-B11}{B8+B11}$................................(2)

Short Wave Infrared Composite (SWIR).
Short wave infrared (SWIR) measurements (based on bands B12, B 8A, B4)can help estimate how much water is present in plants and soil, as water absorbs SWIR wavelengths.

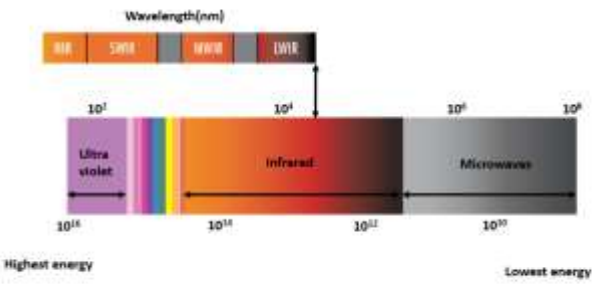

Photo. 7. Electromagnetic Spectrum Illustrating SWIR Wavelength Range
Source: Authors' drawing.

Short wave infrared bands (a band is a region of the electromagnetic spectrum) are also useful for distinguishing between cloud types (water clouds versus ice clouds), snow, and ice, all of which appear white in visible light. In this composite vegetation appears in shades of green, soils and built-up areas are in various shades of brown, and water appears black as shown in Photo 7.

Normalized Difference Water Index (NDWI)
NDWI Index based on a combination of bands (B3 and B8) is a remote sensing index that is commonly used to identify the presence of water in various environments and is particularly useful for distinguishing between water bodies and other land cover types. It is based on the fact that water absorbs light in certain spectral bands, leading to differences in reflectance values.

NDWI=$\frac{B3-B8}{B3+B8}$................................(3)

Agriculture Composite
This composite based on bands B11, B8, B2 uses short-wave infrared, near-infrared and blue bands to monitor crop health (a band is a region of the electromagnetic spectrum). Both short-wave and near infrared bands are particularly good at highlighting dense vegetation, which appears dark green in the composite. Crops appear in a vibrant green and bare earth appears magenta.

Soil Adjusted Vegetation Index (SAVI).
The soil adjusted vegetation index is similar to (NDVI) but is used in areas where vegetative cover is low (< 40%). The index is a transformation technique that minimizes soil brightness influences from spectral vegetation indices involving red and near-infrared (NIR) wavelengths. The index is helpful when analysing young crops, arid regions with sparse vegetation and exposed soil surfaces.

SAVI=$\frac{B8-B4}{B8+B4+L}x(1+L)$.....................(4)
where:
L is the soil brightness correction factor and could range from (0 -1).

-Climatic And Environmental Indices.
Sunshine Duration
Sunshine duration, which is usually expressed in hours per day, is the length of time that the sun is visible or the amount of sunshine that occurs over a given period of time. The

following formula can be used to determine the length of sunshine, and it is based on the ratio of the actual length of sunshine to the maximum length of sunshine that can occur in a given period:

$$SD=\frac{ActualSunshineDuration}{\text{Maximum Possible Sunshine Duration}}\,x24,\text{min} \quad \ldots\ldots\ldots(5)$$

Relative Humidity

Relative Humidity (RH) is a measure of the amount of moisture present in the air compared to the maximum amount of moisture the air can hold at a specific temperature. It is expressed as a percentage and indicates how close the air is to being saturated with moisture, andis given by the following formula:

$$RH=\frac{\text{Actual Water Vapor Pressure}}{\text{Saturated Water Vapor Pressure at the Same Temperature}}\,x100(6)$$

Longwave Radiation

Terrestrial, thermal, and infrared radiation are other names for long wave radiation. It is electromagnetic radiation that falls between about 3 and 100 mm in the spectral band. This range of emissions is produced by Earth surface temperatures, with the highest terrestrial radiation occurring at a wavelength of roughly 10 mm. Spectrally combined longwave radiation can be estimated from the Stefan-Boltzmann equation:

$$Q=\varepsilon\sigma A\,T^4 \ldots\ldots\ldots(7)$$

where:
Q is the longwave radiation (in watts) emitted by the surface, W/m^2
ε is the emissivity of the surface, which ranges from 0 to 1 and represents the efficiency of the surface in emitting radiation.
σ is the Stefan–Boltzmann constant (5.67×10^{-8} W m^{-2}K^{-4}).
A is the surface area of the emitting body, m^2
T is the absolute temperature of the emitting body in Kelvin.

Ultraviolet Radiation, W/m^2

UV radiation is a form of electromagnetic radiation with shorter wavelengths than visible light but longer wavelengths than X-rays. It is invisible to the human eye.

Direct Radiation, W/m^2

The solar radiation that travels in a straight line from the Sun to the Earth's surface is referred to as direct radiation, sometimes known as direct sunlight or direct solar radiation. It is the portion of solar radiation that passes through the atmosphere of Earth directly without being absorbed or scattered by particles, water vapor, or other gases in the atmosphere.

$$P=A\,G\,\cos\theta,\ \text{W/m}^2 \ldots\ldots\ldots(8)$$

where:
A is the surface area perpendicular to the sun's rays, m^2
G is the solar constant (approximately 1361 W/m^2)
θ is the angle of incidence of the sun's rays on the surface.

Diffuse Radiation, W/m^2

Diffuse radiation refers to solar radiation that reaches the Earth's surface after being scattered or reflected by the atmosphere.

$$D=K_d x\, I_{extraterrestrial},\ \text{W/m}^2 \ldots\ldots\ldots(9)$$

where:
K_d is the diffuse fraction, representing the ratio of diffuse radiation to extra-terrestrial radiation,
$I_{\text{extra-terrestrial}}$ is the extra-terrestrial solar radiation on a horizontal surface (in W/m²).

Soil Temperature, ºC

Soil temperature refers to the measure of the thermal energy present in the soil. It is an important parameter that influences various soil processes, and plant growth activity.

FAO Reference Evapotranspiration (ET_o)

Evapotranspiration is a combined process involving the evaporation of water from surfaces and the transpiration of water from plants.

$$ET_o=\frac{0.408\,\Delta(R_n-G)+\gamma\left(\frac{900}{T+273}\right)u2\,(e_s-e_a)}{\Delta+\gamma(1+0.34\,u2)},\ \text{mm}\ldots\ldots(10)$$

where:
R_n the net radiation at the crop, MJ m^{-2} day^{-1}
G is the soil heat flux density, MJ m^{-2} day^{-1}
Δ the slope of the saturation vapour pressure curve, KPa/^{o}C,
γ the psychometric constant, KPa/^{o}C,

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T is the mean daily air temperature at 2 meters above the ground, ^{o}C
u2 is the wind speed at 2 meters above the ground/s
e_s is the saturation vapour pressure, KPa
e_a is the actual vapour pressure, KPa

Shortwave Radiation

The term "shortwave radiation" describes the solar radiation that reaches Earth's surface. Shorter wavelength electromagnetic waves, such as visible light and some ultraviolet (UV) and infrared (IR) radiation, make up the majority of it.

Although the sun emits energy across a wide range, shortwave radiation makes up the majority of solar radiation that reaches Earth.

Shortwave Radiation (SW)=Solar Constant×Solar Declination×(cos(Latitude)×cos(Solar Hour Angle)×sin(Solar Elevation Angle)+ $\frac{2\pi \; x \; 10^{-7}}{8000}$ xElevation, W/m^2 ……………... .(11)

RESULTS AND DISCUSSIONS

Data sets for the research region are provided for four time periods (November, December, January, and February) through season 2021-2022, processed togive resemble false-color infrared photography, with red indicating the presence of thick green vegetation, as shown in Photo 8. It also offers a clear indication and overview of the sorts of changes that have occurred throughout the region over the last many months (faba bean crop growth periods).

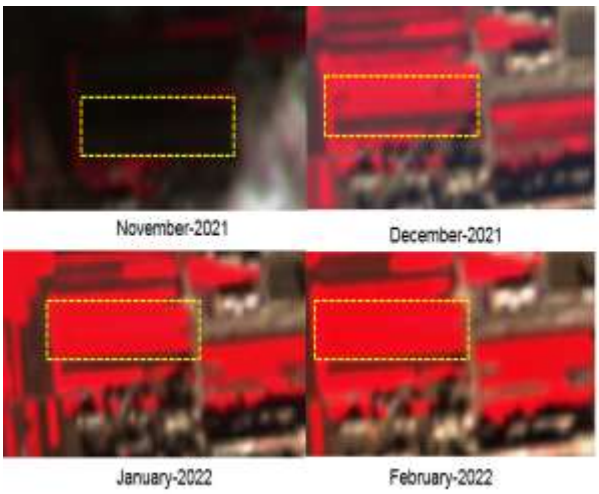

Photo 8. False color composite index during periods of crop growth
Source: Authors' determination.

The results show an increase in plant density from December to February, particularly in the box area of the picture, as shown by the degree of red (associated with the greenness of the flora) in the photos.By increasing vegetation cover, the NDVI values increased as shown in Photo 9.

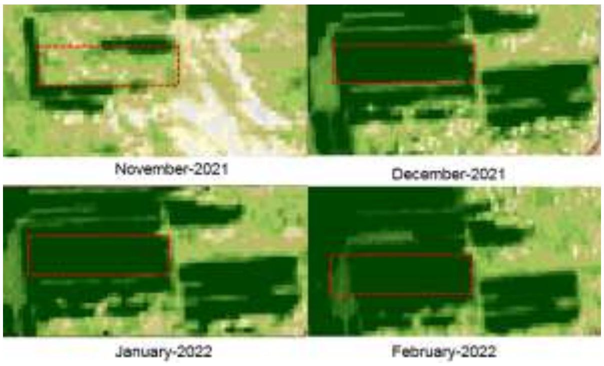

Photo 9. Normalized difference vegetation index during periods of crop growth
Source: Authors' determination.

Also, the frequency distribution curve shows the maximum values for growth periods were 0.052, 0.083, 0.12, and 0.03 as shown in Photo 10, and this means that NDVI values were decreased during the study time.

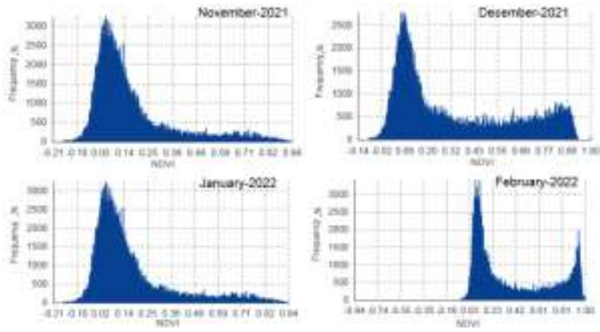

Photo 10. Frequency distribution of normalized difference vegetation index
Source: Authors' determination.

Photo 11 and Photo 12 show that the value of NDWI and NDMI has been observed, and direct correlations reveal that an increase or decrease in the value of NDVI corresponds to an increase or reduction in the value of NDMI and NDWI based on frequency distribution carve which shows the maximum values of NDMI and NDWI during growth periods were (-0.11, -0.27), (-0.07, -0.24), (-0.09, -0.91), and (-0.05, -0.22) respectively as shown in Photo 13 and Photo 14.

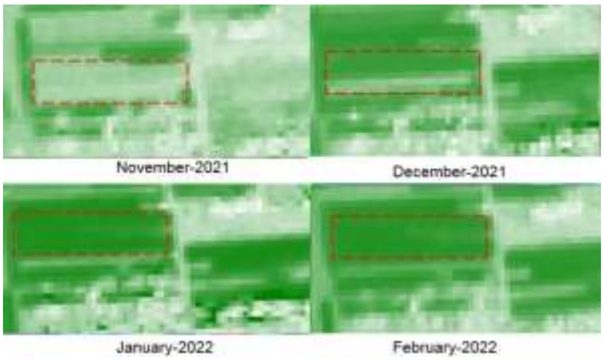

Photo 11. Normalized difference water index during periods of crop growth
Source: Authors' determination.

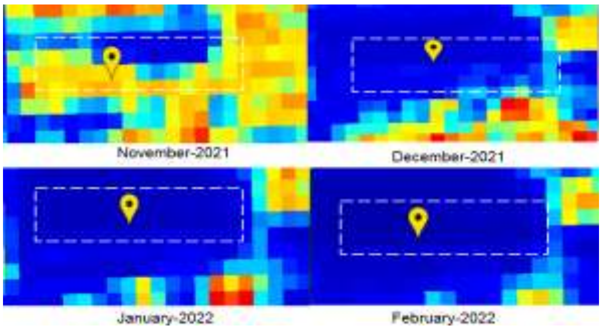

Photo 12. Normalized difference moisture index during periods of crop growth
Source: Authors' determination.

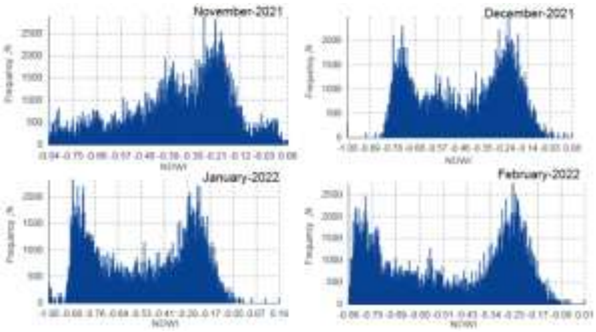

Photo 13. Frequency distribution of normalized difference water index
Source: Authors' determination.

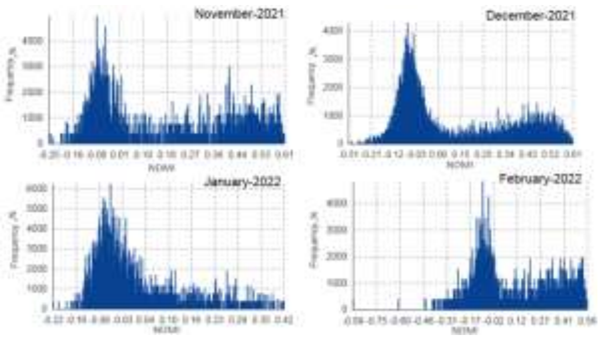

Photo 14. Frequency distribution of normalized difference moisture index
Source: Authors' determination.

The results of the SWIR and agriculture composite index show an increase in plant density during the crop growth periods until harvest, especially in January and February 2022 as shown in Photo 15 and Photo 16.

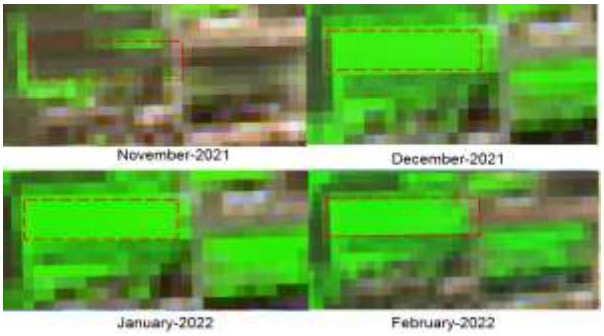

Photo 15. Short wave infrared composite during periods of crop growth
Source: Authors' determination.

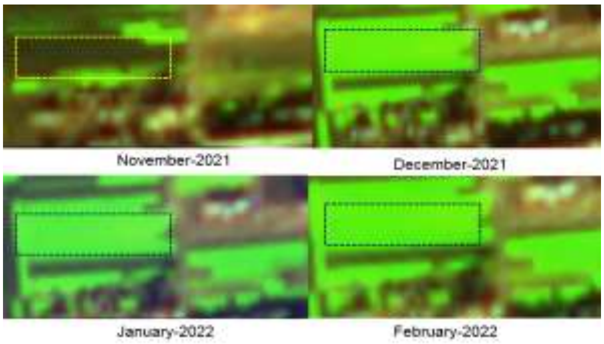

Photo. 16. Agriculture composite during periods of crop growth
Source: Authors' determination.

The results show an increase in the SAVI during the crop growth period based on NDVI results as shown in Photo 17, and the frequency distribution curve shows the maximum values during growth periods were 0.015, 0.043, 0.055, and 0.011 as shown in Photo 18.

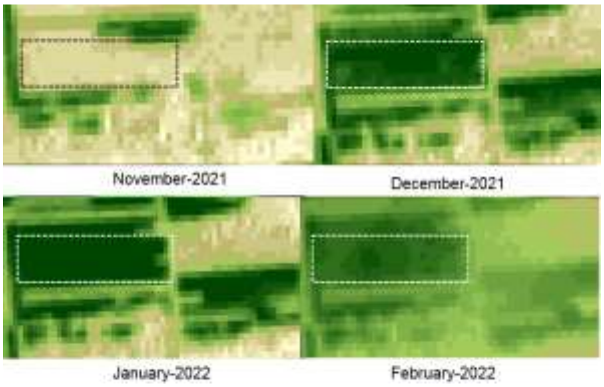

Photo 17. Soil adjusted vegetation index during periods of crop growth
Source: Authors' determination.

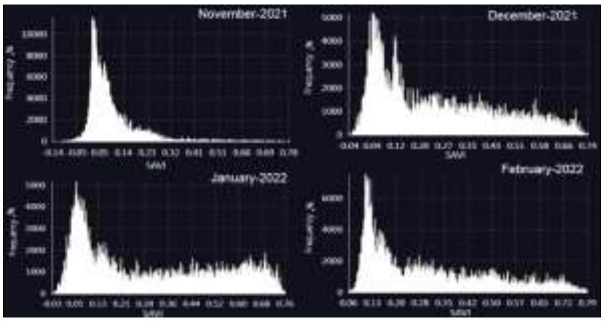

Photo 18. Frequency distribution of soil adjusted vegetation index
Source: Authors' determination.

Climatic and environmental indices

Fig. 1 showed the maximum and the minimum values of direct and diffuse short wave radiation were (56.69, and 34.67), and (13.74, and 17.32 W/m^2) in February 2022 and December 2021 respectively. In January 2022, the minimum values of sunshine duration and uv radiation were (5.14, and 4.66 W/m^2), and the maximum values of same indices were (13.99, and 9.34 W/m^2) in February 2022 respectively as shown in Fig. 2.The results of evapotranspiration and FAO reference evapotranspiration as shown in Fig. 3, the maximum values were (0.043, and 0.047 mm) in November 2021, February 2022. Also, the minimum values were (0.30, 0.022 mm) in February 2022 and December 2021 respectively. The maximum and minimum values of temperature and soil temperature during growth periods of faba bean crop were (7.64,10.83), and (4.41, 3.70^{o}C)respectively as shown in Fig. 4.

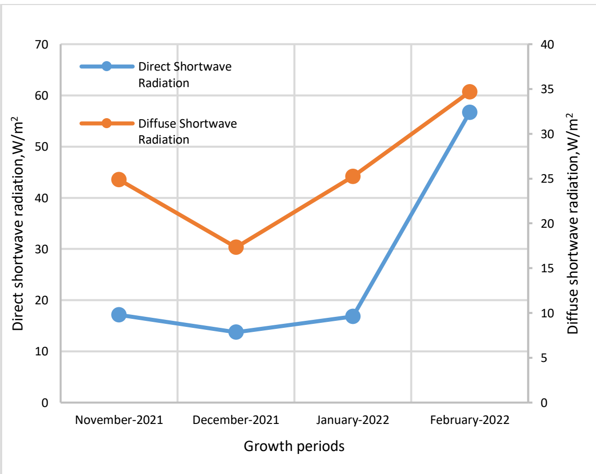

Fig. 1. Relationship between direct and diffuse short wave radiationduring periods of crop growth
Source: Authors' determination.

Therefore, the previous results show an expulsion relationship between the indicators. Fig. 5 and Fig. 6 showed the results of relative humidity, short and long wave radiation were (84.91.36%, and 304.33W/m^2) as a maximum values, when the minimum values of the same indices were (79.03%, 31.07, and 272.21 W/m^2) during growth periods.

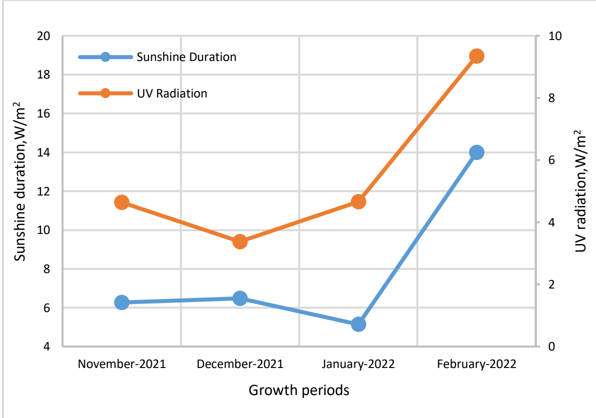

Fig. 2. Relationship between sunshine duration and uv radiation during periods of crop growth
Source: Authors' determination.

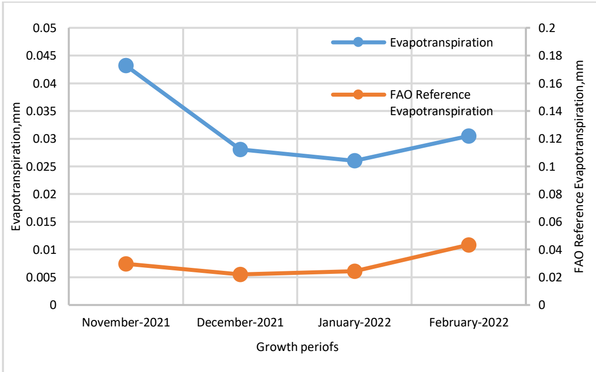

Fig. 3. Relationship between evapotranspiration and FAO reference evapotranspiration during periods of crop growth
Source: Authors' determination.

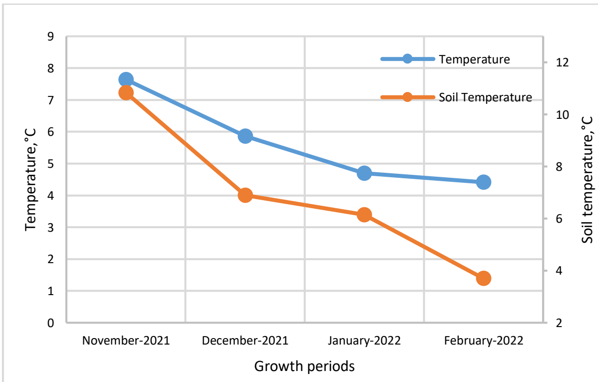

Fig. 4. Relationship between temperature and soil temperature during periods of crop growth
Source: Authors' determination.

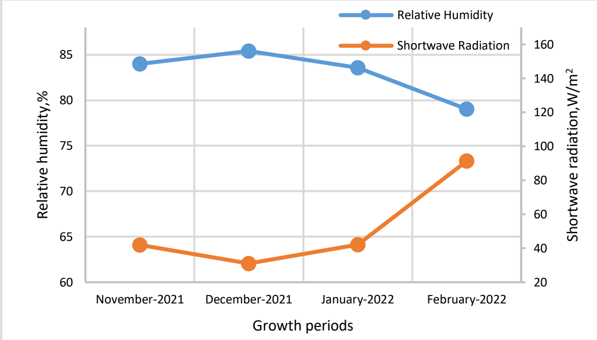

Fig. 5. Relationship between relative humidity and short wave radiationduring periods of crop growth
Source: Authors' determination.

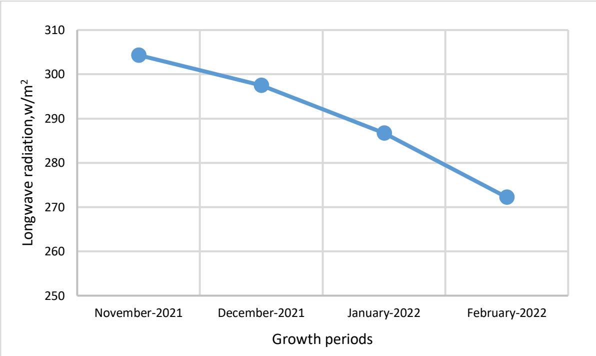

Fig. 6. Relationship between long wave radiation and periods of crop growth
Source: Authors' determination.

CONCLUSIONS

Hyperspectral imaging become a popular research tool that facilitates thorough non-destructive analyses by simultaneous acquisition of both spectral and spatial information of agricultural samples. it can be used as an emerging technology for monitoring quality parameters in field crops. The open-access remote-sensing datasets and the processing capacity of the EO platform were critical to realizing the goals of this research. In this study It is possible to use hyperspectral reflectance dataextracted monthly from composite pictures were produced using Sentinel-2 to monitor and observation of faba bean crop growth which evaluated by analysis of NDVI, NDMI, SWIR, NDWI, Agriculture Composite, and SAVI of vegetation cover per pixel, and the maximum values of climatic indices such as sunshine duration, relative humidity, long, short wave radiation, ultraviolet radiation direct, diffuse radiation, soil temperature, FAO reference evapotranspiration (Eto) during faba bean growth period.

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SUBSIDIES AND PROFITABILITY IN THE AGRICULTURAL SECTOR: EXAMINING THE RELATIONSHIP IN BULGARIA

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Abstract

The article examines the impact of subsidies on agricultural holdings of different economic sizes in Bulgaria for the period 2014-2020. The objective is to dissect the dispersion and repercussions of these subsidies on the gross and net earnings of these enterprises. The research is rooted in a thorough exploration of existing literature and utilizes a spectrum of analytical techniques, including comparative analysis, regression analysis, and fixed effects models. The findings underscore the substantial role of subsidies in shaping the revenue of Bulgarian agricultural producers. This validates the primary hypothesis that subsidies bolster the financial health of enterprises and foster the resilience of the agricultural sector overall. Nonetheless, it's crucial to note that the magnitude and efficacy of the subsidies' impact fluctuate based on the economic scale of the enterprises. This underscores the need for a differentiated approach in determining subsidy policies, taking into account the specific needs of different groups of agricultural producers.

Key words: *subsidies, farms, Bulgaria, income, sustainability, environment*

INTRODUCTION

Agricultural producers in Bulgaria, as well as throughout Europe, receive significant support through various forms of subsidies from national and European institutions. The subsidies aim to strengthen agricultural farmers, ensure the sustainability of rural farming, and guarantee food security.

Despite this, the effectiveness of these subsidies is the subject of lively discussions, due to several main reasons. First, there are differences in the type and size of subsidies provided to agricultural farmers in different countries and regions. This can lead to discrepancies and imbalance in competition, complicating the assessment of the effectiveness of subsidies. Second, questions arise about the ability of subsidies to achieve their goals, such as sustainability of farms, food security, and environmental protection. Some studies show that despite significant amounts spent on subsidies, they do not always succeed in achieving these goals. Thirdly, there are concerns about the effectiveness of subsidies as a tool for maintaining farmers' incomes. In many cases, subsidies can lead to economic distortions, such as excessive dependence on state aid or reduction of incentives for innovation and efficiency.

Literature Review

The question of the effectiveness of subsidies for the current activities of agricultural farmers is complex and multi-layered, including both economic and social and environmental aspects. It is the subject of research by many authors. Subsidies can be a useful tool for financing agriculture, but they need to be used carefully and with consideration of their potential negative impacts [28]. More research is needed on the effectiveness of subsidies, and the design of subsidies needs to ensure that they achieve planned goals. Direct payments are provided to farmers based on the size of the farm and the land cultivated, to ensure stable incomes and encourage environmentally friendly practices [6]. Westhoek et. al. [27] argue that agricultural support programs should focus not only on direct financial assistance to farmers but also on promoting sustainable practices beneficial to society as a whole.

A study in Sweden [18] found that subsidies have a significant positive impact on farm productivity, likely by helping farmers adopt innovations that increase productivity. Kravcakova and Kotulic's [15] findings align with these conclusions, demonstrating that subsidies significantly enhance farm productivity and profitability in Slovakia, particularly benefiting smaller and less efficient farms. Bezlepkina and Lansink [2] examine the effects of debt and subsidies on Dutch agriculture. They find that debt has a negative effect, while subsidies have a positive impact. Moreover, the impact of subsidies is greater for smaller farms and those with lower debt levels. Biagini et al. [3] analyze the impact of CAP subsidies on the productivity of cereal farms in six EU countries - France, Germany, Hungary, Italy, Poland, and Spain. The authors suggest that subsidies positively influence productivity, although this effect is less pronounced for larger farms. They note a more significant impact on farms that are more efficient and have higher human capital.

Kleinhanß et al. [12] corroborate the beneficial influence of subsidies on livestock farming efficiency, but observe a diminished effect for larger farms. They advocate for policies that are customised to cater to the requirements of diverse farm types, fostering both efficiency and environmental sustainability. Zhu et al. [31] investigate the influence of the Common Agricultural Policy (CAP) subsidies on technical efficiency and productivity disparities among dairy farms in three EU nations - Hungary, Slovenia, and Slovakia. They deduce that while subsidies enhance technical efficiency and productivity, the impact is less pronounced for larger farms. The impact is greater for more efficient farms with higher human capital. The same conclusions are reached by studies on the technical efficiency of farms in three other European countries - Germany, Netherlands, Sweden [30], as well as Slovakia [29].

Some authors [19, 21, 26] find that direct payments have a small positive effect, but this varies depending on the crop and region. Harkness et al. [7] establish the positive impact of agri-environmental schemes, providing payments to farmers who adopt environmentally friendly practices such as cover cropping, reduced soil tillage, and maintaining living fences. These schemes improve the viability of farms while reducing environmental impact. Severini et al. [20] find that direct CAP payments can help stabilize the income of Italian farms, especially for smaller, more vulnerable operations. However, the income stabilization effects vary depending on the type of farm and region. Ciliberti and Frascarelli [4] highlight the problems with income concentration on Italian farms, as larger farms still receive a significant share of subsidies.

Uzunova [25] found that direct payments and national top-ups stabilize producer incomes in Bulgaria, encourage good agricultural practices and support expanded reproduction. Sokolova [23] examined the impact of direct payments on income distribution in mountain farms and inequality in Bulgaria. It was found that the payments have a limited impact on reducing income inequality, as larger and more profitable farms continue to receive a disproportionate share of support. Kaneva et al. [9] state that the CAP-related support plays an important role in the development of livestock farms in Bulgaria. Beluhova et al. [1] study direct payments and their impact on Bulgarian agriculture, finding that they support financial stability and recommend a differentiated subsidy policy approach to meet the specific needs of different agricultural groups. Koteva et al. [13] discover that while CAP subsidies significantly contribute to the advancement of larger and more efficient farms, smaller farms and rural households are often overlooked. Kirechev [11] sees subsidies as an important factor for net income for Bulgarian agricultural holdings. Koteva and Ivanov [14] and Turlakova [24] establish the uneven distribution of direct payments among Bulgarian farms.

There is also a group of authors who dispute the positive effect of subsidies. Key [10] finds that decoupled payments in the US may have limited impact on supply responses. Laborde, et al. [16] argue that reducing agricultural subsidies is an important step in addressing climate change. By reducing the impact of greenhouse gas emissions in agriculture, we can help preserve our planet for future generations. Damania et al. [5] believe that redirecting environmentally harmful subsidies could be a powerful tool for promoting sustainable development. Heyl et al. [8] contend that subsidies might adversely affect the environment, potentially leading to an increase in greenhouse gas emissions and a reduction in biodiversity. A Slovenian study [22] found that agricultural payments have a significant positive impact on nitrate concentrations in groundwater, probably because payments encourage higher use of fertilizers and nitrate leaching.

The objective of this study is to augment and broaden the findings of prior research on the correlation between subsidies and agricultural incomes. It does this by offering an exhaustive analysis of the influence of subsidies on the financial success of Bulgarian farms from 2014 to 2020.

Purpose of the article

The purpose of this article is to analyze the distribution and impact of subsidies on farms of differing economic sizes in Bulgaria during the period from 2014 to 2020. This article will examine how subsidies influence the gross and net income of these farms, assessing their level of dependence on these subsidies, and the potential variation in net income that may be caused by the size of the subsidies.

Research tasks

-To analyze the dynamics and trends in the distribution of subsidies among farms of differing economic sizes in Bulgaria during the period from 2014 to 2020;

-To analyze the relative share of current subsidies as a source of revenue for agricultural holdings of differing economic sizes, and to assess their dependence on these subsidies for maintaining their incomes;

-To scrutinize the correlation between current subsidies and the gross income of farms in different economic groups (small, medium, and large), to quantify the extent to which subsidies account for variations in gross income, and to ascertain if this relationship varies among the different economic groups;

-To investigate the impact of subsidies on the net income of farms and to determine the strength of this relationship and its statistical significance.

MATERIALS AND METHODS

The study analyses data from the Agricultural Accounting Information System (AAIS), provided by the Ministry of Agriculture and Food of Bulgaria, for the period 2014-2020. Six categories of farms have been studied, divided by economic size: up to 8,000 euros, 8-25,000 euros, 25-50,000 euros, 50-100,000 euros, 100-500,000 euros and over 500,000 euros. The representative sample of AAIS includes the following number of farms: 2,229 for 2014; 2,272 for 2015; 2,261 for 2016; 2,253 for 2017; 2,241 for 2018; 2,252 for 2019; and 2,235 for 2020.

The article presents a comparative analysis of the subsidies received by farms of different economic sizes during the period from 2014 to 2020, examining how they change over time. A comparison is also presented of the percentage distribution of revenue, including current subsidies, for the different economic sizes of farms is also presented.

A fixed effects model was used to analyze the relationship between gross income and current subsidies. Analyzing this relationship can provide insight into the effectiveness of subsidies as a stimulating mechanism for growth and development. In this way, it can be determined whether subsidies are achieving their goals of supporting the respective sector. The main idea behind fixed effects models is that they control for time-invariant unobserved characteristics of each subject (agricultural holding) that could influence the outcome (gross income). This is done by including a catch-all term for each group of agricultural holdings that absorbs these effects. For example, factors like soil quality, climate, managerial skills, etc. may differ across holdings and affect incomes but are not observed in the data. The fixed effects capture all these time-invariant factors in the farm-specific intercepts. This helps isolate the effect of the time-varying predictor (subsidies) on the outcome (gross income) while avoiding bias from the unobservable.

A regression analysis has been executed, designating net income as the dependent factor and current subsidies as the independent factor. This method can offer insights into the societal influence of subsidies, especially when they are directed towards lower-income brackets and vulnerable communities. Analyzing net income in the context of subsidies can help determine whether they are achieving their goals of reducing social inequalities and improving incomes. There are several reasons why using net income in the regression analysis is better. First, net income is a more stable measure of the financial condition of an agricultural enterprise than gross income. This is because net income is not influenced as much by fluctuations in market prices or production costs. As a result, net income is a better indicator of the long-term financial health of the agricultural holding. Second, net income is a more accurate measure of the impact of subsidies on the income of agricultural producers.

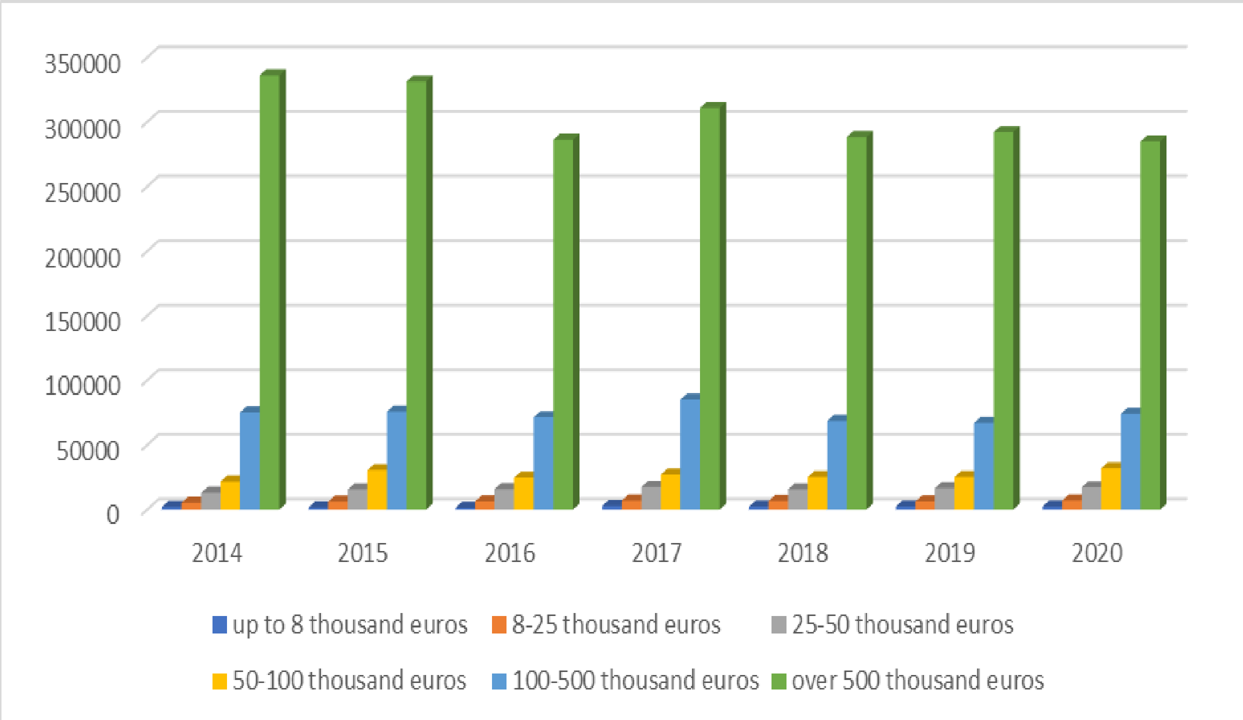

Fig. 1. Received current subsidies in euro by the studied population by economic size in the period 2014-2020
Source: Own calculations based on AAIS data [17].

This is because subsidies can affect both gross revenues as well as costs.

RESULTS AND DISCUSSIONS

Analysis of the distribution and relative share of subsidies in revenues

Figure 1 presents the data on the current subsidies that farms of different economic sizes from the studied population receive during the period from 2014 to 2020. Farms with an economic size over 500,000 euro receive the largest amount of subsidies in all years.

However, there is a decreasing trend in the subsidies they receive from 2014 to 2020. Farms with an economic size from 100,000 to 500,000 euro also show a decreasing trend in received subsidies over the period.

For farms with an economic size from 8,000 to 100,000 euro, the subsidies vary, but the overall trend is towards an increase in received subsidies over the years.

Farms with an economic size up to 8,000 euro show variations in received subsidies, but the overall trend is stable or slightly increasing.

Figure 2 presents the percentage distribution of revenue for 2020 for agricultural holdings with different economic sizes from the studied population. The revenue of agricultural producers can be conditionally divided into operating revenue (revenue from sales of products and other revenue) and revenue from subsidies. Current subsidies have the largest relative share in revenue for holdings with an economic size up to 8 thousand euros (31.19%). This means that the smallest holdings have the least own revenue and are therefore more dependent on external financing. It is obvious that agricultural holdings with an economic size of 25-50 thousand euro and 8-25 thousand euro the smallest relative share of current subsidies in total revenue (16.71% and 20.66%, respectively). They manage to generate a significant percentage of their revenue without current subsidies and are most independent of them. This shows that subsidies play an important role for agricultural holdings with an economic size above 50 thousand euro, the revenue from subsidies increases its relative share in their total annual revenue. The analysis important role in maintaining the income of the smallest agricultural holdings, while medium-sized holdings in economic terms have more opportunities to generate income without them.

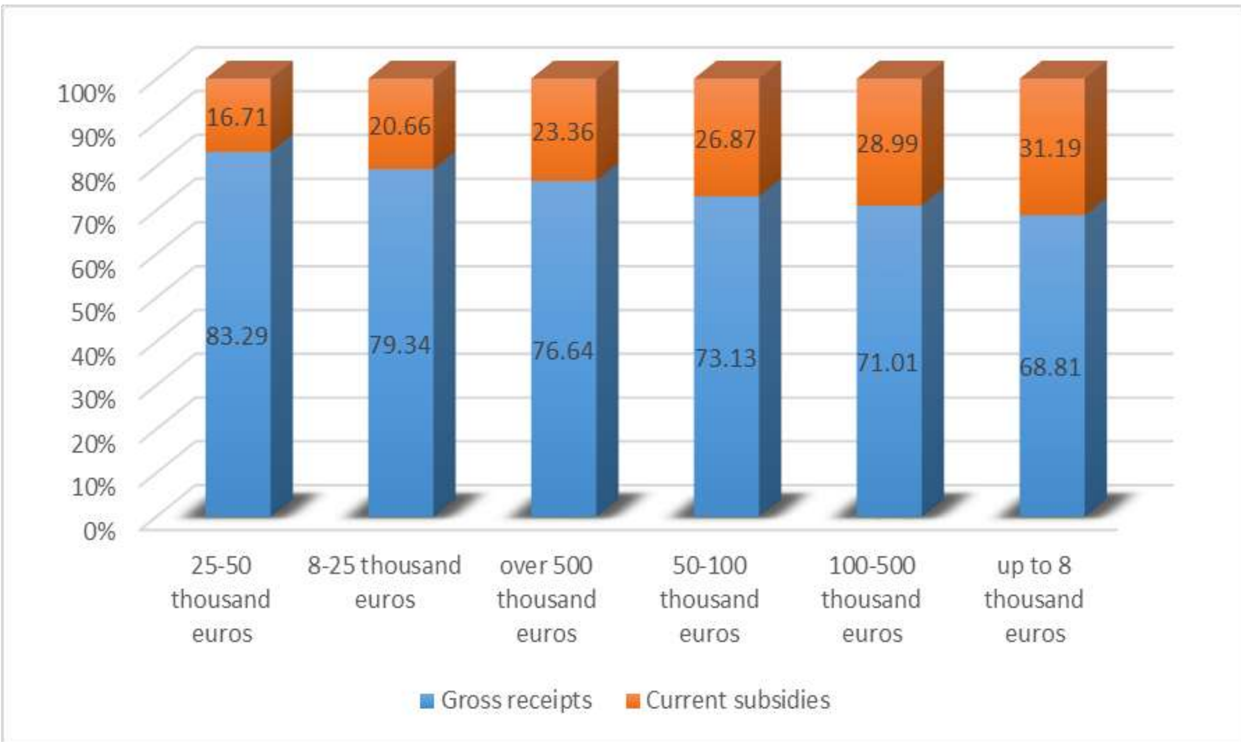

Fig. 2. Percentage distribution of income in the studied population of farms by economic size in 2020
Source: Own calculations based on AAIS data [17].

Fixed effects model

A fixed effects model is applied to study the relationship between gross income and subsidies. Based on the fixed effects panel data analysis, here are some key findings on the effect of subsidies on the income of farmers:

• For farms with an economic size up to 8,000 euros: The subsidy coefficient is positive and significant (0.754), indicating that subsidies are associated with higher incomes. But the fixed effect for this group is negative and large (-15,000), meaning that small farms have significantly lower income levels on average compared to other groups, even after controlling for subsidies. This suggests that small farms are more dependent on subsidies to maintain their incomes;

• For farms with an economic size between 8,000 and 50,000 euro: The subsidy coefficient is still positive (0.670) but smaller compared to small farms. The fixed effects are smaller and negative (-5,000) than in small farms, indicating higher base income levels. Subsidies still increase income, but these farms are less dependent on them compared to smaller farms;

• For farms with an economic size between 50,000 to 500,000 euro: The subsidy coefficient remains positive and significant

(0.510). The fixed effects are now positive (10,000), reflecting higher average income levels for these larger farms. But subsidies still increase income, although the marginal effect may be smaller than in smaller farms;

• For farms with an economic size over 500,000 euro: The positive subsidy coefficient (0.410) suggests increased income with higher subsidies. The fixed effect is the largest (100,000), indicating a very high base income for these largest farms. They still benefit from the subsidies, albeit with smaller marginal effects.

In summary, subsidies boost income levels for farms of all sizes. However, smaller farms rely more heavily on these subsidies and inherently have lower income levels. On the other hand, larger farms, despite having a higher base income, also gain from these subsidies. However, the incremental benefits tend to diminish for larger farms.

Multiple regression

Multiple linear regression models were evaluated to determine the most appropriate model for predicting net income based on current subsidies received and other financial variables. The model with the best balance of explanatory power, parsimony, and lack of multicollinearity includes current subsidies, output produced, depreciation, wages and salaries, land rents, interest expenses, investment subsidies, VAT balance(difference between VAT collected from customers and VAT paid to suppliers), fixed assets, and intermediate consumption (expenses on materials and services) as independent variables (Table 1). This model explains 99.9% of the variance in net income (R-squared = 0.999) and has statistically significant coefficients for all variables ($p<0.05$). While some collinearity diagnostics indicate potential issues, there is no definitive evidence of multicollinearity based on the condition index, variance proportions, and standard errors. The condition index is 335.44 and no individual predictor has variance proportions above 0.96.

Table 1. Regression Model Coefficients

Independent Variable	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	614.800	123.558		4.976	0.000
Current subsidies (EUR)	1.077	0.017	1.452	65.231	0.000
Production (EUR)	0.975	0.007	6.662	133.972	0.000
Depreciation (EUR)	-1.003	0.029	-0.969	-34.641	0.000
Wages and social contributions expenses (EUR)	-1.147	0.032	-0.898	-35.946	0.000
Land rent (EUR)	-952.623	25.630	-1.301	-37.169	0.000
Interest expenses (EUR)	-1.270	0.138	-0.165	-9.176	0.000
Subsidies on investments (EUR)	0.981	0.015	0.075	63.551	0.000
VAT Balance - Investment (EUR)	2.610	0.532	0.004	4.905	0.000
Long-term assets (EUR)	0.011	0.003	0.096	3.079	0.004
Intermediate consumption (EUR)	-0.993	0.012	-3.961	-82.804	0.000

Source: Own calculations using SPSS software.

The regression equation is as follows:

$$y = 614.80 + 1.077\ x_1 + 0.975\ x_2 - 1.003\ x_3 - 1.147\ x_4 - 952.623\ x_5 – 1{,}270\ x_6 + 0.981\ x_7 + 2{,}610\ x_8 + 0.011\ x_9 – 0.993\ x_{10} \qquad ....(1)$$

where:

y is the net income, x_1 is the current subsidies, x_2 is the produced output, x_3 is the depreciation, x_4 is the wages and social security contributions, x_5 is the rent for land, x_6 is the interest expenses, x_7 is the investment subsidies, x_8 is the VAT balance for current transactions, x_9 is the long-term assets, and x_{10}

is the intermediate consumption (expenses for materials, insurance, etc.).

The net income is expected to change based on each variable in the model, assuming that all other variables are constant as follows:

-*Current subsidies: Increasing current subsidies by 1 unit* is associated with an increase in net income by 1.077 units;

-*Produced production*: Increasing the produced production by 1 unit is associated with a 0.975unit increase in net income;

-*Depreciation*: Increasing depreciation by 1 unit is associated with a decrease in net income by 1.003 units;

-*Wages and insurance*: An increase in wages by 1 unit is associated with a decrease in net income by 1.147 units;

-*Land rent*: An increase in land rent by 1 unit is associated with a 952.623unit decrease in net income;

-*Interest expenses*: An increase in interest expenses by 1 unit is associated with a decrease in net income by 1.270 units;

-*Investment subsidies*: A 1unit increase in investment subsidies is associated with a 0.981unit increase in net income;

-*VAT balance*: A unit increase in VAT balance corresponds to a 2.610 unit increase in net income;

-*Long-term assets*: A unit increase in long-term assets correlates with a 0.011 unit increase in net income;

-*Intermediate consumption*: An increase in intermediate consumption by 1 unit is associated with a decrease in net income by 0.993 units. Higher operating expenses reduce net revenues.

Standardized coefficients allow us to compare the effects of different variables on net income directly, even though they are measured in different units. Based on the values of the standardized coefficients, the variables with the greatest influence on net income in the model are: Produced production (6.662); Intermediate consumption (-3.961); Current subsidies (1.452); Wages and insurance (-0.898); Depreciation (-0.969).

Produced production exerts the most substantial positive impact on net income - a surge by one standard deviation in its size corresponds to a rise in net income by 6.662 standard deviations. Conversely, intermediate consumption and depreciation exert significant negative impacts. An increase of one standard deviation in these factors correlates with a reduction in net income of 3.961 and 0.969, respectively.

Based on the multiple regression analysis, we can conclude the following about the relationship between current subsidies and net income:

-The current subsidies received during a given year have a significant positive relationship with net income, even when controlling for other financial factors such as produced production, expenses, assets, etc.;

-An increase in current subsidies by 1 unit is expected to increase net income on average by 1.077 units, with all other variables of the model being constant;

-The standardized coefficient for current subsidies (1.452) shows that subsidies have one of the largest positive impacts on net income compared to other financial indicators;

-The model assumes that while current subsidies do have a positive impact on net income as expected, they are not the only or main driver of profitability. Other factors such as produced production, expenses, and assets also play a very important role.

CONCLUSIONS

The analyses conducted in this study lead to several conclusions regarding the distribution and impact of agricultural subsidies in Bulgaria for the period 2014-2020:

-The analysis of the distribution shows that the largest farms (over 500,000 euro) receive the highest absolute amount of subsidies, but there is a trend of decline in subsidies received by these farms during the period 2014-2020. Smaller farms (under 25,000 euros) show a slight trend of increase in subsidies received over the period 2014-2020;

-The analysis of revenue sources shows that the smallest farms (under 8,000 euro) rely most heavily on subsidies, which make up 31% of their total revenues. Medium-sized farms (8,000-50,000 euro) generate a larger share of revenues from their own activities and are least dependent on subsidies;

-The fixed effects model analyzing gross income suggests that subsidies increase the incomes of farms of all sizes, but smaller farms benefit more in terms of marginal effects. Larger farms have higher base levels of income;

-The regression model shows that current subsidies have a significant positive relationship with net income, but produced production, expenses, and assets also significantly stimulate profitability.

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PRODUCTIVITY OF SOME SUNFLOWER HYBRIDS - COMPARATIVE ANALYSIS

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Abstract

The study comparatively analyzed the productivity level of 48 commercial sunflower hybrids, under the specific crops conditions of the Western Plain of Romania. The field experiment took place within ARDS Lovrin, agricultural year 2021-2022. 27 hybrids from the Imazamox class (IH; IH1 to IH27) and 21 hybrids from the Tribenuron Methyl class (TMH; TMH1 to TMH21) were cultivated. The cultivation of the 48 hybrids was carried out under the conditions of a chernozem type soil, and non-irrigated system. In the case of Imazamox class hybrids (IH), the production varied between 2012.47 kg ha^{-1} (IH4) and 3,545.08 kg ha^{-1} (IH1, and IH23). In the case of hybrids from the Tribenuron Methyl class (TMH), production varied between 2,437.64 kg ha^{-1} (TMH17) and 3,713.15 kg ha^{-1} (TMH4, and TMH19). Based on the production data recorded for each hybrid, the average value was calculated for each class of hybrids (IH-Avg=3,038.13 kg ha^{-1}, TMH-Avg=3,287.98 kg ha^{-1}). In order to verify whether there are differences between the two groups IH (N=27) and TMH (N=21) regarding the recorded production, the Null Hypothesis (H0) was defined. The application of the t-test for Equality of Means, led to the value of t=2.302 with p=0.02. Additionally, the non-parametric Mann-Whitney test was applied. The U=180 value with p=0.03 also indicated significantly different productions between the related series of the two classes of hybrids. The increase in production (kg ha^{-1}, %) was calculated for each class of hybrids (ΔIH, ΔTMH) and a classification was made within each class. The cluster analysis facilitated the clustering of sunflower hybrids in relation to the recorded production.

Key words: *classification, hybrids categories, Mann-Whitney test, production, sunflower*

INTRODUCTION

Sunflower (*Helianthus anuus* L.), is a highly important crop plant, with food benefits [2, 25], pharmaceutical and medicinal benefits [2, 5, 16], for feeding animals through residual products [4, 13], for different industrial sectors [14], and in ornamental interest [23, 30]. The sunflower is an oleaginous plant, which occupies high areas within the crop plants in different agricultural areas of the world [15, 22, 24].
From the perspective of cultivated plants, the sunflower is an environmentally friendly plant, with protective technologies, a plant that fits well into the structure of cultivated plants, crop rotations and crop rotation [9]. At the same time, the sunflower is considered and studied as a bioindicator plant regarding environmental pollution [18].
The sunflower was studied in relation to the soil and climate conditions, in order to establish the most suitable culture areas for different genotypes [3, 10, 27].
Numerous sunflower genotypes have been studied in terms of diversity and variability, from the perspective of breeding programs [1, 29], but also from the perspective of agricultural technologies [20], and improving oil production [19].
Production, yield, economic aspects and certain quality indices in sunflower production were studied in relation to different genotypes and culture conditions [8, 15].
Santos et al. (2018) [26] used a multivariate evaluation to analyze and quantify yield potential in sunflower genotypes from different genetic classes. Sunflower breeding programs aim at the production of hybrids adapted to different pedoclimatic conditions, pollination conditions and pollinators, with

high production potential, customized to the specifics of certain agricultural technologies, with economic yield, with very good quality indices in relation with the destination of seed production [6, 11, 21].
The present study comparatively analyzed the productivity of 48 sunflower hybrids, by hybrid classes (Imazamox – IH, Tribenuron Methyl – TMH), hybrids grown in representative soil and climate conditions, specific to the Western Plain of Romania, within ARDS Lovrin.

MATERIALS AND METHODS

The study analyzed, based on production and yield, the response of some sunflower hybrids from two classes, to the crop conditions. The study and field experiments took place at the Agricultural Research and Development Station Lovrin, Romania, Photo 1, in specific climatic conditions, Figure 1.

Photo. 1. Aspect from the experimental field of comparative crops, sunflower hybrids, agricultural year 2021 – 2022
Source: Original photo taken by authors (UAV image).

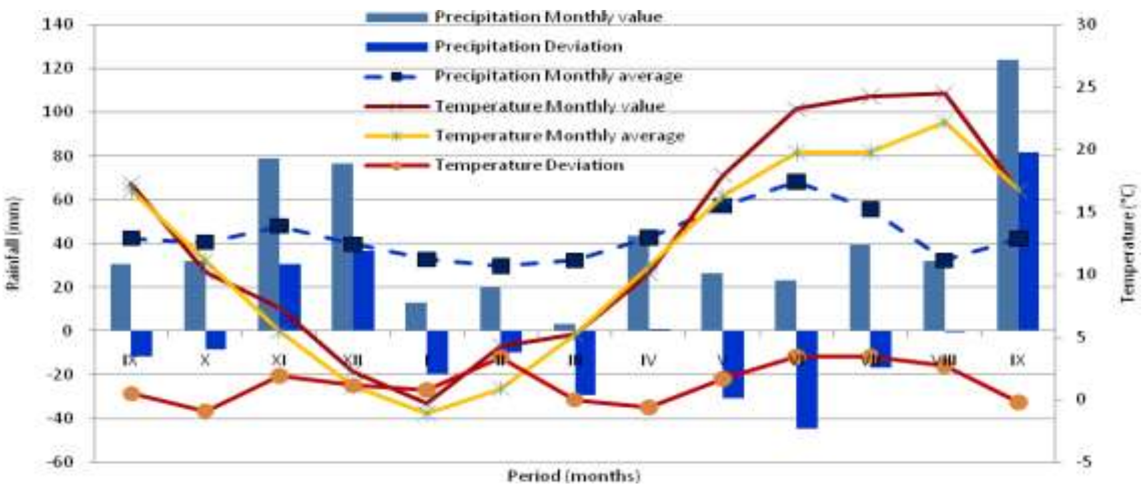

Fig. 1. Climatic conditions during the study period, Lovrin locality
Source: Original figure, generated based on the data recorded at ARDS Lovrin.

Two categories of sunflower hybrids, from different classes of culture technology, were considered in the comparative study; Imazamox class (I) 27 hybrids (H); class Tribenuron Methyl (TM) 21 hybrids (H). For facilities associated with the study (calculations and graphic representations), the hybrids were assigned a code, which contains the class (Imazamox - I, Tribenuron Methyl - TM), hybrid (H) and the order number of the hybrids (the presentation was made associated with the companies, in alphabetical order of the companies). There were 27 trial codes for hybrids from the Imazamox class (IH1 to

IH27) and 21 trial codes for hybrids from the Tribenuron Methyl class (TMH1 to TMH21). The study was conducted based on the flow chart, presented in Figure 2.

The culture of sunflower hybrids from the two technology classes was in non-irrigated conditions. At physiological maturity, the production for each sunflower hybrid was harvested, and based on the recorded data, studies and comparative yield analysis were made.

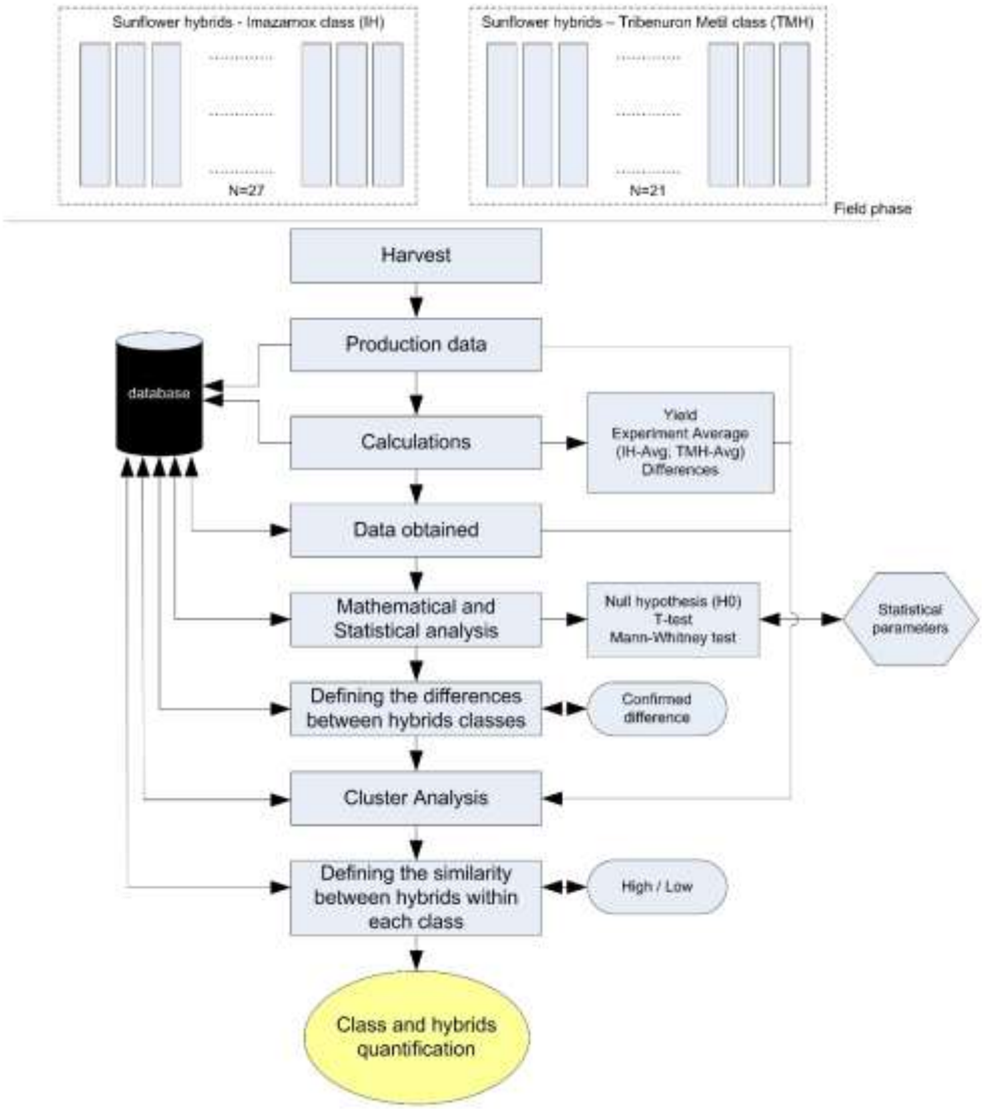

Fig. 2. Flowchart for the comparative study of sunflower hybrids
Source: Original figure.

The recorded production results and results from the calculations were analyzed to evaluate the safety of the data and the presence of variance, to evaluate the growth of each hybrid, on the two classes, compared to the average of each class (IH-Avg; TMH-Avg), and compared to the average hybrids within each company on each technology class (IH, TMH). A cluster classification of the hybrids was also made in relation to the yield, for each technology class (IH, TMH). Appropriate mathematical and statistical tools were used, in relation to the purpose of the study [17].

RESULTS AND DISCUSSIONS

Sunflower production results varied in relation to the hybrids grown on the two classes, Imazamox and Tribenuron Methyl.

The recorded values (average values per class and group of hybrids per company), as well as the calculated differences, are presented in Tables 1 and 2. In the case of hybrids from the Imazamox class (IH), production varied between 2,012.47 kg ha^{-1} (IH4) and 3,545.08 kg ha^{-1} (IH1, and IH23). In the case of hybrids from the Tribenuron Methyl (TMH) class, production varied between 2,437.64 kg ha^{-1} (TMH17) and 3,713.15 kg ha^{-1} (TMH4, and TMH19). The analysis of the distribution of the data series confirmed their statistical reliability (r=0.967 for IH data series; r=0.965 for TMH data series.

The two series of data were analyzed comparatively, by classes of hybrids, respectively class IH with 27 hybrids, and class TMH with 21 hybrids. In order to check whether there are differences between the two classes IH (N=27) and TMH (N=21) regarding the recorded production, the Null Hypothesis (H0) was defined, which consists in the fact that the averages of the two statistical series are not different.

Specifically, the average value of the data from the IH series was IH-Avg=3,038.13 (kg ha^{-1}) while for the TMH series the average production value of TMH-Avg=3,287.98 (kg ha^{-1}) was obtained. The application of the t-test for Equality of Means, led to the value of t=2.302, with p=0.02. This fact indicated the rejection of the Null Hypothesis, therefore there are significant differences between the two groups of hybrids (IH, and TMH).

Table 1. Production results in sunflower hybrids, Imazamox class (IH)

Company Name	Imazamox hybrids	Trial code	Y	Experiment Average (IH-Avg)	Differences compared to Avg (IH-Avg)		Average per company (C-Avg)	Differences compared to C-Avg
			(kg ha^{-1})	(kg ha^{-1})	(kg ha^{-1})	(%)	(kg ha^{-1})	(kg ha^{-1})
BASF	Acordis	IH1	3,543.08	3,038.13	504.95	116.62	3,042.33	500.76
	Aluris	IH2	3,429.71	3,038.13	391.58	112.89	3,042.33	387.38
	Coloris	IH3	2,862.81	3,038.13	-175.32	94.23	3,042.33	-179.52
	Dracaris	IH4	2,012.47	3,038.13	-1025.66	66.24	3,042.33	-1,029.86
	Insun 200	IH5	2,919.50	3,038.13	-118.63	96.10	3,042.33	-122.83
	Insun 222	IH6	3,486.39	3,038.13	448.26	114.75	3,042.33	444.06
Chemirol	Rustica	IH7	2,239.23	3,038.13	-798.90	73.70	2,239.23	0.00
Corteva	LP180CL	IH8	2,834.47	3,038.13	-203.66	93.30	2,834.47	0.00
	LP170CL	IH9	2,834.47	3,038.13	-203.66	93.30	2,834.47	0.00
Donau-Saat	Jonasun	IH10	3,458.05	3,038.13	419.92	113.82	3,202.95	255.10
	Irinasol	IH11	3,032.88	3,038.13	-5.25	99.83	3,202.95	-170.07
	Florasun	IH12	3,117.91	3,038.13	79.78	102.63	3,202.95	-85.04
KWS	Delicio	IH13	2,947.85	3,038.13	-90.28	97.03	2,670.07	277.78
	Achiles	IH14	2,777.78	3,038.13	-260.35	91.43	2,670.07	107.71
	Apache	IH15	2,692.74	3,038.13	-345.39	88.63	2,670.07	22.67
	Fourios	IH16	2,551.02	3,038.13	-487.11	83.97	2,670.07	-119.05
	Tahiti	IH17	2,380.95	3,038.13	-657.18	78.37	2,670.07	-289.12
MASS Seeds	MAS 92 CP	IH18	3,174.60	3,038.13	136.47	104.49	3,344.67	-170.07
	MAS 920 CP	IH19	3,514.74	3,038.13	476.61	115.69	3,344.67	170.07
RAGT	Charlotte	IH20	3,089.57	3,038.13	51.44	101.69	3,214.29	-124.72
	Sillos	IH21	3,004.54	3,038.13	-33.59	98.89	3,214.29	-209.75
	Guillermo	IH22	3,401.36	3,038.13	363.23	111.96	3,214.29	187.07
	Valencia	IH23	3,543.08	3,038.13	504.95	116.62	3,214.29	328.79
	Vollcano	IH24	3,032.88	3,038.13	-5.25	99.83	3,214.29	-181.41
Syngenta	SY Barilio	IH25	3,231.29	3,038.13	193.16	106.36	3,382.46	-151.17
	SY Michigan	IH26	3,514.74	3,038.13	476.61	115.69	3,382.46	132.28
	SY Onestar	IH27	3,401.36	3,038.13	363.23	111.96	3,382.46	18.90

Source: Original data from experiment.

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Table 2. Production results of sunflower hybrids, Tribenuron Methyl class (TMH)

Company Name	Tribenuron Metyl hybrids	Trial code	Y	Experiment Average (TMH-Avg)	Differences compared to Avg (TMH-Avg)		Average per company (C-Avg)	Differences compared to C-Avg
			(kg ha^{-1})	(kg ha^{-1})	(kg ha^{-1})	(%)	(kg ha^{-1})	(kg ha^{-1})
BASF	Averon	TMH1	3,032.88	3,287.98	-255.10	92.24	3,032.88	0.00
Corteva	P64le25	TMH2	3,202.95	3,287.98	-85.03	97.41	3,395.69	-192.74
	Pe64le162	TMH3	3,458.05	3,287.98	170.07	105.17	3,395.69	62.36
	Pe64le137	TMH4	3,713.15	3,287.98	425.17	112.93	3,395.69	317.46
	P64le99	TMH5	2,976.19	3,287.98	-311.79	90.52	3,395.69	-419.50
	HE144	TMH6	3,628.12	3,287.98	340.14	110.34	3,395.69	232.43
Donau-Saat	Bravosu	TMH7	3,146.26	3,287.98	-141.72	95.69	3,127.36	18.90
	Prontosol	TMH8	3,061.22	3,287.98	-226.76	93.10	3,127.36	-66.14
	Helesun	TMH9	3,174.60	3,287.98	-113.38	96.55	3,127.36	47.24
Expert Fundulea	Hestia	TMH10	3,231.29	3,287.98	-56.69	98.28	3,287.98	-56.69
	Hera	TMH11	3,458.05	3,287.98	170.07	105.17	3,287.98	170.07
	Soleea	TMH12	3,373.02	3,287.98	85.04	102.59	3,287.98	85.04
	Demetera	TMH13	3,089.57	3,287.98	-198.41	93.97	3,287.98	-198.41
MASS Seeds	MAS 83	TMH14	3,543.08	3,287.98	255.10	107.76	3,458.05	85.03
	MAS 85	TMH15	3,373.02	3,287.98	85.04	102.59	3,458.05	-85.03
RAGT	Volter	TMH16	2,976.19	3,287.98	-311.79	90.52	2,706.92	269.27
	Interstelar	TMH17	2,437.64	3,287.98	-850.34	74.14	2,706.92	-269.28
Syngenta	Suvex 1	TMH18	3,486.39	3,287.98	198.41	106.03	3,543.08	-56.69
	NX02267	TMH19	3,713.15	3,287.98	425.17	112.93	3,543.08	170.07
	Suomi	TMH20	3,344.67	3,287.98	56.69	101.72	3,543.08	-198.41
	Sureli	TMH21	3,628.12	3,287.98	340.14	110.34	3,543.08	85.04

Source: Original data from experiment.

In order to verify in an additional way the existence of differences between the two groups of hybrids, the non-parametric Mann-Whitney test was also applied. The U=180 value with p=0.03 also indicated significantly different productions between the related series of the two groups of hybrids.

In order to compare the two classes of hybrids (IH, TMH), the average production value (IH-Avg; TMH-Avg) was calculated for each class. In the class of Imazamox hybrids, the average production of the 27 tested hybrids was IH-Avg=3,038.13 kg ha^{-1}. Within the class of Tribenuron Methyl hybrids, the average production of the 21 tested hybrids was TMH-Avg=3,287.98 kg ha^{-1}. From the analysis of the two average values, a higher value was found in the case of the TMH hybrid class, with 249.85 kg ha^{-1}, compared to the IH hybrid class. Within the class of Imazamox hybrids (IH), Table 1, in relation to the average of the experiment (3,038.13 kg ha^{-1}), the increase in production generated by the hybrids (ΔIH) varied between 101.69% (3,089.57 kg ha^{-1}) for the hybrid Charlotte (IH20) and 115.62% (3,543.08 kg ha^{-1}) in the case of Acordis (IH1) and Valencia (IH23) hybrids. Within the class of Tribenuron Methyl hybrids (TMH), Table 2, in relation to the average of the hybrids of the experiment (3,287.98 kg ha^{-1}), the increase in production generated by the hybrids (ΔTMH) varied between 101.72% (3,344.67 kg ha^{-1}) at hybrid Soumi (TMH20), and 112.93% (3,713.15 kg ha^{-1}) in the case of hybrids Pe64le137 (TMH4), and NX02267 (TMH19) respectively.

In order to evaluate the degree of similarity of the hybrids in relation to the production level, Cluster Analysis was applied to each class of hybrids (IH, and TMH). Within the class of IH hybrids, the cluster analysis led to the dendrogram from Figure 3 (Coph corr.= 0.827), and within the class of TMH hybrids, the cluster analysis led to the dendrogram from Figure 4 (Coph corr.=0.860). The 27 hybrids, from class IH, were grouped into two distinct clusters. A C1 cluster included three hybrids (IH4, IH7 and IH17) with low production levels. The other 24 IH hybrids were grouped within one C2 cluster, in several sub-clusters, in relation to the level of similarity for production.

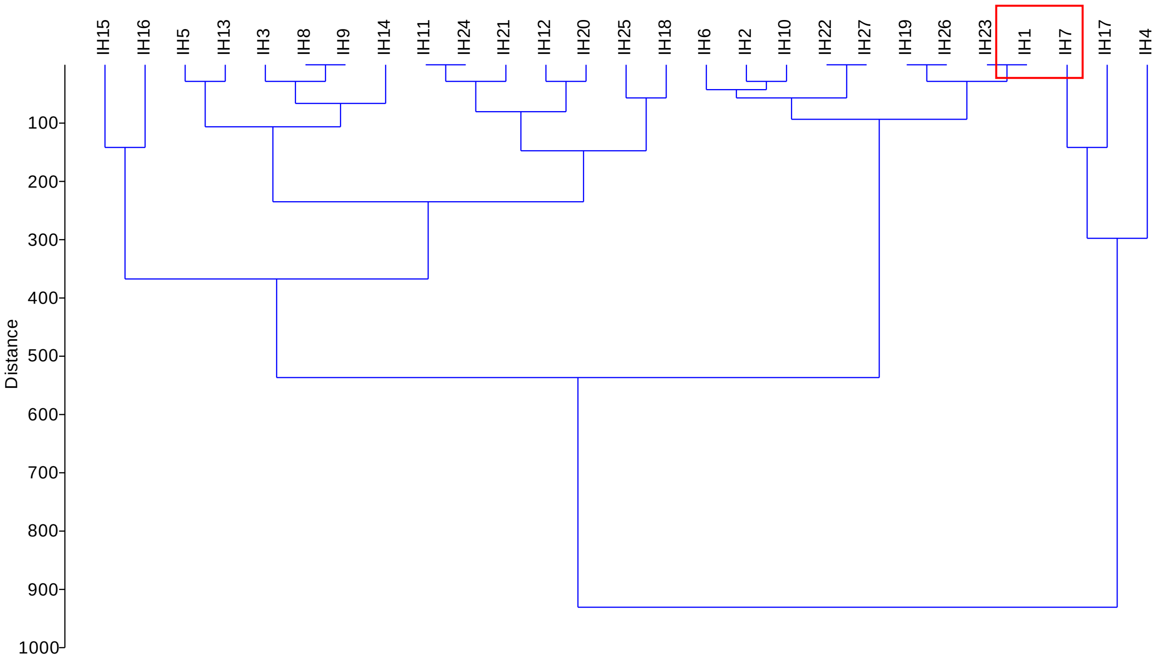

Fig. 3. Cluster dendrogram in the case of sunflower hybrids, class IH
Source: Original figure.

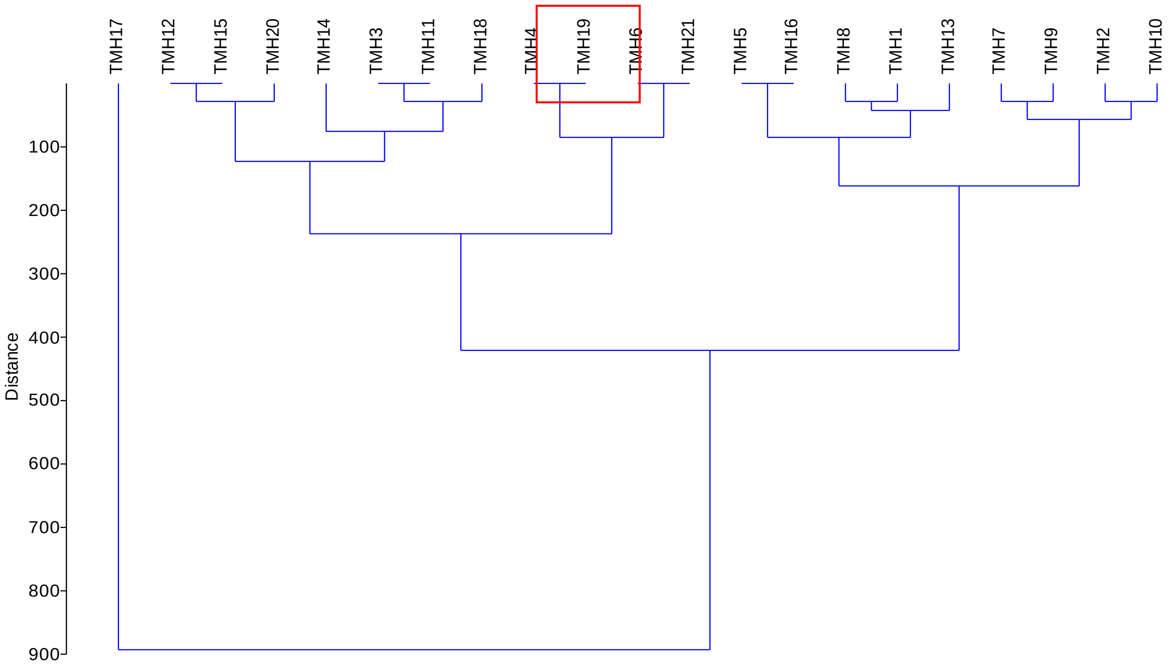

Fig. 4. Cluster dendrogram in the case of sunflower hybrids, class TMH
Source: Original figure.

Within the class of TMH hybrids, the MH17 hybrid was placed in a separate position, with the lowest level of production.
The other 20 IH hybrids were grouped within one C2 cluster, in several sub-clusters.
The level of similarity was evaluated based on SDI values, Tables 3 and 4.

Table 3. SDI values for sunflower hybrids, class IH (Imazamox hybrids)

	IH1	IH2	IH3	IH4	IH5	IH6	IH7	IH8	IH9	IH10	IH11	IH12	IH13	IH14	IH15	IH16	IH17	IH18	IH19	IH20	IH21	IH22	IH23	IH24	IH25	IH26	IH27
IH1		113.4	680.3	1,530.6	623.6	56.7	1,303.8	708.6	708.6	85.0	510.2	425.2	595.2	765.3	850.3	992.1	1,162.1	368.5	28.3	453.5	538.5	141.7	0.0	510.2	311.8	28.3	141.7
IH2	1,13.37		566.9	1,417.2	510.2	56.7	1,190.5	595.2	595.2	28.3	396.8	311.8	481.9	651.9	737.0	878.7	1,048.8	255.1	85.0	340.1	425.2	28.4	113.4	396.8	198.4	85.0	28.4
IH3	680.27	566.9		850.3	56.7	623.6	623.6	28.3	28.3	595.2	170.1	255.1	85.0	85.0	170.1	311.8	481.9	311.8	651.9	226.8	141.7	538.6	680.3	170.1	368.5	651.9	538.6
IH4	1,530.6	1,417.2	850.3		907.0	1,473.9	226.8	822.0	822.0	1,445.6	1,020.4	1,105.4	935.4	765.3	680.3	538.6	368.5	1,162.1	1,502.3	1,077.1	992.1	1,388.9	1,530.6	1,020.4	1,218.8	1,502.3	1,388.9
IH5	623.58	510.2	56.7	907.0		566.9	680.3	85.0	85.0	538.6	113.4	198.4	28.4	141.7	226.8	368.5	538.6	255.1	595.2	170.1	85.0	481.9	623.6	113.4	311.8	595.2	481.9
IH6	56.69	56.7	623.6	1,473.9	566.9		1,247.2	651.9	651.9	28.3	453.5	368.5	538.5	708.6	793.7	935.4	1,105.4	311.8	28.4	396.8	481.9	85.0	56.7	453.5	255.1	28.4	85.0
IH7	1,303.8	1,190.5	623.6	226.8	680.3	1,247.2		595.2	595.2	1,218.8	793.7	878.7	708.6	538.6	453.5	311.8	141.7	935.4	1,275.5	850.3	765.3	1,162.1	1,303.8	793.7	992.1	1,275.5	1,162.1
IH8	708.61	595.2	28.3	822.0	85.0	651.9	595.2		0.0	623.6	198.4	283.4	113.4	56.7	141.7	283.5	453.5	340.1	680.3	255.1	170.1	566.9	708.6	198.4	396.8	680.3	566.9
IH9	708.61	595.2	28.3	822.0	85.0	651.9	595.2	0.0		623.6	198.4	283.4	113.4	56.7	141.7	283.5	453.5	340.1	680.3	255.1	170.1	566.9	708.6	198.4	396.8	680.3	566.9
IH10	85.03	28.3	595.2	1,445.6	538.6	28.3	1,218.8	623.6	623.6		425.2	340.1	510.2	680.3	765.3	907.0	1,077.1	283.5	56.7	368.5	453.5	56.7	85.0	425.2	226.8	56.7	56.7
IH11	510.2	396.8	170.1	1,020.4	113.4	453.5	793.7	198.4	198.4	425.2		85.0	85.0	255.1	340.1	481.9	651.9	141.7	481.9	56.7	28.3	368.5	510.2	0.0	198.4	481.9	368.5
IH12	425.17	311.8	255.1	1,105.4	198.4	368.5	878.7	283.4	283.4	340.1	85.0		170.1	340.1	425.2	566.9	737.0	56.7	396.8	28.3	113.4	283.5	425.2	85.0	113.4	396.8	283.5
IH13	595.23	481.9	85.0	935.4	28.4	538.5	708.6	113.4	113.4	510.2	85.0	170.1		170.1	255.1	396.8	566.9	226.8	566.9	141.7	56.7	453.5	595.2	85.0	283.4	566.9	453.5
IH14	765.3	651.9	85.0	765.3	141.7	708.6	538.6	56.7	56.7	680.3	255.1	340.1	170.1		85.0	226.8	396.8	396.8	737.0	311.8	226.8	623.6	765.3	255.1	453.5	737.0	623.6
IH15	850.34	737.0	170.1	680.3	226.8	793.7	453.5	141.7	141.7	765.3	340.1	425.2	255.1	85.0		141.7	311.8	481.9	822.0	396.8	311.8	708.6	850.3	340.1	538.6	822.0	708.6
IH16	992.06	878.7	311.8	538.6	368.5	935.4	311.8	283.5	283.5	907.0	481.9	566.9	396.8	226.8	141.7		170.1	623.6	963.7	538.6	453.5	850.3	992.1	481.9	680.3	963.7	850.3
IH17	1,162.1	1,048.8	481.9	368.5	538.6	1,105.4	141.7	453.5	453.5	1,077.1	651.9	737.0	566.9	396.8	311.8	170.1		793.7	1,133.8	708.6	623.6	1,020.4	1,162.1	651.9	850.3	1,133.8	1,020.4
IH18	368.48	255.1	311.8	1,162.1	255.1	311.8	935.4	340.1	340.1	283.5	141.7	56.7	226.8	396.8	481.9	623.6	793.7		340.1	85.0	170.1	226.8	368.5	141.7	56.7	340.1	226.8
IH19	28.34	85.0	651.9	1,502.3	595.2	28.4	1,275.5	680.3	680.3	56.7	481.9	396.8	566.9	737.0	822.0	963.7	1,133.8	340.1		425.2	510.2	113.4	28.3	481.9	283.5	0.0	113.4
IH20	453.51	340.1	226.8	1,077.1	170.1	396.8	850.3	255.1	255.1	368.5	56.7	28.3	141.7	311.8	396.8	538.6	708.6	85.0	425.2		85.0	311.8	453.5	56.7	141.7	425.2	311.8
IH21	538.54	425.2	141.7	992.1	85.0	481.9	765.3	170.1	170.1	453.5	28.3	113.4	56.7	226.8	311.8	453.5	623.6	170.1	510.2	85.0		396.8	538.5	28.3	226.8	510.2	396.8
IH22	141.72	28.4	538.6	1,388.9	481.9	85.0	1,162.1	566.9	566.9	56.7	368.5	283.5	453.5	623.6	708.6	850.3	1,020.4	226.8	113.4	311.8	396.8		141.7	368.5	170.1	113.4	0.0
IH23	0	113.4	680.3	1,530.6	623.6	56.7	1,303.8	708.6	708.6	85.0	510.2	425.2	595.2	765.3	850.3	992.1	1,162.1	368.5	28.3	453.5	538.5	141.7		510.2	311.8	28.3	141.7
IH24	510.2	396.8	170.1	1,020.4	113.4	453.5	793.7	198.4	198.4	425.2	0.0	85.0	85.0	255.1	340.1	481.9	651.9	141.7	481.9	56.7	28.3	368.5	510.2		198.4	481.9	368.5
IH25	311.79	198.4	368.5	1,218.8	311.8	255.1	992.1	396.8	396.8	226.8	198.4	113.4	283.4	453.5	538.6	680.3	850.3	56.7	283.5	141.7	226.8	170.1	311.8	198.4		283.5	170.1
IH26	28.34	85.0	651.9	1,502.3	595.2	28.4	1,275.5	680.3	680.3	56.7	481.9	396.8	566.9	737.0	822.0	963.7	1,133.8	340.1	0.0	425.2	510.2	113.4	28.3	481.9	283.5		113.4
IH27	141.72	28.4	538.6	1,388.9	481.9	85.0	1,162.1	566.9	566.9	56.7	368.5	283.5	453.5	623.6	708.6	850.3	1,020.4	226.8	113.4	311.8	396.8	0.0	141.7	368.5	170.1	113.4	

Source: Original data.

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Table 4. SDI values for sunflower hybrids, class TMH (Tribenuron Methyl hybrids)

	TMH1	TMH2	TMH3	TMH4	TMH5	TMH6	TMH7	TMH8	TMH9	TMH10	TMH11	TMH12	TMH13	TMH14	TMH15	TMH16	TMH17	TMH18	TMH19	TMH20	TMH21
TMH1		170.1	425.2	680.3	56.7	595.2	113.4	28.3	141.7	198.4	425.2	340.1	56.7	510.2	340.1	56.7	595.2	453.5	680.3	311.8	595.2
TMH2	170.1		255.1	510.2	226.8	425.2	56.7	141.7	28.4	28.3	255.1	170.1	113.4	340.1	170.1	226.8	765.3	283.4	510.2	141.7	425.2
TMH3	425.2	255.1		255.1	481.9	170.1	311.8	396.8	283.5	226.8	0.0	85.0	368.5	85.0	85.0	481.9	1,020.4	28.3	255.1	113.4	170.1
TMH4	680.3	510.2	255.1		737.0	85.0	566.9	651.9	538.6	481.9	255.1	340.1	623.6	170.1	340.1	737.0	1,275.5	226.8	0.0	368.5	85.0
TMH5	56.7	226.8	481.9	737.0		651.9	170.1	85.0	198.4	255.1	481.9	396.8	113.4	566.9	396.8	0.0	538.6	510.2	737.0	368.5	651.9
TMH6	595.2	425.2	170.1	85.0	651.9		481.9	566.9	453.5	396.8	170.1	255.1	538.6	85.0	255.1	651.9	1,190.5	141.7	85.0	283.5	0.0
TMH7	113.4	56.7	311.8	566.9	170.1	481.9		85.0	28.3	85.0	311.8	226.8	56.7	396.8	226.8	170.1	708.6	340.1	566.9	198.4	481.9
TMH8	28.3	141.7	396.8	651.9	85.0	566.9	85.0		113.4	170.1	396.8	311.8	28.4	481.9	311.8	85.0	623.6	425.2	651.9	283.5	566.9
TMH9	141.7	28.4	283.5	538.6	198.4	453.5	28.3	113.4		56.7	283.5	198.4	85.0	368.5	198.4	198.4	737.0	311.8	538.6	170.1	453.5
TMH10	198.4	28.3	226.8	481.9	255.1	396.8	85.0	170.1	56.7		226.8	141.7	141.7	311.8	141.7	255.1	793.7	255.1	481.9	113.4	396.8
TMH11	425.2	255.1	0.0	255.1	481.9	170.1	311.8	396.8	283.5	226.8		85.0	368.5	85.0	85.0	481.9	1,020.4	28.3	255.1	113.4	170.1
TMH12	340.1	170.1	85.0	340.1	396.8	255.1	226.8	311.8	198.4	141.7	85.0		283.5	170.1	0.0	396.8	935.4	113.4	340.1	28.4	255.1
TMH13	56.7	113.4	368.5	623.6	113.4	538.6	56.7	28.4	85.0	141.7	368.5	283.5		453.5	283.5	113.4	651.9	396.8	623.6	255.1	538.6
TMH14	510.2	340.1	85.0	170.1	566.9	85.0	396.8	481.9	368.5	311.8	85.0	170.1	453.5		170.1	566.9	1,105.4	56.7	170.1	198.4	85.0
TMH15	340.1	170.1	85.0	340.1	396.8	255.1	226.8	311.8	198.4	141.7	85.0	0.0	283.5	170.1		396.8	935.4	113.4	340.1	28.4	255.1
TMH16	56.7	226.8	481.9	737.0	0.0	651.9	170.1	85.0	198.4	255.1	481.9	396.8	113.4	566.9	396.8		538.6	510.2	737.0	368.5	651.9
TMH17	595.2	765.3	1,020.4	1,275.5	538.6	1,190.5	708.6	623.6	737.0	793.7	1,020.4	935.4	651.9	1,105.4	935.4	538.6		1,048.8	1,275.5	907.0	1,190.5
TMH18	453.5	283.4	28.3	226.8	510.2	141.7	340.1	425.2	311.8	255.1	28.3	113.4	396.8	56.7	113.4	510.2	1,048.8		226.8	141.7	141.7
TMH19	680.3	510.2	255.1	0.0	737.0	85.0	566.9	651.9	538.6	481.9	255.1	340.1	623.6	170.1	340.1	737.0	1,275.5	226.8		368.5	85.0
TMH20	311.8	141.7	113.4	368.5	368.5	283.5	198.4	283.5	170.1	113.4	113.4	28.4	255.1	198.4	28.4	368.5	907.0	141.7	368.5		283.5
TMH21	595.2	425.2	170.1	85.0	651.9	0.0	481.9	566.9	453.5	396.8	170.1	255.1	538.6	85.0	255.1	651.9	1,190.5	141.7	85.0	283.5	

Source: Original data.

For the IH hybrids, Figure 5, within the C2-1 sub-cluster, the IH1 and IH23 hybrids with the highest production level are marked in red. For the TMH hybrids, Figure 6, within the C2-1 sub-cluster, the TMH4 and TMH19 hybrids with the highest level of production are marked in red. The evaluation of the level of similarity, based on value data, in addition to the graphic distribution (Figures 5 and 6), was made on the basis of the SDI values for the hybrids of each class, Table 3 in the case of the hybrids of the IH class, and Table 4 for the hybrids of the TMH class.

Ebeed et al. (2019) [12] communicated production results and quality indices of certain sunflower hybrids, under conditions of stress (hydric and saline) and of the genotype x environment interaction, as well as the response of the hybrids to irrigation. The comparative analysis of seven sunflower hybrids facilitated the quantification of some physiological and biometric parameters, achene production, yield and quality indices as a response of the hybrids to the crop conditions [28]. Increased production in some types of sunflower (up to 323 kg ha^{-1}) was reported by Brewer et al. (2023) [7] in relation to pollinators (bees), and the authors recommended based on the study, holistic insect management in sunflower, with benefits on yield (bees) and the reduction of harmful insects.

CONCLUSIONS

Sunflower hybrids from the two classes (Imazamox – IH, 27 hybrids; Tribenuron Methyl – TMH, 21 hybrids) ensured different productions in the study conditions (chernozem soil, non-irrigated crop system). Different values were recorded for the average production calculated on the two classes of hybrids (IH-Avg=3,038.13 kg ha^{-1}, TMH-Avg=3,287.98 kg ha^{-1}).

Appropriate mathematical and statistical tests (Null Hypothesis (H0), t-test for Equality of Means; non-parametric Mann-Whitney test) confirmed the differences between the two classes of hybrids (IH, N=27; TMH, N=21), with regarding the registered and calculated production.

By comparing the productions for each hybrid, in relation to the average production calculated on the two classes of hybrids (IH-Avg; TMH-Avg), as well as in relation to the average production per company, within each class (C-Avg), of it was possible to classify the hybrids under the aspect of production and yield.

The cluster analysis of the data on each class of hybrids facilitated the classification of hybrids in relation to the degree of similarity for production, and the results show importance for research and agricultural practice, in order to select genotypes with an adequate response.

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ECONOMIC ANALYSIS OF OIL PALM PROCESSING IN OLA OLUWA LOCAL GOVERNMENT AREA, OSUN STATE, NIGERIA

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Abstract

The study investigated the profitability of oil palm processing venture in Ola Oluwa Local Government Area of Osun State, Nigeria. The sampled 120 respondents for the study were selected using a multistage sampling procedure. Field surveys were carried out using structured interview schedule to obtain primary data utilized for the study. Data analysis was carried out using frequencies, percentages, means, and regression analysis. Results of the descriptive analysis revealed that the majority of the respondents were middle-aged (mean = 58.43 years) (92.5%), married (55.83%), female (100%), having a mean of the household size of 5 persons per household. The majority (60.00%) of the respondents had no formal education; do not own an oil palm processing unit (77.31%); small-scale processors (44.54%), with a mean of 37.21 litres of palm oil per production cycle. The mean years of oil palm processing experience, total revenue, total production cost, gross margin, and net income from oil palm processing per year were 28.39 years, ₦243,472.900, ₦103,088.808, ₦155,521.592 and ₦140,384.092 respectively. Regression results revealed that the cost of oil palm bunches, the cost of firewood, the cost of kerosene, and matches, and the cost grinding were positive significant determinants of the level of gross margin from oil palm processing in the study area. Based on the findings, the study concluded that despite the profitability oil palm processing venture in the study area, it is operated on a small-scale predominantly by aged married and widowed women; hence provision of financial assistance through low-interest loans from agricultural banks or any other related financial institution would help improve their productivity.

***Key words**: Oil palm, Oil palm processor, small scale oil processing, gross margin, palm bunches cost*

INTRODUCTION

The oil palm is of significant economic value globally, its production and yield per unit area have increased in recent times as a result of surging demand for palm oil in the global market [6].
Oil palm (*Elaeis guineensis*), a tree crop, is of immense economic importance in the economy of Nigeria. It is a monocotyledonous plant, and a member of the palm family known as *Arecaceae*. There are about 225 genera with over 2,600 species. A monoecious species, producing unisexual male and female inflorescences alternately, with a better performance in humid tropics [12].
Palm oil production involves the extraction of the oil from oil palm fruit fleshy mesocarp.
Also, palm oil extracted from coconut palm, a different species of oil palm is used in production of palm sugar which is combined with mulberry leaf to serve as an energy source in the production of silkworms in Indonesia [13].
Globally, Nigeria is ranked as one of the topmost producers of palm oil. The commodity is an essential commodity in the

diet of human and livestock, as well as in production of others products.

Palm oil could bring important revenues to farmers. Over 70% of crude palm oil produced in Nigeria is not refined before consumption. Crude palm oil is utilized in various food recipes, including frying [7].

The continuous increase in global consumption of palm oil as result of population explosion has created a serious deficit in supply relative to demand [3].

Oil palm processing is made up of series of activities and operation which include: harvesting and reception of bunches, removal of oil palm fruits from the bunches, sterilization of the fruits harvested from oil palm , mashing of the fruits from oil palm to extract the oil containing fibres from the kernels, heating to extract the oil from the fibres using an oil seed expeller, clarification using a filter press using the principle of sedimentation, and final storage of the extracted oil in 25 litres capacity plastic kegs or 200 litres capacity drums [3] and [12].

Oil palm value chain is a steady source of income for all actors in the chain. Palm oil and other derivatives from oil palm processing are indispensable raw material for food and agro-allied industries, thus indirectly providing employment for the teeming population. Annually, palm oil is consumed in large volume in Nigeria. Statistically, in 2018, about 1.34 x 10^6 metric tonnes of palm oil was reported to be consumed [2] and [3]. Before independence, Nigeria is the leading global producer of palm oil, with the export of the commodity contributing significantly to revenue from agricultural exports [3].

The discovery of crude petroleum in the early part of 1970, and its subsequent export led to massive influx of foreign exchange earnings which led to serious neglect of the agricultural export sector by the government. This phenomenon is known as "Dutch disease". The aftermath of this government action is a serious decline in the production and productivity of agricultural export commodities, including palm oil. Subsequently, Nigeria lost her leadership in global production of palm oil to other countries such as Malaysia and Indonesia. This situation created a serious supply-demand deficit, thus the country had to retort to palm oil importation to augment local production to meet rising demand [4] and [5].

Import of palm oil affects internal producers and supply, but export ahs to be encouraged to bring foreign currency in the country [11].

Recently, Indonesia, the world largest oil palm and palm oil producer stopped the export of crude palm oil and its derivatives to other nations across the globe. This created a huge pressure on domestic production and consumption in Nigeria. However, this scenario resulted in the creation of a huge opportunities in palm production and processing, especially for countries with huge potential in the two areas, including Nigeria. Currently, in the global market, a barrel of crude palm oil is sold at a higher price than a barrel of crude oil, giving Nigeria a massive opportunities to improve her revenue from increased foreign exchange earnings from palm oil exports and other derivatives. The Central Bank of Nigeria (CBN) is currently pursuing a policy of reviving the agro-business sector’s oil palm sub-sector in Nigeria. The intervention of CBN in the oil palm value chain, is timely as it is aimed at increasing oil palm production from 1,250,000 metric tonnes in 2021 to 2,500,000 metric tonnes by 2028 by expanding land area under oil palm production to approximately 350,000 hectares. The specific objectives of the CBN policy are to satisfy local demand for palm oil and its derivatives, improve local processing quality and standards; conserve foreign exchange reserves; create jobs and enhance the skills of Nigerian people along the oil palm value chain; facilitate easier access to funding for palm oil majors, Small and Medium Enterprises (SMEs), and smallholders in a way that will improve economic growth [8].

There are different techniques used in processing of agricultural commodities including palm oil and these range from climate change resilient modern methods to traditional methods [1]. However, the traditional method of processing is more prevalent among small scale processors and these small scale processors are responsible for the bulk of palm oil processed in Nigeria [9].

Presently, a myriad of problems have affected the oil palm processing sub-sector; incomplete and obsolete processing facilities, sole reliant small scale processors, land fragmentation induced by land tenure system, dilapidating infrastructure, and dearth of financial facilities for the processors [10] and [3]. The production and productivity of the oil palm processing sub-sector have been retarded by these problems, with negative consequences on profitability of this sub-sector.

Consequently, the study investigated the profitability of oil palm processing venture in Ola Oluwa Local Government Area of Osun State, Nigeria. The specific objectives of the study is to examine the socio-economic characteristics of the oil palm processors, examine their level of oil palm processing, evaluate the profitability of oil palm processing among the processors, determine significant factors affecting the profitability of oil palm processing venture, and constraints to oil palm processing in the study area.

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MATERIALS AND METHODS

The study was carried out Ola Oluwa Local Government, Osun State, Nigeria. The local government is located in Osun State, a state in the South Western part of Nigeria. The area has a high population of oil palm processors due to abundance of oil palm trees. The sampled 120 respondents for the study were selected using a multistage sampling procedure. The first stage involved the selection 10 oil palm processing communities were randomly selected from oil processing clusters in the local government area. In the second stage, 5 villages with the highest oil palm processing clusters were randomly selected from the 10 communities. In the final stage, 25 oil palm processors were randomly selected from the 5 villages to make 125 oil palm processors as sample for the study.

Primary data was used for the study. Primary data was collected through field survey using structured interview schedule. Data was collected on the following:

(i)Socio-economic variables such as age of the respondents, sex, household size, family size, education level, marital status, income and oil palm processing experience.

(ii)Oil palm processing variables such as amount of oil palm bunches harvested (nos), labour utilization (man-day) total output obtained, costs of inputs, product(s) price(s), marketing costs and returns.

Data analysis

Data collected was analysed with both descriptive and inferential statistics. The descriptive statistical tools that were employed in the study include means, percentages and frequency counts. These will be used to examine the socio-economic characteristics of the oil palm processors. The profitability of the oil palm processing was determined using the budgetary analysis. The major inferential statistical tool employed in the study is the multiple regression analysis which is used to determine significant factors affecting profitability of oil palm processing venture in the study area. The implicit regression model that was used for the study is stated as:

$$Y = f(X_1, X_2, X_3, X_4, X_5 \text{ and } E_t) \text{ -----------(1)}$$

where:

Y is gross margin from oil palm processing
$X_1$is cost of palm bunches in Naira
X_2 is costs of variable inputs in Naira
X_3 is costs of labour in Naira
X_4 is the fixed cost (renting) in Naira
X_5 is levies paid in Naira
X_6 is oil palm processing experience in years
X_7 is household size
E_t is the random error term.

RESULTS AND DISCUSSIONS

Socio-economic characteristics of the oil palm processors

One of the study specific objectives is to examine socio-economic related characteristics of the oil palm processors in the study area. These characteristics include age, gender, marital status, household size, years of formal education, ownership of the oil palm processing unit, and oil palm processing experience. The descriptive analysis results are presented in Table 1.

The distribution of the oil palm processors based on their age is shown in Table 1. The Table reveals that virtually all (92.50%) of the oil palm processors falls within the age range of 41-80 years, with an average of 58.43 years. This implies that the respondents are still in their economically active age which may influence their level of profitability in the study area.

Similarly, gender distribution of the sampled oil palm processors is presented in Table 1. The Table shows that virtually all (100.00%) of the oil palm processors were female, implying that the venture is dominated by the female gender in the study area.

Also, the marital status distribution of the oil palm processors is presented in Table 1. Data in the Table reveals that majority (55.83%) of the oil palm processors were married, while minority (44.17%) of them have lost their husbands (widowed).

In the same way, household size distribution of the oil palm processors is shown in Table 1. Virtually all (93.34%) of the oil palm processors had between 1-10 persons in their households, with an average of 5 persons per household. This may be connected to family labour supply required by the venture in the study area.

In addition, the years of formal education distribution of the sampled oil palm processors is shown in Table 1. The Table reveals that most (70.00%) of the oil palm processors had between 4-8 years of formal education, while few (30.00%) of the respondents had between had between 9-16 years of formal education, with a mean of 5 years, reflecting the significance of formal education in oil palm processing venture in the study area.

Furthermore, the distribution of the oil palm processors according to their ownership of assets used in palm oil production is shown in Table 1. The Table reveals that most (77.31 %) of the oil palm processors do not individually own oil palm processing units, however few (22.69%) of the oil palm processors owned their oil palm processing units. This situation may be attributed their financial incapability to purchase their own processing units.

Finally, Table 1 shows the distribution of the oil palm processors based on their oil palm processing experience. Results from the Table shows that almost all (85.83%) of the processors had been engaged in oil palm processing for about 2-40 years, while, a few (14.17%) had been involved in oil palm processing for about 41-60 years. The mean years of oil palm processing experience of the oil palm processors is 28.39 years, suggesting that the oil palm processors in the study area were highly experienced.

Table 1. Socio-economic characteristics of the oil palm processors

Socio-economic characteristics (n=120)	**Frequency**	**Percentage (%)**
Age		
30-40	9	7.50
41-50	38	31.67
51-60	25	20.83
61-70	29	24.17
71-80	19	15.80
Mean age = 58.43 Years		
Gender		
Male	0	0.00
Female	120	100.00
Marital status		
Single	0	0.00
Married	67	55.83
Separated	0	0.00
Widowed	53	44.17
Household size		
1-5	68	56.67
6-10	44	36.67
11-15	8	6.67
Mean = 5 person per household		
Years of formal education		
0-4	62	51.67
5-8	22	18.33
9-12	35	29.17
13-16	1	0.83
Mean = 5 years		
Ownership of oil palm processing unit		
Owned	27	22.69
Not owned	93	77.31
Years of oil palm processing		
2-20	66	55.00
21-40	37	30.83
41-60	17	14.17
Mean = 28.39 years		

Source: Field Survey, 2023.

Respondents' level of oil palm processing

Results in Table 2 reveals oil palm processing level among the respondents. The data reveals that most (79.17%) of the oil palm processors' level of palm oil production ranges from 25-

39 litres, with few (20.83%) of them producing between 40-54 litres of palm oil. The average palm oil production among the respondents stood at 37.21 litres, suggesting that most of the oil palm processors in the study area operates at small scale level.

Table 2. Respondents' level of oil palm processing

Level of oil palm processing (litres)	Frequency	%
25-29	11	9.17
30-34	31	25.83
35-39	53	44.17
40-44	7	5.83
45-49	3	2.50
50-54	15	12.50
Total	120	100

Mean = 37.21 litres
Source: Field Survey, 2023.

Budgetary analysis

Table 3. Annual Cost and Return Analysis per oil palm processor

S /N	Item	Amount (₦)	Scale
A	Revenue (TR)	243,472.900	
B	Variable Cost		% of TVC
	Cost of oil palm bunches	9,748.167	11.084
	Cost of water	4,377.731	4.977
	Cost of fire wood	31,862.500	36.227
	Cost of matches and kerosene	1,292.083	1.470
	Cost of grinding	6,874.167	7.816
	Miscellaneous expenses	15,308.330	17.405
	Cost of labour	18,488.330	21.021
C	Total variable cost (TVC)	87,951.308	100
D	Gross margin (TR-TVC)	155, 521.592	
E	Cost of fixed assets	15,137.500	
F	Total production cost= B+E	103,088.808	
G	Net oil palm processing income	140,384.092	

Source: Field Survey 2023.

The cost and returns associated with oil palm processing among the respondents is shown in Table 3.

Budgetary analysis results from the Table reveals that the fixed asset cost is ₦15,137.500, while that of the total variable cost is ₦87,951.308, and the total revenue is ₦243,472.900.

The result further revealed that on the average, a processor realized a net oil palm processing income of ₦140,384.092 per annum. The results revealed that oil palm processing is a profitable enterprise in the study area.

Regression analysis results

The regression analysis results indicating significant factors affecting the gross margin of the oil palm processors in the study area is presented in Table 4.

The adjusted R-squared is 0.486 and the F-value (12.46) is significant at 1% level, showing that the model has a good fit.

The coefficient of cost of oil palm bunches (X_1) and cost of grinding (X_5) is positive and is statistically significant at 1% level, implying that a positive relationship between these variables and the level of gross margin from palm oil production in the study area.

In the same way, the coefficients of cost of kerosene and matches (X_4) and cost of firewood (X_3) are positive and statistically significant at 5% and 10% level respectively; showing that these variables are directly related with the oil palm processors' gross margin level in the study area.

Table 4. Regression analysis results

Variable	Coefficient	Standard error	t-value	Probability
Cost of palm bunches (X_1)	5.319	0.918	5.790	0.000*
Cost of water (X_2)	2.348	3.918	0.600	0.550
Cost of fire wood (X_3)	-2.032	1.235	-1.650	0.103***
Cost of matches and kerosene (X_4)	31.556	14.788	2.130	0.035**
Cost of grinding (X_5)	20.044	4.552	4.400	0.000*
Cost of labour (X_6)	-1.087	0.898	-1.210	0.228
Fixed costs (X_7)	0.764	1.089	0.700	0.484
House hold size (X_8)	94.942	1436.194	0.070	0.947
Oil palm processing experience (X_9)	20.851	23.302	0.089	0.373
Constant	-18.265	21.243	-0.860	0.392

R-squared = 0.507, Adj R-squared = 0.486, F value = 12.46
*significant at 1% level, **significant at 5% level, ***significant at 10% level
Source: Data Analysis, 2023.

CONCLUSIONS

From the study findings, it is concluded that oil palm processing, a profitable business venture dominated by the female gender who are married is operated on small-scale in the study area.

Based on these findings of the study, it is suggested that financial facilities such as credit and low interest loans facilitated by agricultural banks or any other related financial institution should be made accessible to the oil palm processors for the procurement of oil palm processing assets which would improve their scale of production and their standard of living.

Also, oil palm processors should be encourage to organise themselves into cooperative societies in order to secure credit facilities for better production technology and market access.

Finally, since the processors are mostly aged married and widowed women, there is need to empower them through vocational training to sustain them during the off season period.

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ANALYSIS OF SEASONAL FLUCTUATIONS IN EGG PRICES IN TÜRKIYE

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Abstract

The aim of this study was to analyse the seasonal movements in chicken egg prices in Türkiye. In this framework, the main material of the study consisted of data obtained from Afyonkarahisar Başmakçı Poultry Cooperative, TURKSTAT and FAO. In the study, real prices of eggs received by farmers reached its lowest value in June 2022. On the other hand, it was determined that it reached its highest value in January 1996. In the same period, on a monthly basis, it was determined that the prices received by egg producers showed a decreasing trend and price volatility continued (Y1994-2022 = -0.00001x + 0.33387; R² = 0.51568). Between 1994 and 2022, egg prices followed a highly fluctuating course. The reason for this fluctuation can be said to be the restrictions on imports and exports in some years in the egg poultry sector. The monthly price movements of Başmakçı cooperative were analysed as guide, broiler, pullets, new mother, old mother and double eggs. The average real price of pilot egg was the lowest in July with 40.89 TRY and the highest in December with 63.24 TRY. The average real price of "chicken eggs" was the lowest in July with 53.46 TRY and the highest in December with 76.33 TRY. The average real price of "Pullets" was the lowest in July with 66.36 TRY. With 88.47 TRY, it reached its highest value in December. The average real price of new mother egg was the lowest in May with 66.19 TRY and the highest in December with 92.87 TRY. The average real price of "old main egg" was the lowest in May with 69.66 TRY and the highest in December with 96.02 TRY. The average real price of double eggs was the lowest in May with 71.50 TRY and the highest in December with 97.86 TRY. Between 2003 and 2022, it was determined that the price of eggs on consumer basis increased against wheat flour, bread, apples, beef, poultry, fish and milk. As a result, in addition to the measures to be taken to ensure price stability, it was foreseen that increasing the production potential rather than import tendency in the supply of feed raw materials and a possible input subsidy to be provided to producers will contribute to price stability.

Key words: *price, export, import, price analysis, eggs*

INTRODUCTION

Poultry production is less affected by climatic and natural conditions compared to other agricultural production branches, which puts it in an advantageous position among agricultural production activities worldwide [2]. In addition, the fact that chicken meat and eggs have a rich nutritional content, their production in a short time and their relatively low cost increase their importance [10].
Eggs have an important place especially in meeting the protein, which is the most basic nutritional need of humans. Egg is a sought-after food product in meeting the nutritional values of middle and low-income families due to its affordable price and rich nutritional content [10]. In this context, fluctuations in egg prices will affect middle and low-income families the most.
The importance of eggs, which are so important for humanity, has become more understood especially in this process of Covid-19 pandemic. Because antibodies must fulfil their duty in body defence in order to increase body resistance against viruses and bacteria, which are disease agents.
In order for antibodies to take an active role in the body defence mechanism, the body needs to get enough protein every day. Eggs are one of the most important food sources for this protein requirement [4].
Price formation in agricultural products is different from other sectors. Because in most other sectors, prices are determined by equating the final unit cost with marginal

income, while price formation in agricultural products occurs outside the initiative of sector stakeholders. In other words, the prices of agricultural products are shaped by the total supply and demand in the market rather than the costs of agricultural products for that year [5][7].

When the previous studies on price analysis were analysed; Yılmaz and Gül [14] in their study on the analysis of seasonal price fluctuations in banana prices, determined that the average real prices and seasonal index of banana had the highest values in May and the lowest values in July. Gül et al. [8] analysed the developments and seasonal fluctuations in vegetable prices and found that there was a decreasing trend in vegetable real prices. They found that fluctuations in product prices have an impact on crop pattern and trade. Şirikçi and Gül [11] argued about how the world's and Türkiye's onion pricing and output have changed. According to their analysis, the development of crop area and yield led to a 4.37-fold rise in dry onion production between 1980 and 2017. Türkiye was the seventh-largest producer of dry onions worldwide. They came to the conclusion that the dried onion trade has significantly expanded on a global scale, with export values and quantities rising by 6.73 and 3.94 times, respectively. According to their report, Türkiye's export and manufacturing share of global output fell. They discovered that the marketing margin rose in Türkiye and that the pricing of producers of dried onions changed considerably. They stated that producer prices rose mostly as a result of the rising exchange rate. Acar and Gül [1] analysed the domestic and foreign market developments of onion production in the world and Türkiye using FAO and TURKSTAT data. As a result of the study, it was determined that onion input and sales prices on producer basis were very important in onion supply.

The aim of the study was to analyse and examine the prices of chicken eggs in Türkiye on producer and consumer basis.

MATERIALS AND METHODS

The main material of the study consists of data obtained from Afyonkarahisar Başmakçı Poultry Cooperative, TURKSTAT and FAO. In addition, national and international researches on the subject were also utilised. In this context, seasonal analysis of the prices of eggs received by producers and the prices paid by consumers were carried out in order to contribute to minimising the risk by making the right production planning, marketing and storage decisions of egg producers. In order to eliminate the effect of increases in general prices on egg prices, real prices were calculated and interpreted. The real prices of eggs were found by using the PPI (Producer Price Index - 2003=100) for the period 1994-2022.

The general trend of this real price series, seasonal index and coefficients of variation were calculated using the simple average method. The current prices paid by the consumers were calculated by using the CPI (2003=100) data.

Thus, the changes and developments in prices over the years were determined and the reasons were tried to be revealed. The simple ratio method was used to calculate seasonal fluctuations in prices. In addition, the parity of wheat, maize, apple, milk and meat prices on producer basis was calculated by proportioning them to egg prices.

On the consumer basis, parities were calculated by comparing wheat, bread, apple, beef, poultry, fish and milk prices to egg prices. Afyonkarahisar Başmakçı Poultry Co-operative classifies according to egg weights. These were guide, chicken, pullets, new mother, old mother and double eggs. Coefficient of variation and price volatility were calculated to measure the change in egg prices according to seasonal fluctuations. Price volatility determines the fluctuation in prices in a certain period by using the standard deviation [1].

In addition, in order to measure how the standard deviation in egg prices is distributed according to the seasonal average, the coefficient of variation was calculated using the formula Coefficient of variation = (Standard Deviation)/(Arithmetic Mean)*100.

RESULTS AND DISCUSSIONS

Egg Poultry in Türkiye and the World

Egg production is widespread in approximately 190 countries around the world. Egg production in the world, which was 51.13 million tonnes in 2000, increased by 69% and reached 86.38 million tonnes by the end of 2021. The most important producer country in egg production as of 2021 was China with a share of 34.43%. This was followed by India with a share of 7.77% and the USA with a share of 7.69%. Türkiye's egg production increased by 43% from 844 287 tonnes in 2000 to 1,206,099 tonnes by the end of 2021 [6].

Considering the world egg (shell) exports in the 2000-2021 period; egg exports, which was 944,794 tonnes in 2000, increased by 126% and reached 2,137,406 tonnes by the end of 2021. As of 2021, the Netherlands ranked first with a share of 16.43% of world egg (shell) exports, followed by Türkiye with a share of 10.35% and the USA with a share of 9.42%. The world egg (shelled) export value was 4.09 billion USD in 2021. The Netherlands, USA, Türkiye, Germany and Poland were the leading countries with the largest share in the export value [6].

According to FAO 2021 data, 36.59% of the total eggs produced in the world are imported by Germany, the Netherlands and China. In this context, Germany ranks first with a share of 15.35% of the total amount of egg (shell) imports, followed by the Netherlands with a share of 11.89% and China with a share of 9.35%. In this context, the total import value of eggs imported in the world in 2021 was 4.21 billion USD. Türkiye, on the other hand, has a share of 0.12% in the world egg imports and ranks 59th, with a total import value of 51 million dollars [6].

Egg production per capita was 328 units in the USA, 276 units in the EU, 207 units on average in the world and 228 units in Türkiye. In this context, Türkiye's egg production per capita was above the world average [6].

According to FAO data for 2021, the average egg consumption per capita in the world was calculated to be 207 units. Egg consumption per capita in the USA was 326 units, 273 units in the EU and 222 units in Türkiye [6]. These consumption figures were above the world average.

In 2010, the amount of egg production per capita in Türkiye was 161 units, while it increased by 45% and reached 232 units by the end of 2022 [13].

In 2010, per capita egg consumption in Türkiye was 157, while it reached 222 units with an increase of 41% by the end of 2021 [13]. In order to have a healthy diet, per capita egg consumption should be 300 eggs per year [3]. However, in order for per capita egg consumption in Türkiye to reach the desired level for a healthy diet, consumption needs to be increased more.

The number of laying hens in Türkiye, which was 60,275,674 in 2005, increased by 82% and reached 109,806,327 in 2022 [13].

As of 2022, Afyonkarahisar ranks first with a share of 13.58% in the most important laying hen breeding province. This was followed by Manisa with a share of 10.27% and Konya with a share of 8.05% [13].

The amount of egg (shell) production, which was 844,287 tonnes in 2000, increased by 43% and reached 1,206,099 tonnes by 2021. In 2000, the amount of egg exports was 3,556 tonnes and the export value was 3.63 million USD. In 2021, the export amount increased 62 times compared to 2000 and reached 221,215 tonnes.

Export value increased 103 times to $374.9 million. In the same period, the amount of imports increased by 152% from 1,051 tonnes to 2,645 tonnes, while the import value increased by 1,635% from $3 million to $51.96 million. In other words, Türkiye was a net egg exporter country. In addition, Iraq, United Arab Emirates, Iraq, Syria and Qatar were the leading countries where Türkiye exports eggs the most [13].

Monthly Price Analysis by Producer

Türkiye Average

The real prices of eggs received by farmers were found to be the lowest in June 2022 and the highest in January 1996. It was observed that egg prices followed a rather fluctuating course between 1994 and 2022. The reason for this fluctuation can be said to be the diseases that occurred in the egg poultry sector in some years, as well as the restrictions imposed by countries on imports and exports (Figure 1).

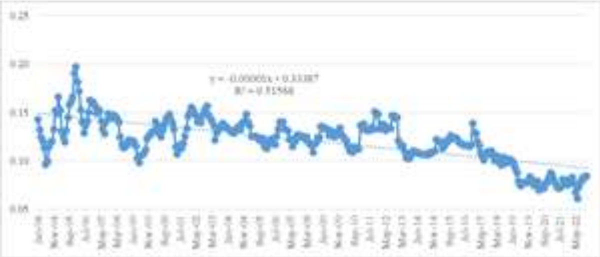

Fig. 1. Development of producer monthly egg prices in real prices in the period 1994-2022 (TL/pcs)
Source: Own calculation.

Significant monthly fluctuations were observed in egg prices during the period analysed, but in general, the prices received by egg producers show a decreasing trend and price volatility continues ($Y_{1994\text{-}2022} = -0.00001x + 0.33387$; $R^2 = 0.51568$). Price volatility in the egg sector was 6.78% in the 1994-1999 period, 4.11% in the 2000-2009 period, 5.12% in the 2010-2022 period and 5.19% as the average of the 1994-2022 period (Figure 2).

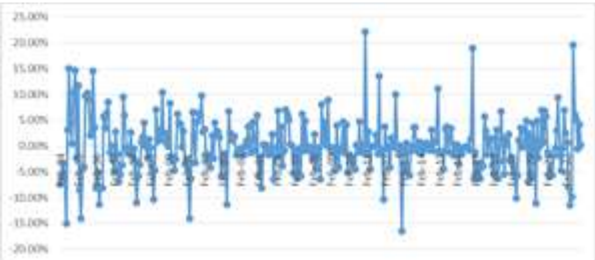

Fig. 2. Producer monthly egg price volatility in real prices
Source: Own calculation.

Başmakçı Cooperative Monthly Price Movements

Genotype is the main factor determining egg weight or size. Besides, feeding and environmental factors are also effective. They are divided into 6 groups according to egg weight [9].

(i) Guide Egg: Eggs weighing between 42 and 48 grams.

(ii) Chicken Egg: Eggs weighing between 48 and 53 grams.

(iii) Pullets Egg: Eggs weighing between 53 and 58 g.

(iv) New Mother Egg: Eggs weighing between 58 and 62 g.

(v) Old Mother Egg: Eggs weighing between 62 and 67 g.

(vi) Double Egg: Eggs with a weight of 62 or more.

Guide, broiler and pullets eggs are obtained from hens up to 24th week of age.

New mother and old mother eggs are obtained from hens between 24th week and 34th week.

Double eggs are obtained from hens at the 34th week and beyond.

Guide egg monthly prices

In Figure 3, data on producer monthly guideline egg prices of Başmakçı Cooperative for the period 2003-2022 in real prices were given. It was determined that the real prices of eggs received by farmers were the lowest in January 2006 and July 2019, and the highest in October 2004 and December 2016. In the period in question, guide egg prices followed a very fluctuating trend.

Fig. 3. Development of producer monthly guideline egg prices of Başmakçı Cooperative in real prices in the period 2003-2022 (TL/1,000 units)
Source: Own calculation.

During the period analysed, it was determined that there was a monthly price volatility in guide egg prices. The price volatility was 24.81% in the 2003-2009 period, 23.79% in the 2010-2022 period and 24.10% as the average of the 2003-2022 period (Figure 4).

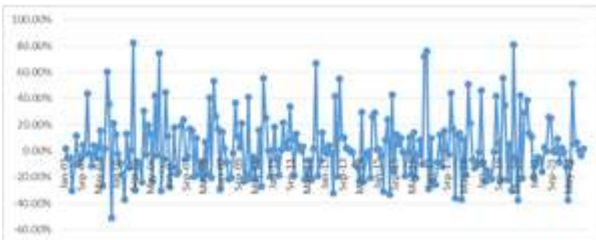

Fig. 4. Producer monthly guideline egg price volatility of Başmakçı Cooperative in real prices for the period 2003-2022
Source: Own calculation.

The average real price of pilot egg was lowest in July with 40.89 TRY and highest in December with 63.24 TRY. The seasonal index reaches its lowest value in June and July and reaches its highest value in December. The coefficients of variation for the months of January, February, March, September, October, November and December, when the prices were above the seasonal fluctuations, were 24.23, 21.15, 23.33, 25.32, 32.46, 24.27, 26.50, respectively (Table 1).

Table 1. Seasonal fluctuations in real prices of guideline eggs for the period 2003-2022 (TL/1000 pieces)

	Arithmetic mean	Standard deviation	Coefficient of variation	Seasonal index
January	58.24	14.11	24.23	114
February	58.74	12.42	21.15	114
March	54.27	12.66	23.33	106
April	49.70	9.99	20.10	97
May	41.52	6.98	16.82	81
June	41.23	9.03	21.91	80
July	40.89	8.73	21.35	80
August	45.32	10.92	24.09	88
September	53.16	13.46	25.32	104
October	53.88	17.49	32.46	105
November	55.54	13.48	24.27	108
December	63.24	16.76	26.50	123

Source: Own calculation on the basis of data from Başmakçı Cooperative data base 2003-2022 [15].

Chicken egg monthly prices

When the producer monthly chicken egg prices of Başmakçı Cooperative in the period 2003-2022 in real prices were analysed; the average real prices of chicken eggs received by the farmer was found to be 63.67 TRY for the period 2003-2009, 65.62 TRY for the period 2010-2022 and 64.938 TRY for the period 1993-2022. It was found to be the highest in October 2004 and December 2016 and the lowest in January 2006 and October 2019 (Figure 5).

Fig. 5. Development of producer monthly chicken egg prices of Başmakçı Cooperative in real prices in the period 2003-2022 (TL/1,000 pieces) [15].
Source: Own calculation.

It was determined that the highest monthly price volatility in chicken egg prices was in September 2022 and the lowest in November 2004. The price volatility of chicken eggs was 22.38% in the 2003-2009 period, 20.49% in the 2010-2022 period and 21.12% in the 2003-2022 period average.

The average real price of chicken eggs was lowest in July with 53.46 TRY and highest in December with 76.33 TRY. The seasonal index was the lowest in June and July. It reaches its highest value in December. The coefficients of variation for the months of January, February, March, September, October, November and December, when prices were above the average, were 22.03, 18.26, 19.46, 20.96, 26.41, 19.39 and 23.08, respectively (Table 2).

Table 2. Seasonal fluctuations in real prices of chicken eggs for the period 2003-2022 (TRY/1,000 pieces)

	Arithmetic mean	Standard deviation	Coefficient of variation	Seasonal index
January	72.17	15.90	22.03	111
February	72.08	13.16	18.26	111
March	67.60	13.16	19.46	104
April	62.37	9.85	15.79	96
May	53.50	9.36	17.50	82
June	53.46	11.87	22.21	82
July	54.34	10.75	19.79	84
August	61.60	14.13	22.94	95
September	69.80	14.63	20.96	107
October	67.87	17.92	26.41	105
November	68.14	13.21	19.39	105
December	76.33	17.62	23.08	118

Source: Own calculation on the basis of data from Başmakçı Cooperative data base 2003-2022 [15].

Pullet egg monthly prices

Figure 6 showed the data on the monthly prices of pullets in real prices for the period 2003-2022 in Başmakçı Co-operative.

It was found that the real prices of pullets received by farmers were the lowest in January 2006 and the highest in June 2003.

Fig. 6. Development of producer monthly pullet egg prices of Başmakçı Cooperative in real prices in the period 2003-2022 (TL/1,000 pieces) [15].
Source: Own calculation.

In the this period, it was determined that the prices of pullets followed a highly fluctuating course and had a decreasing trend.

The price volatility of pullet was 26.70% in the period 2003-2009, 18.77% in the period 2010-2022 and 21.80% as the average of the period 2003-2022.

The average real price of pullet was the lowest in July with 66.36 TRY. With 88.47 TRY, it reaches its highest value in December. The seasonal index was the lowest in May and reaches its highest value in December. The months when the prices were above the seasonal fluctuation were January, February, March, September, October, November and December, while the months when the prices were below the seasonal fluctuation were April, May, June and July (Table 3).

Table 3. Seasonal fluctuations in real prices of pullet for the period 2003-2022 (TRY/1,000 pieces)

	Arithmetic mean	Standard deviation	Coefficient of variation	Seasonal index
January	83.93	17.40	20.73	109
February	83.61	13.93	16.67	108
March	78.35	14.55	18.57	101
April	72.72	10.59	14.56	94
May	62.32	10.44	16.75	81
June	68.58	28.49	41.55	89
July	66.36	12.78	19.26	86
August	76.28	17.22	22.57	99
September	84.47	15.87	18.79	109
October	81.03	20.04	24.73	105
November	80.56	14.71	18.26	104
December	88.47	19.32	21.83	115

Source: Own calculation on the basis of data from Başmakçı Cooperative data base 2003-2022 [15].

New mother egg monthly prices

The real prices of new mother egg received by farmers were determined as 79.73 TRY for the period 2003-2009, 17.37 TRY for the period 2010-2022 and 81.22 TRY for the period 2003-2022.

Fig. 7. Development of producer monthly new mother egg prices of Başmakçı Cooperative in real prices in the period 2003-2022 (TRY/1,000 pieces) [15].
Source: Own calculation.

It was determined that it reached its highest value in October 2004 and December 2016 and its lowest value in January 2006 (Figure 7).

When the price volatility was analysed on a monthly basis, the price volatility of new main eggs was 18.82% in the 2003-2009 period, 17.37% in the 2010-2022 period and 17.85% as the average of the 2003-2022 period (Figure 8).

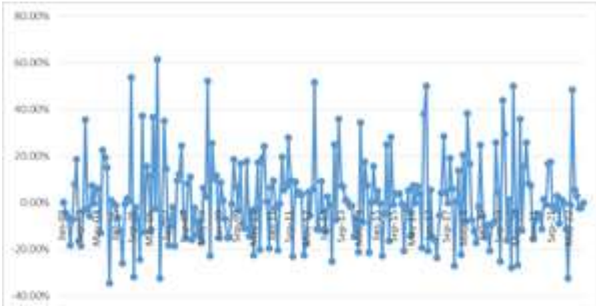

Fig. 8. Producer monthly new mother egg price volatility of Başmakçı Cooperative in real prices for the period 2003-2022 [15].
Source: Own calculation.

The average real price of new mother eggs was the lowest in May with 66.19 TRY and the highest in December with 92.87 TRY. The seasonal index was the lowest in May and the highest in December.

The months when the prices were above the seasonal fluctuation were January, February, March, August, September, October, November and December, while the months when the prices were below the seasonal fluctuation were April, May, June and July (Table 4).

Table 4. Seasonal fluctuations in real prices of new mother eggs for the period 2003-2022 (TRY/1,000 units)

	Arithmetic mean	Standard deviation	Coefficient of variation	Seasonal index
January	88.20	17.09	19.38	109
February	87.46	14.09	16.11	108
March	82.30	14.51	17.63	101
April	76.44	10.44	13.65	94
May	66.19	10.79	16.30	81
June	67.35	11.88	17.64	83
July	71.42	12.37	17.33	88
August	81.74	16.78	20.52	101
September	89.99	15.94	17.71	111
October	85.57	19.49	22.77	105
November	85.11	13.80	16.21	105
December	92.87	18.47	19.89	114

Source: Own calculation on the basis of data from Başmakçı Cooperative data base 2003-2022 [15].

Old mother egg monthly prices

Between 2003 and 2022, it was determined that the highest value of old mother egg prices on a monthly basis in Başmakçı cooperative was in October 2004 and December 2016, while the lowest value was in January 2006. During the period analysed, old mother egg prices followed a fluctuating course on a monthly basis and it was determined that price volatility was in question (y=0.00061x +59.51436; R^2 = 0.00595) (Figure 9).

Fig. 9. Development of producer monthly old mother egg prices of Başmakçı Cooperative in real prices in the period 2003-2022 (TRY/1,000 pieces)[15]
Source: Own calculation.

Old mother egg price volatility was 17.88% in 2003-2009 period, 16.59% in 2010-2022 period and 17.01% in 2003-2022 period.

The average real price of old mother egg was the lowest in May with 69.66 TRY and the highest in December with 96.02 TRY. The seasonal index was the lowest in May and the highest in December.

Table 5. Seasonal fluctuations in real prices of old mother eggs for the period 2003-2022 (TRY/1000 units)

	Arithmetic mean	Standard deviation	Coefficient of variation	Seasonal index
January	91.04	17.91	19.68	107
February	90.72	14.10	15.55	107
March	85.40	14.17	16.59	101
April	79.60	10.53	13.22	94
May	69.66	10.44	14.99	82
June	70.95	12.18	17.16	84
July	75.63	11.62	15.37	89
August	87.23	15.87	18.19	103
September	94.57	15.67	16.57	111
October	88.99	19.63	22.06	105
November	88.34	13.85	15.68	104
December	96.02	18.67	19.44	113

Source: Own calculation on the basis of data from Başmakçı Cooperative data base 2003-2022 [15].

The months when prices were above the seasonal fluctuation were January, February, March, August, September, October, November and December, while the months when prices were below the seasonal fluctuation were April, May, June and July (Table 5).

Double egg monthly prices

Between 2003 and 2022, it was determined that the highest value of double egg prices in Başmakçı cooperative on producer monthly basis was in October 2004 and December 2016, while the lowest value was in January 2006. During the period analysed, double egg prices followed a fluctuating course on a monthly basis and it was determined that there was price volatility (y = 0.00078x +54.70207; R^2 = 0.00943) (Figure 10).

Fig. 10. Development of producer monthly double egg prices of Başmakçı Cooperative in real prices in the period 2003-2022 (TRY/1,000 pieces) [15].
Source: Own calculation.

Double egg price volatility was calculated as 17.64% in the 2003-2009 period, 15.99% in the 2010-2022 period and 16.54% in the 2003-2022 period.

The average real price of double eggs was the lowest in May with 71.50 TRY and the highest in December with 97.86 TRY. The seasonal index was the lowest in May and the highest in December.

The months when the prices were above the seasonal fluctuation were January, February, March, August, September, October, November and December, while the months when the prices were below the seasonal fluctuation were April, May, June and July (Table 6).

Table 6. Seasonal fluctuations in real prices of double eggs for the period 2003-2022 (TRY/ unit)

	Arithmetic mean	Standard deviation	Coefficient of variation	Seasonal index
January	92.62	17.80	19.22	107
February	91.95	14.12	15.35	106
March	86.80	14.26	16.43	100
April	81.13	10.63	13.10	94
May	71.50	10.61	14.84	82
June	72.84	12.45	17.09	84
July	78.21	11.94	15.27	90
August	89.65	15.94	17.78	103
September	97.31	15.91	16.35	112
October	91.10	19.84	21.78	105
November	90.17	14.08	15.61	104
December	97.56	18.55	19.02	112

Source: Own calculation on the basis of data from Başmakçı Cooperative data base 2003-2022 [15].

Annual change in egg prices in Türkiye

In real terms, egg prices have fluctuated over the years. The main reason for this variability was the decrease in production in the egg sector, restrictions on exports and imports, and the effects of input prices due to high inflation in recent years. In the period analysed, the lowest egg prices in real terms were in the 2020-2022 period. While the first highest value was in 2015, the second highest value was determined in 1992. It can be said that the main factor of the decline in egg prices between 2015 and 2020 was the restrictions imposed by the Iraqi government, which was one of the leading exporter countries of Türkiye, on egg imports in order to increase domestic egg production after 2018 [12]. There was a reverse correlation between world egg export prices, Dutch egg prices, US egg prices and Turkish egg prices received by farmers in real terms. However, there was a positive correlation between world egg prices, Dutch egg prices, US egg prices and farmer's egg prices on a current basis (Figure 11).

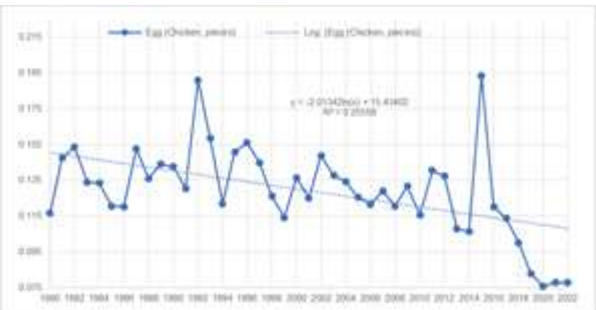

Fig. 11. Annual change in egg prices in real prices in the period 1980-2022 (TRY/pcs)
Source: Own calculation.

It can be said that the fluctuations in wheat and maize prices in the 1980-2022 period were parallel. However, since the change in maize prices was higher than wheat prices, the annual fluctuation was higher. Whilst maize prices reached their highest value in 1981-1982, wheat prices reached their highest value in 1996. While maize prices were generally higher than wheat prices until 1980-2007, they were generally lower than wheat prices between 2007-2022 (Figure 12).

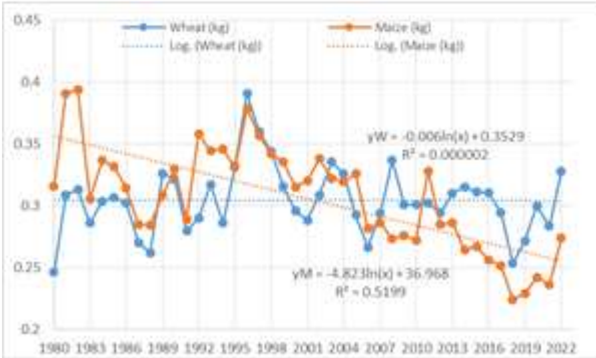

Fig. 12. Annual change in real prices of wheat and maize in the period 1980-2022
Source: Own calculation.

Seasonal fluctuations were more pronounced in apple prices in the periods analysed. Although there was a fluctuating trend in milk prices in the 1980-1998 period, it reached its highest value in 1998. In the period 1999-2022, it was determined that there was a decreasing trend in milk prices. In the same period, apple prices followed a fluctuating trend in the 1980-1995 period and reached its highest value in 1995. Seasonal fluctuations in apple prices were lowest in the 2002-2011 period and highest in the 2012-2022 period (Figure 13).

Fig. 13. Change in real prices of apples and milk in annual terms between 1980-2022
Source: Own calculation.

When the change in real prices of cattle or calf carcass prices on an annual basis between 1994 and 2022 was analysed, there was a general price volatility and a downward trend. It was determined that the highest year of cattle or calf carcass prices was 1995 and the lowest year was 2022. Beef or calf carcass prices decreased between 1995-1997, 2000-2001, 2004-2008, 2011-2014, 2018-2022, while they increased between 1994, 1998-1999, 2002-2003, 2009-2010, 2015-2016 (Figure 14).

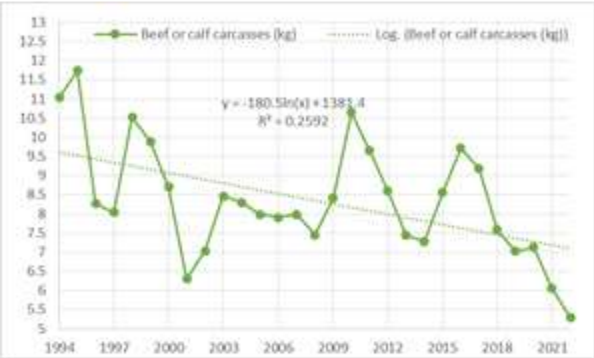

Fig. 14. Change in real prices of cattle or calf carcasses on annual basis between 1980 and 2022
Source: Own calculation.

When the annual real change in maize, milk and egg prices between 1980-2022 was analysed, it was found that milk prices showed more variability than maize and egg prices. While milk prices reached their highest value in 1998, maize prices reached their highest value in 1981-1982 and egg prices reached their highest value in 1992-2015 (Figure 15).

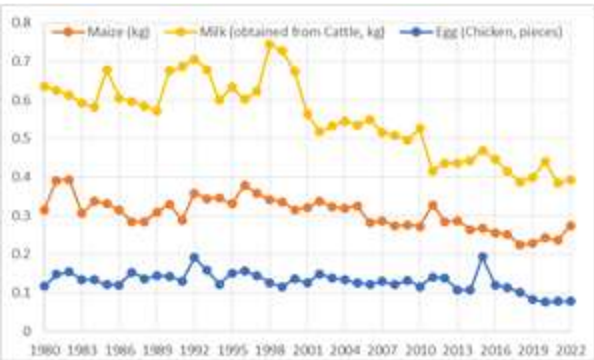

Fig. 15. Change in real prices of maize-dairy and egg prices on annual basis between 1980-2022
Source: Own calculation.

When the parities of wheat, maize, apple, milk and meat prices against egg prices for the period 1980-2022 were analysed, the parities of wheat, maize, apple and milk prices against egg prices in 1980 were 2.11 eggs with 1 kg of wheat, 2.71 eggs with 1 kg of maize, 4.18 eggs with 1 kg of apple and 5.44 eggs with 1 kg of milk. 71 eggs with 1 kg of wheat, 4.18 eggs with 1 kg of apple and 5.44 eggs with 1 kg of milk, while 4.21 eggs with 1 kg of wheat, 3.52 eggs with 1 kg of corn, 4.33 eggs with 1 kg of apple and 5.05 eggs with 1 kg of milk were obtained by the end of 2022, respectively. In addition, while 90.40 eggs were obtained with 1 kg of meat in 1994, 68.06 eggs could be obtained with 1 kg of meat by the end of 2022. In the period analysed, wheat was the product that gained the most value against eggs, while meat was the product that lost the most value.

Price Analysis on Consumer Basis

Between 2003 and 2022, the parity of wheat, bread, apple, beef, poultry, chicken, fish and milk prices with respect to egg prices decreased. In the period analysed, it was determined that egg price increased by 25%, 12%, 52%, 25%, 13%, 15%, 43% against wheat flour, bread, apple, beef, chicken meat, fish and milk, respectively. According to these results, it can be said that the increase in egg prices has more impact on the consumer than other product prices.

CONCLUSIONS

On an annual basis, real prices received by farmers for eggs were lowest in June 2022 and highest in January 1996. In the same period, on a monthly basis, the prices received by egg producers show a decreasing trend and price volatility continues. The reason for this fluctuation can be attributed to the restrictions in imports and exports.

In the period analysed, wheat was the product that gained the most value against eggs, while meat was the product that lost the most value.

Between 2003 and 2022, it was determined that the price of eggs increased against wheat flour, bread, apples, beef, poultry, fish and milk on consumer basis. According to these results, it can be said that the increase in egg prices has a greater impact on consumers than other product prices.

The ongoing price instability in egg prices and the fact that input costs were largely supplied through imports can be stated among the important weaknesses of the sector.

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THE ECONOMIC EFFICIENCY OF SOME CEREALS UNDER THE INFLUENCE OF CLIMATE CHANGES IN THE CENTRAL AREA OF MOLDOVA, ROMANIA

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Abstract

Cereals are essential for human nutrition. Unfortunately, the worldwide demographic evolution (continually increasing) makes it difficult to maintain the security of this food source. To overcome this situation, increasing the yield of these species is necessary. The aim of the present research is to make a comparative economic analysis between different varieties of winter barley, winter wheat and triticale varieties in the period 2018-2023 at Agricultural Research and Development Station (ARDS) Secuieni, Neamt County, Romania. The economic indicators taken into consideration were: yield, production value, production cost, total expenditures, gross and net profit. The data were processed and statistically interpreted based on variance analysis, coefficient of variation, using Microsoft Excel and ANOVA 2013 programs. The results regarding yield showed that on the first place is winter wheat with an average yield of 7,413 kg · ha^{-1}, the second place is winter barley with an average yield of 6,340 kg · ha^{-1}, and the last place is triticales, with an average yield of 6,145 kg · ha^{-1}. From an economic point of view, winter wheat is on first place, with a net profit of approximately double compared to the other two cereals. The net profit was 3,109 lei · ha^{-1} for winter wheat, 1,766 lei · ha^{-1} for winter barley, and 1,635 lei · ha^{-1} for triticale.

Key words: *advantage, barley, triticale, wheat, economic efficiency*

INTRODUCTION

Cereals are essential for human nutrition. Unfortunately, the worldwide demographic evolution (continually increasing) makes it difficult to maintain the security of this food source. To overcome this situation, increasing the yield of these species is necessary. Given the increased importance of these species, research must continue in this regard because the yield of winter cereals especially winter wheat must cope with the high demand worldwide [7]. Solutions must be found, in particular, to reduce the negative impact of global climate change on the yield of winter cereals [13, 14].

In our country, winter cereals represent the predominant species in agriculture. Due to this fact, the essential objective in the cultivation of these species is to obtain a main yield (grains/seeds) as high as possible per surface unit but which also possesses a superior quality for use in the three major directions, namely: human consumption, animal feed, and industrialization. In recent years, the yield of winter cereals varieties has increased considerably in many regions of the world, including Romania [2, 6, 4], a fact due both to the improvement of genetics as well as the adaptation of crop technology to these species according to the new climatic conditions and according to the new varieties created.

Effects produced by climate change: drought, floods, and desertification affect agricultural activity.

Winter cereals have certain bioclimatic requirements, influencing the vegetative processes and yield. These bioclimatic requirements are about the main climatic factors: light, temperature, and rainfall. The annual fluctuation of climatic factors determines the variability of productions from one year to another, and their analysis is the basic criterion for adopting measures to prevent, mitigate, or combat the damage caused to agriculture [3].

The constantly changing climatic conditions have negative influences on the physiological mechanisms of the development of cereals, which are disturbed especially by the prolonged droughts that are more and more frequent in our country [1]. Analyzing the latest studies carried out in our country, we can see a decrease in the size of cereals, the values of the productivity elements, and, of course, the yield.

The identification of more valuable varieties than the existing ones is a major objective in scientific research, it is known that the variety participates directly in increasing yield, using other technical measures more effectively [11]. The assessment of drought tolerance in different pluviometric conditions allows the varieties to be ranked according to this in each environment (with stress or non-stress). In various studies carried out in our country, Romanian varieties have been identified that show tolerance to environmental conditions, one of them being the Glosa wheat variety [5].

Agricultural production, which also includes the cultivation of winter cereals, especially wheat, is the main activity of the Romanian rural society [12]. For Romanian farmers to face the new climate changes, it is necessary to know the factors that help to form agricultural production, which are: the use of seeds from higher biological categories, the use of varieties that show adaptability to the conditions of the area, the establishment/ expansion of irrigation systems, access to new agricultural research, increasing the level of training of agricultural personnel, intensive application of fertilizers and pesticides [8].

Taking into account this aspect, at A.R.D.S. Secuieni, over a period of five years (2018 - 2023), a wide range of winter cereal varieties were observed, the results obtained for some of them being detailed in this paper. In addition to grain yield, it was also evaluated the stability of yield and the economic efficiency of crops under the new environmental conditions.

MATERIALS AND METHODS

The results presented in this paper come from comparative crops with Romanian varieties of winter cereals, placed in the experimental field, one for each species in winter wheat, barley and triticale. The method of fielding these comparative crops was that of the balanced square grid, in three repetitions, the soil type used being the typical phaeozem (chernozem) cambic. The soil on which the comparative crops were placed is characterized as being well supplied in phosphorus (P_2O_5 - 39 mg · kg^{-1}) and mobile potassium (K_2O - 161 mg · kg^{-1}), moderately supplied with nitrogen, the soil nitrogen index being 2.1, weakly acidic, with pH values (in aqueous suspension) of 6.29 and poorly fertile, with a humus content of 2.3% [10]. Fertilization was carried out with 100 kg active substance · ha^{-1} fractionated nitrogen - 40 kg active substance when preparing the germinal bed and 60 kg active substance · ha^{-1} and with 40 kg P_2O_5 · ha^{-1} applied in spring.

Given that these winter cereal varieties have been tracked over the past five years, which have been characterized as hot and dry, the yield variability has been driven to a large extent by climatic conditions.

From a climatic point of view, the period 2018 - 2022 was characterized as hot and very dry.

a) Air temperature. From a thermal point of view, the five years analyzed were characterized as atypical for all field crops, all of them being warm, registering deviations from the multiannual average between 1.0 °C (2019 - 2020 and 2020 – 2021) and 1.5 °C (2021 - 2022).

Analyzing the average temperatures recorded during the analyzed period (2017 - 2022), we observe an accelerated air warming by 1.4 °C, compared to the multiannual average (1962 - 2022) (Fig. 1).

Analyzing the temperatures recorded in the last five springs, we observe an accelerated air warming by 0.2 °C to 0.9 °C, compared to the multiannual average (1962 - 2019). The greatest air warming is observed in March, which shows an increase in temperature by 0.9 °C. On average, an air warming of 0.4 °C was observed in spring (Fig. 1).

Analyzing the temperatures recorded in the last five summers, we observe an accelerated air warming by 0.7 °C – 2.1 °C, compared to the multiannual average (1962 – 2019).

On average over the last five years, a summer air warming of 1.4 °C was observed, with the highest air warming observed in June (1.4 °C) and August (2.1 °C), July being warmer by 0.7 °C (Fig. 1).

In the last five years, the autumn months have recorded air warming between 0.9 °C and 1.5 °C compared to the multiannual average. The October and November were warmer with 1.4-1.5 °C above the multiannual average (Fig.1).

The winter between 2017 to 2022 showed a strong air warming between 2.3 °C and 3.0 °C compared to the multiannual average. The February was the warmest, registering a deviation from the multiannual average of 3.0 °C (Fig. 1).

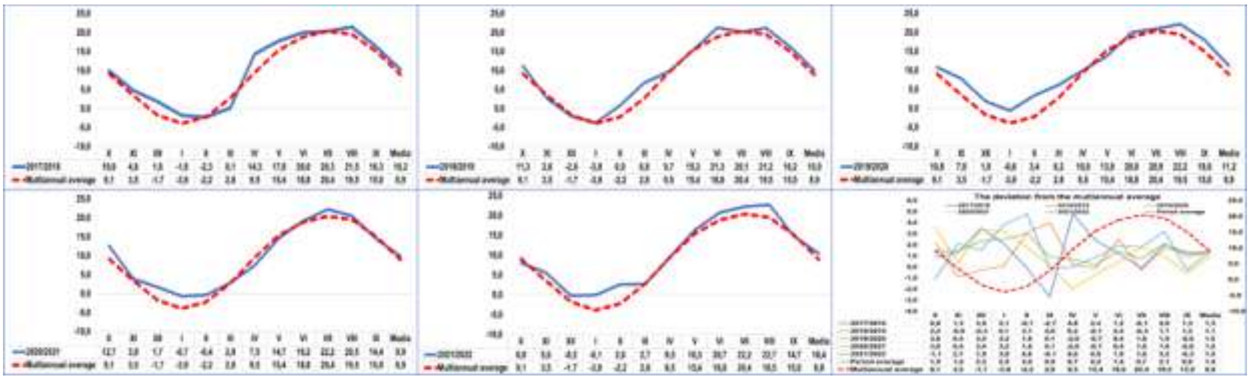

Fig. 1. Temperatures recorded at A.R.D.S. Secuieni in the period 2017 – 2022 and their deviation from the multiannual average (1962 – 2022)
Source: Own design.

b) Atmospheric rainfall. From a pluviometric point of view, in the period 2017 - 2022, a general trend of decrease in the amount of rainfall during the plants vegetative period was observed. The distribution of rainfall over the growth stages of agricultural plants was extremely uneven.

From a pluviometric point of view, the five years analyzed were characterized differently, the first being considered normal, having a deviation from the multiannual average of 3%. The other four years analyzed were characterized as dry and very dry, with the deviations recorded being between 21 % (2018 – 2019) and 52 % (2021 – 2022) (Fig. 2).

From a pluviometric point of view, spring, during the analyzed period, was characterized as being very dry, recording an average deviation of 35 % compared to the multiannual average. March and May were characterized as drought, with deviations from the multiannual average of 26 - 27 %, and April it was very dry, with the deviation reaching 51 % (Fig. 2). The low amounts of rainfall registered in the spring months caused difficulties in the soil preparation and led to an uneven emergence of spring crops, and also negatively influenced the development of autumn crops.

The last five summers (2018 - 2022) were characterized as dry, registering an average deviation compared to the multiannual average of 22 %. While June was characterized as normal from a pluviometric point of view (5 % deviation), July and August were excessively dry with deviations between 25 % and 44 % (Fig. 2).

Autumn, was characterized as dry, with the average deviation of 30 % from normal. September and October were characterized as dry, with deviations between 22 % and 30 %, and November was very dry with an average deviation of 39 % (Fig. 2).

The winter between 2017 to 2022 was characterized as being less dry, the deviation being 20 %. December was normal from a pluviometric point of view (2 % deviation), January was excessively dry (49 % deviation), and February was less dry (19 %) (Fig. 2).

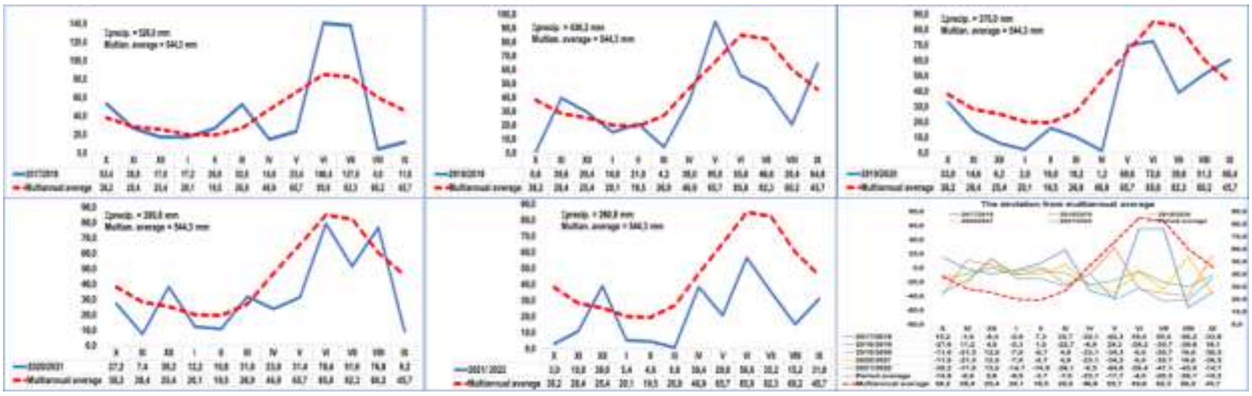

Fig. 2. Rainfall at A.R.D.S. Secuieni in the period 2017 – 2022 and their deviation from the multiyear average (1962 – 2022)
Source: Own design.

During the experiment, the technology specific to the area was respected [15], and the data obtained were processed and statistically interpreted according to the variance analysis method, and the yield stability was valued based on the coefficient of variation [9], using Microsoft Excel and ANOVA 2013 programs.

RESULTS AND DISCUSSIONS

- In winter barley, the variability of yield according to climatic conditions was extremely high, the amplitude of yield/variety being between 2,332 kg · ha^{-1} (Andreea) and 3,148 kg · ha^{-1} (Univers). The most favorable year for barley was 2022, when the average yield was 7,591 kg · ha^{-1}, in this year the yield variation was smaller and was between 7,352 kg · ha^{-1} (Dana) and 7,814 kg · ha^{-1} (Univers). 2021 also offered favorable conditions for the growth and development of barley, a year in which an average yield of 7,003 kg · ha^{-1} was achieved, the yield variation being this year between 6,493 kg · ha^{-1} (Univers) and 7,312 kg · ha^{-1} (Andreea). The climatic conditions of the years 2019 and 2020 were extremely unfavorable to barley, with the average yield obtained in these years being only 5,155 kg · ha^{-1} and 5,244 kg · ha^{-1}, respectively (Table 1).

On average, over the five years of experimentation, the yield was between 6,063 kg · ha^{-1} (Dana) and 6,820 kg · ha^{-1} (Cardinal). Compared to the control, the average experience (6,340 kg · ha^{-1}), the Cardinal variety achieved a very significant increase in yield, while the Andreea variety achieved a significant negative yield difference (Table 2).

Table 1. Yields at winter barley in the pedoclimatic conditions from A.R.D.S. Secuieni, during 2018 - 2022 period

Variety/ Year	Yield (kg · ha^{-1})				Average (kg·ha^{-1})
	Dana	Cardinal	Univers	Andreea	
2018	5,874	8,212	7,414	5,323	6,706
2019	5,684	5,100	4,666	5,169	5,155
2020	4,356	6,045	5,481	5,095	5,244
2021	7,244	6,964	6,493	7,312	7,003
2022	7,352	7,781	7,814	7,417	7,591
Average	6,102	6,820	6,374	6,063	6,340
Amplitude (kg · ha^{-1})	2,996	3,112	3,148	2,322	2,895

Source: Own calculation.

Regarding the adaptability of the varieties to the area conditions, we can say that all four varieties show good adaptability, the coefficients of variation being between 10 and 20 %.

Table 2. The average yields obtained for winter barley and the yield variability in the pedoclimatic conditions from A.R.D.S. Secuieni, 2018 - 2022 average

Variety	Average yield ($kg \cdot ha^{-1}$)		Difference from the control	Significance	VC (%)
	kg/ha	%			
Dana	6,102	96	-238		18.2
Cardinal	6,820	108	480	***	16.6
Univers	6,374	101	34		18.4
Andreea	6,063	96	-277	o	17.6
Average	6,340	100	Control		17.7
LSD 5 % ($kg \cdot ha^{-1}$)			263		
LSD 1 % ($kg \cdot ha^{-1}$)			379		
LSD 0.1 % ($kg \cdot ha^{-1}$)			466		

Source: Own calculation.

Among these varieties, the highest yield stability was presented by the Cardinal variety (16.6 %), which also achieved the highest average grain yield (Table 2). From an economic point of view, winter cereals are productive species and involve average expenses for cultivation. The results obtained during the analyzed period show us that winter barley is a profitable crop, even in adverse environmental conditions. Although, in calculating the economic efficiency, we did not take into account the subsidy received per hectare, it can be seen from Table 3 that the net profit was positive, its values being influenced by the cultivated variety. It stands out with a net profit of 2,088 lei $\cdot$ ha^{-1}, the variant sown with the Cardinal variety.

Table 3. Economic efficiency of winter barley yield results, 2018 – 2022

Variety	Yield ($kg \cdot ha^{-1}$)	Production value ($lei \cdot ha^{-1}$)	Total expenses ($lei \cdot ha^{-1}$)	Production cost ($lei \cdot kg^{-1}$)	Gross profit ($lei \cdot ha^{-1}$)	Net profit ($lei \cdot ha^{-1}$)
Dana	6,102	4,882	2,970	0.49	1,912	1,606
Cardinal	6,820	5,456	2,970	0.44	2,486	2,088
Univers	6,374	5,099	2,970	0.47	2,129	1,789
Andreea	6,063	4,850	2,970	0.49	1,880	1,580
Average	6,340	5,072	2,970	0.47	2,102	1,766
Sale price*: 0.8 $lei \cdot kg^{-1}$						

**The average selling price of barley practiced at A.R.D.S. Secuieni in the period 2018 - 2022*

Source: Own calculation.

The yields obtained in winter wheat varied both according to the cultivated variety and according to the climatic conditions which were extremely variable from one year to another. The yield range was between 2,391 $kg \cdot ha^{-1}$ (Pitar) and 4,341 $kg \cdot ha^{-1}$ (Glosa).

Table 4. Yields at winter wheat in pedoclimatic conditions from A.R.D.S. Secuieni, during 2018 – 2022 period

Variety/Year	Yield ($kg \cdot ha^{-1}$)				Average ($kg \cdot ha^{-1}$)
	Glosa	Miranda	Pitar	Otilia	
2018	9,688	7,296	7,361	7,774	8,030
2019	7,215	5,916	6,809	6,937	6,719
2020	5,347	5,958	5,780	6,375	5,865
2021	8,714	8,376	7,373	7,973	8,109
2022	8,330	7,851	8,171	9,016	8,342
Average	7,859	7,079	7,099	7,615	7,413
Amplitude ($kg \cdot ha^{-1}$)	4,341	2,418	2,391	2,641	2,948

Source: Own calculation.

Although the climatic conditions of the analyzed years were less favorable to the growth and development of winter wheat, the average yields achieved were higher than 7 to $\cdot$ ha^{-1}.

The most favorable year for winter wheat was 2022, when the average yield was 8,342 kg $\cdot$ ha^{-1}, the variation of yield being between 7,851 $kg \cdot ha^{-1}$ (Miranda) and 9,016 $kg \cdot ha^{-1}$ (Otilia) (Table 4).

The average of winter wheat yields obtained between 2018 and 2022 ranged from 7,079 kg $\cdot$ ha^{-1} (Miranda) to 7,859 $kg \cdot ha^{-1}$ (Glosa).

Compared to the average yield of the experience (Control), the variant sown with the Glosa variety obtained a distinctly significant increase in yield, but the variants sown with the Miranda and Pitar varieties showed significant negative production differences.

The coefficients of variation were between 10 and 20 %, which indicates the good adaptability of these varieties to the conditions of the area. The variants sown with the Pitar and Otilia varieties (11.1 % and 11.9 %) stand out with the highest yield stability (Table 5).

From an economic point of view, winter wheat manages to be a profitable crop even in less favorable climates.

The calculated net profit was positive for all tested variants, its values being influenced by the cultivated variety.

It stands out with a net profit of 4,103 lei · ha^{-1}, the variant sown with the Glosa variety (Table 6).

Table 5. The average yields obtained at winter wheat and the yield variability in the pedoclimatic conditions from A.R.D.S. Secuieni, 2018 - 2022 average

Variety	Average yield (kg · ha^{-1})		Difference from the control	Semnification	VC (%)
	kg · ha^{-1}	%			
Glosa	7,859	106	446	**	18.9
Miranda	7,079	95	-334	o	14.0
Pitar	7,099	96	-314	o	11.1
Otilia	7,615	103	202		11.9
Average	7,413	100	Control		14.0
LSD 5 % (kg · ha^{-1}) LSD 1 % (kg · ha^{-1}) LSD 0.1 % (kg · ha^{-1})			298 429 510		

Source: Own calculation.

Table 6. Economic efficiency of winter wheat yield results, 2018 – 2022

Variety	Yield (kg·ha^{-1})	Production value (lei · ha^{-1})	Total expenses (lei · ha^{-1})	Production cost (lei · kg^{-1})	Gross profit (lei · ha^{-1})	Net profit (lei · ha^{-1})
Glosa	7,859	7,073	2,970	0.38	4,103	3,447
Miranda	7,079	6,371	2,970	0.42	3,401	2,857
Pitar	7,099	6,389	2,970	0.42	3,419	2,872
Otilia	7,615	6,854	2,970	0.39	3,884	3,262
Average	7,413	6,672	2,970	0.40	3,702	3,109
Sale price*: 0.9 lei · kg^{-1}						

**The average selling price of winter wheat practiced at A.R.D.S. Secuieni in the period 2018 - 2022*

Source: Own calculation.

At triticale, the average annual yields were lower than winter wheat and winter barley, with favorable conditions for the crop, only the 2017-2018 year being noted, when the average yield was 7,606 kg · ha^{-1} (Table 7).

Table 7. Yields at triticale in the pedoclimatic conditions from A.R.D.S. Secuieni, during 2018 - 2022 period

Variety/ Year	Yield (kg · ha^{-1})				Average (kg · ha^{-1})
	Plai	Haiduc	Tulnic	Utifun	
2018	6,507	7,163	8,291	8,464	7,606
2019	5,704	6,470	6,520	6,250	6,236
2020	4,961	8,682	6,754	4,679	6,269
2021	4,770	3,956	4,273	5,818	4,704
2022	5,488	4,948	6,657	6,552	5,911
Average	5,486	6,244	6,499	6,353	6,145
Amplitude (kg · ha^{-1})	1,737	4,726	4,018	3,785	3,567

Source: Own calculation.

The 2020 – 2021 year had the worst conditions for the growth and development of triticale, the average yield in this year being only 4,704 kg · ha^{-1}. The lowest amplitude of yield was observed at Plai variety, with a value of 1,737 kg · ha^{-1}, while in the Haiduc variety it reached up to 4,726 kg · ha^{-1} (Table 7).

The average yields of triticale obtained between 2018 and 2022 varied depending on the cultivated variety, and were between 5,486 kg · ha^{-1} (Plai) and 6,499 kg · ha^{-1} (Tulnic).

In the variant sown with the Tunic variety, a significant increase was achieved compared to the average experience, and in the variant sown with the Plai variety, a very significant negative yield difference.

Table 8. The average yields obtained at triticale and the yield variability in the pedoclimatic conditions from A.R.D.S. Secuieni, 2018 - 2022 average

Variety	Average yield (kg · ha^{-1})		Difference from the control	Sign.	VC (%)
	kg · ha^{-1}	%			
Plai	5,486	89	-659	ooo	11.2
Haiduc	6,244	102	99		26.6
Tulnic	6,499	106	354	*	19.8
Utrifun	6,353	103	208		19.4
Average	6,145	100	Control		19.3
LSD 5 % (kg · ha^{-1}) LSD 1 % (kg · ha^{-1}) LSD 0.1 % (kg · ha^{-1})			310 442 558		

Source: Own calculation.

With the exception of the Haiduc variety, all the tested varieties stood out for their good stability in the conditions of the area (Table 8).
The Plai variety showed the best stability at the conditions of the area, with the coefficient of variation having value of 11.2% (Table 8).
The climatic conditions of the last five years have negatively influenced the triticale crop, with yields decreasing greatly. However, from an economic point of view, triticale manages to be a profitable crop and under these conditions, the net profit calculated for this crop was positive for all the tested variants, its values being influenced by the cultivated variety. It stands out with net profits between 1,701 lei · ha^{-1} and 1,873 lei · ha^{-1}, the variants sown with the varieties Haiduc, Tulnic and Utrifun (Table 9).

Table 9. Economic efficiency of triticale yield results, 2018 – 2022

Variety	Yield (kg·ha^{-1})	Production value (lei · ha^{-1})	Total expenses (lei · ha^{-1})	Production cost (lei · kg^{-1})	Gross profit (lei · ha^{-1})	Net profit (lei · ha^{-1})
Plai	5,486	4,389	2,970	0.54	1,419	1,192
Haiduc	6,244	4,995	2,970	0.48	2,025	1,701
Tulnic	6,499	5,199	2,970	0.46	2,229	1,873
Utrifun	6,353	5,082	2,970	0.47	2,112	1,774
Average	6,145	4,916	2,970	0.48	1,946	1,635
Sale price*: 0.8 lei · kg^{-1}						

**The average selling price of triticale practiced at A.R.D.S. Secuieni in the period 2018 - 2022*
Source: Own calculation.

Making a comparison between the three species, we can make a ranking according to the obtained yields as follows: on first place is winter wheat with an average yield of 7,413 kg· ha^{-1}, on the second place is winter barley with an average yield of 6,340 kg·ha^{-1}, and on last place triticale, with an average yield of 6,145 kg·ha^{-1}. The same was observed in terms of yield stability, which was 14 % at winter wheat, 17.7 % at winter barley and 19.3 % at triticale (Table 10).

Table 10. Average yields obtained for winter cereals, yield variability and the net profit obtained in pedoclimatic conditions from A.R.D.S. Secuieni, average 2018 – 2022

Variety	Average yield		VC (%)	Net profit (lei · ha^{-1})
	kg · ha^{-1}	%		
Barley	6,340	96	17.7	1,766
Wheat	7,413	112	14.0	3,109
Triticale	6,145	93	19.3	1,635
Average	6,633	100	17.0	2,170

Source: Own calculation.

From an economic point of view, winter wheat ranks first, with a net profit of approximately double compared to the other two cereals. The net profit was 3,109 lei · ha^{-1} for winter wheat, 1,766 lei · ha^{-1} for winter barley and 1,635 lei · ha^{-1} for triticale (Table 10).

CONCLUSIONS

The climatic conditions of the 2020 – 2021 and 2021 – 2022 years were favorable for winter barley cultivation, with the average yields obtained being 7,352 kg · ha^{-1} and 7,591 kg · ha^{-1}, respectively. The climatic conditions of the 2019 and 2020 years were extremely unfavorable to winter barley, the average yield obtained in these years being only 5,155 kg · ha^{-1} and 5,244 kg · ha^{-1}, respectively. On average over the five years of experimentation, yield was between 6,063 kg · ha^{-1} (Dana) and 6,820 kg · ha^{-1} (Cardinal). Regarding the adaptability of the varieties to the conditions of the area, we can say that all four varieties show good adaptability, the coefficients of variation being between 10 and 20 %. With a net profit of 2,088 lei · ha^{-1}, the variant sown with the Cardinal variety stood out.
Although the climatic conditions of the agricultural years analyzed were less favorable for the growth and development of winter wheat, the average yields achieved

were higher than 7 to · ha^{-1}, in all the years of experimentation. The most favorable year for winter wheat was 2022, when the average yield was 8,342 kg · ha^{-1}. The average at winter wheat yields obtained between 2018 and 2022 ranged from 7,079 kg · ha^{-1} (Miranda) to 7,859 kg · ha^{-1} (Glosa). The coefficients of variation were between 10 and 20 %, which indicates the good adaptability of the tested varieties to the conditions of the area. At winter wheat, the variant sown with the Glosa variety stood out with a net profit of 4,103 lei · ha^{-1}.

At triticale, the average annual yields were lower than in winter wheat and barley, with favorable conditions for the culture, only the 2017 - 2018 agricultural year was notable, when the average yield was 7,606 kg · ha^{-1}. The agricultural year 2020 - 2021 had the worst conditions for the growth and development of triticale, the average yield this year being only 4,704 kg · ha^{-1}. The average yields of triticale obtained between 2018 and 2022 varied depending on the cultivated variety, between 5,486 kg · ha^{-1} (Plai) and 6,499 kg · ha^{-1} (Tulnic). With the exception of the Haiduc variety, all the tested varieties stood out for their good stability in the conditions of the area. The variants sown with the Haiduc, Tulnic and Utrifun varieties stand out with net profits between 1,701 lei · ha^{-1} and 1,873 lei · ha^{-1}.

Making a comparison between the three species, we can make a ranking according to the yields obtained as follows: on first place is winter wheat with an average yield of 7,413 kg · ha^{-1}, on second place is winter barley with an average yield of 6,340 kg · ha^{-1}, and in last place is triticale, with an average yield of 6,145 kg · ha^{-1}. The same was observed in terms of yield stability, which was 14 % for winter wheat, 17.7 % for winter barley and 19.3 % for triticale.

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MICRO ENTREPRENEURS' ADOPTION OF INFORMATION AND COMMUNICATION TECHNOLOGIES (ICT) FOR RURAL DEVELOPMENT: EVIDENCE FROM SMALL SCALE POTTERY BUSINESS OF KUALA KANGSAR, MALAYSIA

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Abstract

The advent of Information and Communication Technology (ICT) has profoundly impacted human behaviour, revolutionizing various aspects of life, including business operations. Rural Micro Entrepreneurs (RMEs) were said to gain significant economic benefits from the adoption of ICT in their business including increased productivity, sales, marketing, and ultimately higher income. However, not all rural entrepreneurs effectively leverage ICT advancements to enhance their businesses, prompting a need for further investigations. Derived on quantitative approach i.e., questionnaire guided interview processes, a series of field study have been conducted on March to April 2023, focusing on seven main rural pottery businesses from five villages in the Kuala Kangsar district, Perak. The primary objective is to assess the level of ICT usage among RMEs and identify the factors that motivate the utilization of ICT facilities. The study highlights that majority of respondents acknowledged the importance of ICT that allows flexibility to conduct business alongside with time and cost savings. By embracing ICT, RMEs in the study area not only improve their business efficiency, but also contribute to the overall local economic development. The findings of this study highlighted the opportunities for enhancing ICT adoption among RMEs for local economic development.

Key words: *Rural Micro Entrepreneurs, ICT, pottery business, community business, local economic development*

INTRODUCTION

There is less doubt that the continuous progression of Information and Communication Technology (ICT) has fostered transformative changes in both urban and rural livelihoods. ICT has enhancing interpersonal connectivity; moreover, has redefined the landscape of business practices. Research conducted by [16] illuminated how the utilization of ICT has empowered local entrepreneurs, particularly within the realm of rural and small-scale business. For a rapidly growing economy like Malaysia's, small and medium-sized enterprises (SMEs) play a pivotal role in bolstering the nation's industrial foundation and reducing reliance on the often-volatile global economic landscape.

According to [4], in year 2020, SMEs have emerged as significant contributors to employment and economic growth. Notably, nearly 98.5% of the Malaysian economy comprises SMEs, contributing a substantial 38.3% to the country's Gross Domestic Product (GDP), generating 66% of its employment opportunities, and accounting for approximately 17.3% of Malaysia's total exports [12]. Despite substantial contributions and potential to drive local economic development, especially in rural areas, many entrepreneurs continue to grapple with challenges when it comes to embracing and effectively leveraging ICT to expand their products and services within both local and global markets [5, 7]. These challenges often stem from the lack of awareness and training on the usage of ICT in SMEs, poor infrastructure and inconducive business environment to encourage the usage of ICT [13, 16]. Consequently, there is a pressing need for comprehensive research to examine the factors influencing the adoption of ICT among rural entrepreneurs. Such research should also identify the influential factors to enhance preparedness among rural SME operators to employ ICT facilities for sustainability of their businesses.

Literature review

Rural SMEs in Malaysia Context

Small Rural Industry, also known as Rural Industry or Small Industry, is an industry that plays a significant role in prospering the country's economic growth and driving the rural growth. Rural Industry is an industry that is entirely small-scale and an enterprise that is largely run by salaried workers. A classic study by [6] found that SMEs are companies that employ no more than five workers who do not use machinery or 20 industrial workers who use machinery.

The interpretation by the Ministry of Urban and Rural Development sees Rural Industry as a small-scale industry, driven by rural communities with no more than five permanent employees and no more than RM 250,000 in shares [16]. This enterprise is complementary to medium and large-sized industries/ enterprises, most of which use more advanced production processes and their organizations are more developed due to technological improvements. Village industries or micro enterprises may be owned and operated by individuals, groups or the entire village community through cooperatives or companies in the form of limited partnerships or limited companies or joint ventures [17]. Village industry also uses simple machinery to attract the involvement of the villagers [11].

According to [16], village industry is defined as an enterprise located in the village, worked by the village community to produce simple traditional or modern goods. This industry may be carried out individually and/or in groups through cooperatives or manufacturing companies [11]. SMEs have the importance of driving the economic development of the people because they can accelerate local economic growth by creating local jobs for the people in their communities [2]. Based on the above discussions, it is clear that small/micro enterprise a small-scale industry that is thought suitable to meet the demand or response from the rural population. This industry is operating in strong considerations of local community's need including providing jobs for local people, utilising local natural resources and facilities, and in return, providing income to the local households [8].

Table 1. Main Characteristics of Rural Micro Enterprise (RME)

Characteristic	Explanations
Organisational System	RME has a simpler, small-scale, less bureaucratic and less formal organisational system because the RME organisational system does not involve a large number of employees and mainly consist of family members or relatives or neighbours.
Industrial Location	RME can be located and operates in entrepreneur's own home or in a workshop built in their residential area/living vicinity. However, cost and equipment are also influencing the entrepreneur's choice for the location of RME. For instance, there are entrepreneurs who are looking for cheap industrial area lots close to the city to make it easier for them to reach customers/markets.
Workforce	RME can be a newly set up enterprise and/or a family inherit enterprise and is run either full-time or part-time. This enterprise does not require a large workforce; therefore, entrepreneurs can run the RME as a sole ownership. They often received assistance from family members, indirectly reducing expenses or costs for employee wages.
Capital	Due to the industry being run on a small scale, RME enterprises mostly require small capital and often using their own savings and with some supports from government agencies (small amount development grants, etc.). Most entrepreneurs obtain raw materials from their own gardens, or local producers and smallholders.
Training Support for Entrepreneurs	Occasionally, RMEs entrepreneurs in rural areas received training from relevant agencies for improving their staff management, financial cashflow as well as product marketing through branding and the usage of ICT.
Workers	It is common for RME to employ workers among men and women who have skills needed to boost their products making and services such as making mats, handicrafts, weaving, batik, preparing and cooking dishes and so on. By engaging in RME as an entrepreneur or employee, workers among rural women she can fill her spare time as a housewife who does not work indirectly and can also contribute additional income for their household.
Production Technology and Product Market	The level of technology/high-tech machines usage for RME production is low, remain mostly as labour-intensive. This is because not all rural entrepreneurs get help using technology from related agencies. For the use of high-tech machines, it requires a large capital, skills and training to acquire and operates which most of RME did not possess big financial capital.

Source: [8, 9, 10, 16, 17, 18]

A study by [3] found that rural micro enterprise (RME) is an industry located at the bottom of the hierarchy whereby this hierarchy is measured based on the total number of employees which is less than five people. Furthermore, RME can be determined and/or distinguished it from other type of industries based on certain characteristics such as organisational system, industrial location, workforce, capital, training and support, production technology and market (Table 1).

In many situations, RME produces their products using local raw materials, with low usage of modern technology and highly dependent on traditional skills. RME also requires low investment or capital but produces quick returns from the products. Among the types of RMEs are handicrafts, weaving, carving, embroidery, small-scale food processing or manufacturing enterprises such as making crackers, soy sauce and so on [11, 16].

ICT Application for Rural Micro Enterprise Development

Information and Communication Technology (ICT) plays an important role in rural development. The definition of information technology can be summarised as a process of flow, dissemination, processing and storage of information using technological means [16]. In the context of development, ICT refers to the use of technology such as the internet, mobile devices, computers, software, and applications to speed up and improve access to information and communication. In an empirical study by [14], it was found that ICT is able to offer enterprises various possibilities to increase competitiveness such as providing mechanisms to gain access to new market opportunities and specialised information services. According to [1], ICT usage can potentially improve information and knowledge management within firms and increase the speed and reliability of transactions for both business-to-business (B2B) and business-to-consumer (B2C) transactions. The opportunities offered by ICT were promising, whereby organizations can exchange real-time information and build closer relationships with suppliers or business partners and customers. This study also found the possibility of immediate customer feedback according to customer demand in new markets. The use ICT is important for RMEs business sustainability and several factors that influence the use of ICT by RMEs are shown in Figure 1.

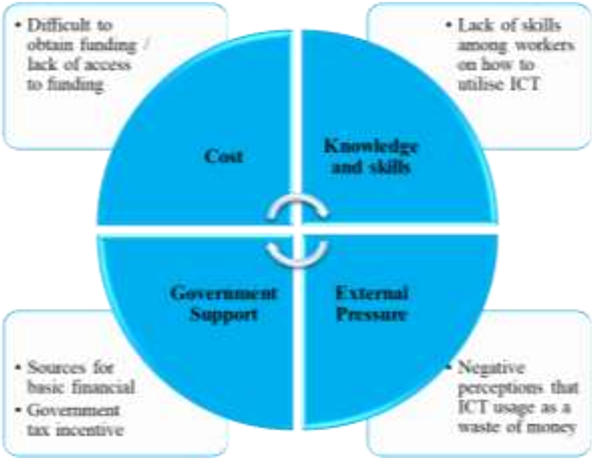

Fig. 1. Factors influencing the low usage of ICT among RMEs.
Source: [1, 9, 10, 14, 16].

Based on the above figure, the four main influential factors or considerations for ICT usage among RMEs are related to the cost, possession of relevant knowledge and skills, government support and external pressure. It seems that RMEs are struggling with lack of access to funding for ICT, followed by lack of skills among workers to use ICT on regular basis, lack of government support for encouraging RMEs to use ICT and negative connotations towards ICT usage by the RMEs. In can summarised that RMEs require an improved access towards funding, provision of appropriate ICT training, government tax incentive to boose ICT adoption and promote positive perception on the benefits of ICT investment for RMEs long-term sustainability.

MATERIALS AND METHODS

Study Area of Kuala Kangsar, Malaysia

This research focuses on a comprehensive examination of five key villages in the Sayong area of Kuala Kangsar, Perak, Malaysia: Kampung Kepala Bendang, Kampung Bukit Lada, Kampung Sayong Tengah, Kampung Sayong Masjid, and Kampung Sayong Hulu. The selection of this specific region is underpinned by the vibrant presence of Rural Micro Enterprises (RMEs) and dedicated entrepreneurs actively involved in craft pottery production. Notably, these villages are renowned for their significant contributions to the art of clay pottery, particularly the famous "Labu Sayong," a craft that has gained national acclaim [8].

Situated in the Royal Town of Kuala Kangsar, recognized as the Heritage Art District in Perak, these villages hold a unique position in the cultural and artistic landscape of the region. Their proximity to each other fosters a rich collaborative environment, facilitating the exchange of knowledge and skills within the local community. Furthermore, their strategic location, merely 5 km away from the town of Kuala Kangsar, ensures convenient accessibility, with a short 10-minute drive by car, as illustrated in Map 1.

Map 1. Location of seven (7) RMEs craft-based located in Kuala Kangsar District, Perak.
Source: Research fieldwork [15].

Based on the data provided by the Malaysian Handicraft Development Corporation, there is a total of 11 small-scale pottery entrepreneurs registered and operated within the study area. Among them are Musmus Enterprise, KZ Craft Enterprise, Harun Pottery and Suriadin Enterprise, Jeyzek Enterprise, Abdul Manan Cams Craft, Era Seramik, Awie Craft, Win Craft, Xtream Craft Deco N Pottery and KT Craft Enterprise. From the above explanations it can be summarised that the selected study area is considered as pioneers in the production of Sayong pottery and handicrafts which is quite famous in Kuala Kangsar in particular, and in Malaysia in general. Furthermore, the Sayong pottery representing a high cultural value and is an important cultural heritage for the local community and is part of the local identity in the study area and has been regarded by rural researcher such as [8] as fulfilling the characteristic of a One Village One Product approach. Out of 11 RME pottery operators, seven of them were agreed to be interviewed during the questionnaire survey conducted between March to April 2023 (Table 2).

Table 2. List of RME pottery operators which participated in the research

Location (Map 1)	Name of enterprise
1	KT Kraf Enterprise
2	Xtream Craft Deco N Pottery
3	Win Craft
4	Era Seramik
5	Jeyzek Enterprise
6	Harun Pottery
7	Musmus Enterprise

Source: Research fieldwork [15].

Methodology

In this research, a quantitative approach was employed for both data collection and analysis. The researchers used a questionnaire-guided interview as the main instrument for data collection. The questionnaires were distributed to respondents consisted of the owner/operator of rural enterprises during visit to their craft outlets in Sayong area. Initial data, sourced from the Malaysian Handicraft Development Corporation, revealed the presence of 11 registered Rural Micro Enterprises (RMEs) within the study area. Given the small number of respondents, researchers had planned for a census study. However, it is worth mentioned that during the fieldwork phase, four respondents were unable to participate due to a variety of commitments, leading to their exclusion from the survey.

Consequently, the study garnered valuable responses from the remaining seven respondents, representing an impressive 64% of the total registered pottery operators in Sayong area. This high participation rate significantly enhances the study's credibility and reliability.

The data collection procedure involved researchers' visit to every premise (pottery making workshop) for conducting a questionnaire-guided interview session the respective RME operators. The survey questionnaire encompasses three primary sections. The first section contains profile of respondents and background of RME. Meanwhile, the second section determines factors that influence/motivate respondents to utilise ICT for their business and factors which hinder the usage of ICT. The third section included the respondents' suggestions on the physical and non-physical needs for enhancing the usage of ICT by RMEs in the future.

For the data analysis, the researcher employed the descriptive statistical analysis method, utilising the SPSS software to extract essential statistical parameters such as percentage values, mean scores, and median values from the collected data. Descriptive statistical analysis serves the purpose of characterising variables and facilitating conclusions drawn from numerical data. The mean or average score analysis involves computing the average value from a given score distribution. This calculation aims to ascertain the typical performance level or achievement attained by an individual or group in a particular measurement or assessment. It provides an overall overview of performance levels and/or for ranking of various indicators or factors influencing the usage of ICT among respondents (Table 3).

Table 3. List of RME pottery operators which participated in the research

Mean Score Range	Category / Level
0.0 – 1.0	Very low influence
1.1– 2.0	Low influence
2.1 – 3.0	Moderate influence
3.1 – 4.0	High influence
4.1 – 5.0	Highly influential

Source: Research Fieldwork [15].

RESULTS AND DISCUSSIONS

Profile of Respondents

The participants in this study, comprising 64% of the total registered pottery entrepreneurs in the Kuala Kangsar district, are detailed in Table 4. All respondents are of Malay ethnicity (100%), with four (57%) being male and the remaining 43% female. These findings highlight the substantial contribution of women entrepreneurs to the operation of rural pottery businesses.

Table 4. Profile of respondents (all villages, n=7)

Question	Answer	Frequency	Percentage
Gender	Male	4	57.0
	Female	3	43.0
Age category	26-35 years	1	14.0
	36-45 years	5	72.0
	46-55 years	1	14.0
Race	Malay	7	100.0
Origin	Born and raised here	7	100.0
Year of business operation	10-15 years	5	71.0
	More than 15 years	2	29.0

Source: Research Fieldwork [15].

The majority of respondents, constituting 72%, belong to the age category of 36-45 years, followed by those aged 26-35 years and 46 and above, each comprising 14%. Additionally, all respondents were born and raised in Sayong and the Kuala Kangsar district, underscoring their deep connection and pride in local pottery-making businesses. The survey reveals that a significant portion (71%) of these entrepreneurs has been engaged in the pottery business for 10-15 years, while the remaining 29% boast more than 15 years of experience, signifying the resilience and enduring relevance of these Rural Micro-Enterprises (RMEs).

As shown in Table 5, prior to engaging in Rural Micro-Enterprises (RMEs), specifically the pottery-making business, none of the respondents reported a monthly income exceeding RM2501. Instead, 42.8% earned an income within the range of RM751-RM1000, followed by those with incomes below RM750 and between RM1001-RM2500, each accounting for 28.6% of respondents. In contrast, after embarking on RMEs, a significant majority now enjoy monthly incomes surpassing RM1000, including 14.3% who receive incomes between RM4851-RM11000. The remaining income categories are RM1001-RM2500 and RM2501-RM4850, each representing 42.8%. Clearly, RMEs did offer the better opportunity for local entrepreneurs to substantially elevated the monthly income status of the respondents.

Table 5. Respondents' monthly income (before and after) (n=7)

Category of income	Before venturing into RMEs		After venturing into RMEs	
	Frequency	Percentage	Frequency	Percentage
<RM750	2	28.6	0	0.0
RM751-RM1000	3	42.8	0	0.0
RM1001-RM2500	2	28.6	3	42.8
RM2501-RM4850	0	0.0	3	42.8
RM4851-RM11000	0	0.0	1	14.3

Source: Research Fieldwork [15].

Usage of ICT among Respondents

Based on the survey, all respondents within the study area currently own a smartphone, and 50% of them have a WIFI hub at their business premises. Only 20% of respondents possess a tablet, while none own a laptop, printer, or scanner. Many respondents mentioned that utilizing electronic gadgets and engaging in online transactions is a relatively new concept for them. However, they find it sufficient for conducting online business and transactions using their smartphones at the moment. Regarding internet usage, the majority of respondents (57.1%) reported spending 1-2 hours per day surfing the internet, with 28.6% doing so only a few days per week. The remaining 14.3% mentioned using the internet only a few times per month Table 6). This finding indicates that all respondents use the internet, allocating time for both business and personal purposes. In terms of frequency, the time spent on internet surfing among respondents appears to be relatively moderate to low, as detailed in Table 6.

Table 6. Time spends on surfing the internet (n=7)

Time spends on surfing internet/web	Frequency	Percentage
1. Rarely use (only few times/month)	1	14.3
2. Only sometimes (few times/week)	2	28.6
3. Normal but not frequent (1-2 hours/day)	4	57.1
4. Frequent (2-3 hours/day)	0	0.0
5. High usage (>3 hours/day)	0	0.0
Total	7	100.0

Source: Research Fieldwork [15].

Table 7 highlights the factors which influencing the usage of ICT among respondents.

Table 7. Factors influencing the Usage of ICT among rural entrepreneurs (n=7)

List of factors	Likert Scale					Mean Score	Ranking
	1	2	3	4	5		
Make works much easier	0	0	3	3	1	3.7	4
Time saving	0	0	1	5	1	4.0	2
Cost saving	0	0	2	4	1	3.8	3
User friendly and easy to be used	0	2	5	0	0	2.7	8
Quick to adapt to ICT usage	0	2	4	1	0	2.8	7
High confident to use ICT for business transaction	0	1	4	2	0	3.1	6
Enhance the reputation and credibility of business	0	0	4	3	0	4.0	2
Easy and faster to promote product	0	1	1	5	0	3.5	5
Pressure of change to progress	0	1	2	3	1	3.5	5
More flexibility (business can be done anywhere)	0	0	1	2	4	4.4	1

Note: Mean score value of 0.0-1.0 denoted very low influence; 1.1-2.0 denoted low influence; 2.1-3.0 (moderate); 3.1-4.0 (high); and 4.1-5.0 (highly influential)
Source: Research Fieldwork [15].

From the list of answers, the top three for the most influential factors are "ICT offers more flexibility for them whereby business can be done anywhere and remotely" (mean score value of 4.4), followed by "time saving" (4.0) and "ability of ICT to enhance the reputation and credibility of business" (4.0). while for the least influential factors mentioned by respondents are "high confident of using ICT for business transaction" with mean score value of 3.1, followed by "quick to adapt to ICT usage" (2.8) and "user friendly and easy to be used" (2.7).

Based on the results from Table 7, it seems that respondents among rural SME operators in the study area are embracing ICT because they are looking for flexibility to conduct business especially in managing booking of their potteries by customers, and also influence by the time and cost savings when they are using ICTs, as compared to the previous conventional approach with minimal ICT usage.

Physical and Non-Physical Needs for ICT Adoption

The study also solicits inputs and opinions of respondents regarding the suggestions on how to improve and enhance the ICT adoption related to RMEs pottery-production business. As a result, respondents highlighted the following suggestions:

(1)Suggestions for physical improvements:

-Giving special voucher to purchase IT devices;

-Identify location and built new communication towers in rural areas

-Introduce free WIFI hotspots;

-Leverage on existing Rural Transformation Centre (RTC) as a training hub for rural entrepreneurs to enrol into ICT training and upscaling classes;

-Diversified the function of Medan Info Desa (rural internet centre) as a strategic meeting point for local entrepreneurs with government agencies and potential clients.

(2)Suggestions for non-physical improvements:

-Updating the training module to enhance ICT literacy, for using including training courses for building website, selling at international e-commerce platforms and mentor-mentee program;

-Strengthening the credibility of existing e-commence platform (desamall.my) to encourage online selling and business transactions;

-Micro financial scheme without interest for RMEs;

-Provide platforms for business networking and collaborations at national and international levels.

Based on the feedback from respondents, there should be a growing need for ministries including the Ministry of Rural Development, Ministry of Entrepreneurs and Cooperative and Malaysian Communication and Multimedia Commission (MCMC) to initiate the disbursement of special voucher for RMEs to purchase ICT devises to be used for business purposes. Respondents also mentioned about the needs to upgrade the internet coverage in rural areas by increasing the location and building of new communication towers as well as the provision of free WIFI hotpots. The remaining two suggestions are more related to enhance the function of existing infrastructure/ buildings namely the Rural Transformation Centre (RTC) at district level and Rural Internet Centre at village level to cater for ICT-related training for RMEs.

As for the non-physical improvement, among suggestions given by the respondents are related to the needs to upgrade the training module for ICT literacy since IT sector experienced rapid changes with the emergence of new tools and platforms to conduct online-related business. To address this challenge, the training modules need to be up to date and relevant with the current and future conditions. Furthermore, there is a need to enhance the credibility of existing e-commerce platform especially the home-grown apps known as “Desamall.my” as an online shopping mall created for marketing and selling of various rural entrepreneurs’ products. Other suggestions are including provision of micro credit loan without interest and establishment of forum or platform that could allow networking and collaboration between local entrepreneurs and international partners to boost their awareness, knowledge and skill through mentor-mentee and sharing of knowledge.

CONCLUSIONS

In summary, this study reveals that rural micro-enterprises (RMEs) engaged in pottery-making in the Kuala Kangsar district exhibit characteristics consistent with those discussed in the literature review. These characteristics include a small-scale organizational system, proximity to raw materials, local ownership, employment of local individuals, and the integration of ICT into business activities. Table 5 illustrates a noteworthy trend, indicating that all respondents experienced an increase in monthly income upon entering RMEs, transitioning from a low-income status to middle and high-income. This data underscores the positive impact of RME activities on monthly income. Regarding ICT usage, a majority of respondents in the study area possess smartphones and have installed WIFI hubs at their business premises. They employ smartphones for online business transactions, with internet usage averaging a moderate 1-2 hours per day, not exceeding 2-3 hours daily.

Respondents emphasized that the primary factors influencing ICT usage are its inherent flexibility, enabling businesses to operate anywhere and remotely, coupled with the time and cost savings it offers compared to conventional approaches. Several suggestions were provided to enhance ICT adoption among respondents and other rural micro-enterprises (RMEs) in the study area. These include capitalizing on existing rural infrastructure such as Rural Transformation Centres (RTCs) and Rural Internet Centres, reinforcing their roles as training hubs for RMEs. Other proposed measures involve tailoring training programs to address current needs, implementing micro-credit schemes, and establishing platforms for knowledge and experience sharing among RMEs. In conclusion, the adoption of ICT has transformed the way rural entrepreneurs conduct their businesses, transitioning from traditional to more flexible approaches. However, ongoing efforts are crucial to raise awareness and enhance ICT skills among RMEs, ensuring their sustained viability in the future.

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ANALYSIS OF THE IMPACT OF DIGITAL TECHNOLOGIES ON THE LEVEL OF DIGITAL SKILLS DEVELOPMENT IN RURAL AREAS OF AZERBAIJAN

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Abstract

Digital technologies have encompassed all spheres of our lives. The application of digital technologies in rural areas is expanding. Mastering these technologies has become more of a requirement than an option. The goal of this work is not only to highlight several activities related to implementing the country's strategy for developing information and communication technologies, increasing the use of digital skills among rural populations, and raising awareness among small and medium-sized agricultural businesses about new technologies. It also aims to investigate gaps between digital skills meeting employer needs and the skills workers actually possess. To achieve this goal, international experiences from various thematic areas related to digital skills were examined. The study employed a general methodology for measuring the effectiveness of digital skills, utilizing statistical analysis tools to assess the digital competency of rural populations and entrepreneurs in comparison to urban areas. This is crucial for Azerbaijan, as the country's small and medium-sized agricultural businesses constitute a significant portion of the national economy. The study conducted variance analysis, allowing the identification of the digital divide and the measurement of digital skills. Recommendations are provided for fostering continuous development of digital skills.

Key words: *digital technologies, digital skills, digital divide*

INTRODUCTION

Digitization brings a positive contribution to the country's comprehensive development and integration with other nations. Through international integration, we can come closer to global trends, adapt to them, and implement them with greater flexibility [2]. The main goals of digitizing society primarily involve upgraded skills shaped by the digital transformation process, used in the professional activities of those directly engaged in, or not engaged in, developments in the field of information and communication technologies. The widespread adoption of digital skills across society has influenced the development of research seeking qualitative and quantitative measures to gauge the digital economy and society. Enhancements in information and communication technologies have led to a rapid surge in Internet usage, altering consumer behavior. Internet users acquire specific digital skills while adapting to the innovations in information and communication technologies. The effectiveness of adopting and mastering these skills depends on the level of a country's socioeconomic development. The impact of digital technologies is evident in shaping a country's development strategy and its economic sectors. The degree of information and communication technology development in rural areas varies among developed countries, developing nations, and those with transitioning economies. The scope of discussions concerning the development of digital technologies in relation to rural progress is continuously expanding [9]. The impact of digital technologies on enhancing the productivity of the food system, spanning a wide array of activities, goods, and services linked to agriculture, is evident. Digital technologies provide access to information about markets, finances, employment, and have the potential to ensure efficiency and transparency within production and distribution chains. Based on a literature review, it has been determined that researchers from various disciplines have shown interest in the causes and consequences of the digital divide between urban and rural areas, employing a binary opposition principle to compare territories in different countries around the world. In this study not only academic scientific research but also governmental documents have been examined in order to obtain current information about the impact of digital technologies on digital skills, digital challenges, and opportunities in rural territories. In the work of Koen Salemink, Dirk Strijker, and Gary Bosworth, the issue of digital inequality between developed countries' urban and rural areas is explored. This is because telecommunication companies are unable to meet the individual needs of rural residents [18].

The focus of this article's research is on the digital opportunities present in rural territories. Pattanapong Tiwasing, Beth Clark, and Menelaos Gkartzios chose the research topic of addressing key issues in rural areas of the United Kingdom concerning the application of digital technologies, the provision of digital services, the hiring and retention of young professionals with digital skills [21]. The author of the present article was intrigued by a similar question about the ability of rural businesses to equally thrive in the digital era in Azerbaijan. Overall, literature in this field suggests that active participation in digitizing rural areas requires affordable mobile broadband connectivity [5], government initiatives to stimulate rural business growth [17;21], creating favorable conditions for entrepreneurs engaged in innovative developments [15], acquiring digital skills [1;10] through enhancing the level of digital education [4] for rural residents. Azerbaijan possesses resources and opportunities for the development of a digital economy. The country's geographical location, its active utilization of digital information and communication technologies, and international collaboration in shaping the information space are among the factors accelerating this process. Given the significant role of digitization in the country's development, this field is considered a priority in all future strategies [22].

The President of the Republic of Azerbaijan has approved "Azerbaijan 2030: National Priorities for Socio-Economic Development" [13], setting the goal of digitizing the economy and society [6] in the country's strategic plan for 2022-2026 [19]. Azerbaijan is currently focused on modernizing digital transformation management [7], leading to the establishment of the Azerbaijani Electronic Agricultural Information System [14] The agricultural sector, a traditional economic domain in Azerbaijan's regions, has entered a qualitatively new stage of development. A significant accomplishment is that our republic has managed to satisfy domestic demand for food products in various important categories solely through local production. Ongoing agricultural reforms envision further rural development, for which the state has implemented extensive support measures. Some of the agricultural reforms implemented in recent years aim at realizing state support for farmers through more transparent mechanisms, minimizing interactions between officials and farmers, thus eliminating negative situations. The Electronic Agricultural Information System (EAIS) has introduced numerous new opportunities for farmers. To leverage these capabilities, farmers must register in the system and create their personal accounts. Notably, farmers have shown significant interest in this new system. Consequently, the registration process of farmers in the new system is almost complete due to this high interest. At present, approximately 410,000 farmers have registered in the Electronic Agricultural Information System and created their personal accounts. Farmers registered in the system can declare the crops they plan to sow for the upcoming year at the end of each year.

Against the backdrop of Azerbaijan's achievements in the digitalization of the country, the goal of this article is to investigate and analyze the acquisition, implementation, and development of digital skills in rural areas based on the utilization of digital technologies.

MATERIALS AND METHODS

To assess the impact and effectiveness of digitalization policy measures, the availability of statistical data holds significant importance in terms of developing medium-term strategies within the framework of the Azerbaijan 2030 development concept. The State Statistical Committee of the Republic of Azerbaijan is currently engaged in digitizing the private sector, including rural territories. The committee collects a very limited set of related indicators, primarily focused on companies' and households' access to the internet. Presently, a range of indicators crucial for successful digital development of the country is being utilized. The Information and Communication Technology (ICT) Development Index is considered a key indicator that characterizes the dynamics of ICT development in countries worldwide. The methodology for calculating this index was proposed by the International Telecommunication Union (ITU). According to the calculation methodology, the IDI index is characterized by a combined representation and synthesis of basic ICT indicators and their comparison over corresponding periods. The advantage of this indicator lies in its ability to compare the level of information and communication technology (ICT) development among countries globally not based on individual indicators, but on the basis of aggregated average indicators. In the first subgroup of the "*access sub-index*", the fundamental indicators include the number of fixed-line telephones per 100 population, the number of mobile cellular subscribers per 100 population, the volume of international communication channels per user, the percentage of households with a computer having internet access. The second indexed group's *"use sub-index"* comprises fundamental coefficients: the number of internet users per 100 individuals in the population, the quantity of fixed broadband internet subscribers per 100 individuals, and the count of mobile broadband internet subscribers per 100 individuals in the population. In the third subgroup of the "*skills sub-index*", fundamental indicators include the adult literacy rate, with the overall ratio of higher and secondary education serving as the basis. Comparing the values of two indicators: computer users and internet users in Azerbaijan, it's possible to determine the trends in their development. As evident from Figure 1, over the past 5 years, the number of computer and internet users has proportionally increased. While taking into account the results of comparing these trends, further investigation can be conducted to determine whether a digital divide exists among social groups or between population categories in the country. For instance, this can be explored when considering the indicator of rural residents' access to active participation in the digital society.

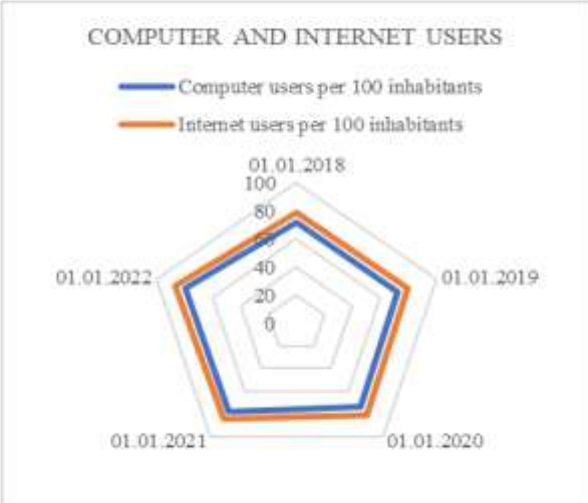

Fig. 1. Computer and internet users per 100 inhabitants
Source: official data of the State Statistics Committee of the Republic of Azerbaijan [20].

The methodological framework for calculating indicators of the digital economy, as mentioned earlier, is based on the synthesis of indexed variables and is in the process of formation. Thanks to the research efforts of scholars worldwide, the calculation methodology is continuously being improved [8].

Researchers contribute to expanding the methodological base by adding both basic and additional indicators that form the aggregated IDI index. Currently, the practical application of skills and the availability of educational programs for developing digital competencies are ahead of the formulation of theoretical methodologies for analyzing the impact of digital technologies on the daily life of institutional entities. While everyone is being taught how to use skills, there isn't a specific methodology for assessing digital skills and the criteria for such assessment. The necessity of analysis arises from the fact that after 2020, when the embryonic period of the Fourth Industrial Revolution concluded, the information environment changed. Following climate and global changes, humanity entered a new era known as BANI – a world characterized by brittleness, anxiety, nonlinearity, and incomprehensibility [3]. The fragility of the world lies in the global threats to further human development, which significantly influences society's concern over the potential loss of familiar systems that become invisible, lack obvious parameters, and fail to form a logical chain with a defined algorithm. Simultaneously, decisions must be made and a new world built, overcoming challenges in situations of uncertainty and enhancing skills: hard skills, soft skills, self-skills, and digital skills. Currently, the demands on employees in the 'information flow' have become extensive and diverse. The nature of attitudes towards work, employers, and money has changed, both in urban and rural settings, in developed as well as developing countries.

Therefore, there is a need to understand how the presence and development of digital technologies influence the acquisition and utilization of digital skills. This can be achieved by employing statistical data analysis techniques from the State Statistical Committee, employing empirical data processing, statistical methods of comparison, grouping, aggregation, and analysis of variance (ANOVA). The ultimate goal is to determine the level of differences and the digital divide between urban and rural areas in Azerbaijan.

RESULTS AND DISCUSSIONS

When systematizing indicators related to information and communication technologies in Azerbaijan, the author conducted a comparative analysis of the main data from 2005 to 2021 and visually presented it in Table 1.

Table 1. Key parameters of information and communication technologies (ICTs)

Indicators	2005	2006	2007	2010	2015	2019	2020	2021
Number of Internet users per 100 people, persons	8	10	11	46	77	81	85	87
Number of broadband Internet access users per 100 people, persons	2	2	4	15	72	77	83	85
Volume of international Internet channels per capita, kbps	0.04	0.09	0.73	4.6	54.0	111.1	181.5	198.6
Share of the population living in the territory covered by mobile communications in the total population of the country	99.0	99.0	99.0	99.8	99.9	100.0	100.0	100.0
Average rate for 20 hours of Internet usage per month, manat	5.0	4.8	4.0	1.9	1.3	0.9	0.9	0.9
Ratio of Internet tariff to average monthly gross national income per capita, in percent	4.5	2.9	1.7	0.6	0.3	0.1	0.1	0.1
Average tariff for 100 minutes of mobile communication during a month, manat	18.0	16.0	12.0	7.7	6.9	6.4	6.4	6.4
Ratio of cell phone call tariff to average monthly gross national income per capita, in percents	16.1	9.7	5.0	2.0	1.5	1.0	1.1	0.8
ICT Development Index	2.58	2.7	2.77	3.78	6.23	6.49	6.64	6.67

Source: official data of the State Statistical Committee of the Republic of Azerbaijan [20].

Despite nearly the entire population residing in the covered area having mobile communication, the number of Internet users per 100 people was relatively low in 2005 and increased almost 11-fold by 2021. Broadband Internet access users accounted for a higher percentage in 2021, at 85%, compared to only 2% in 2005. The more than fivefold increase in Internet usage rates allows for an improvement in digital skills. As a point of comparison, according to the statistical analysis conducted by the International Telecommunication Union (ITU) and the Alliance for Affordable Internet, [12] the cost of internet connectivity as a percentage of

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gross national income per capita rose to 2.0% in 2021 compared to 1.9% in 2020 worldwide. The passage describes how the availability and the development of digital technologies in Azerbaijan have contributed to the acquisition and usage of digital skills. Despite global trends of rising prices and increased use of fixed and mobile broadband connections, relative costs for internet access have remained unchanged in Azerbaijan. Unlike many other countries, where a decreasing number of people have access to affordable internet, Azerbaijan has ensured affordable internet access with consistent quality for its population. The government has launched initiatives such as the "Digital Girls" national education program and the project "Development of Multimedia Online Courses and Web Portals in the Field of Information Technology for Women," [16] both aimed at promoting digital skills, especially among women. However, the global trend of low internet usage in rural areas and among women is also observed in Azerbaijan [11]. For example, in sectors like agriculture, forestry, and fishing, only 27.5% of internet users are women.

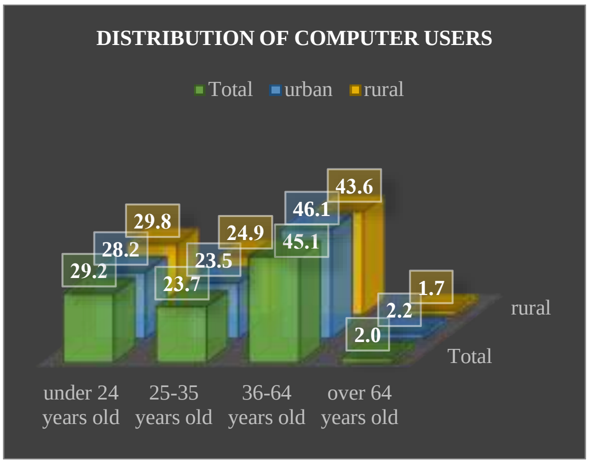

Fig. 2. Distribution of computer users by age groups as % to total, 2021
Source: official data of the State Statistics Committee of the Republic of Azerbaijan [20].

The author of the article conducted research using data collected by the State Statistical Committee of Azerbaijan. The research included over 28.2 thousand household members aged 7 and older, sampled using a sampling method. Given that 47.1% of Azerbaijan's population lives in rural areas, access to telecommunication services in these areas is crucial for the well-being of this demographic.

Figure 2 illustrates the combination of indicators depicting the number of computer users across age groups and territorial structure. This gap has increased for age groups under 24 and 25 to 35 by +5.7% and +6.0%, respectively, while decreasing for age groups 36 to 64 and older than 64 by 94.6% and 77.3%, respectively.

The research on the number of internet users across different age groups and places of residence is depicted in Figure 3.

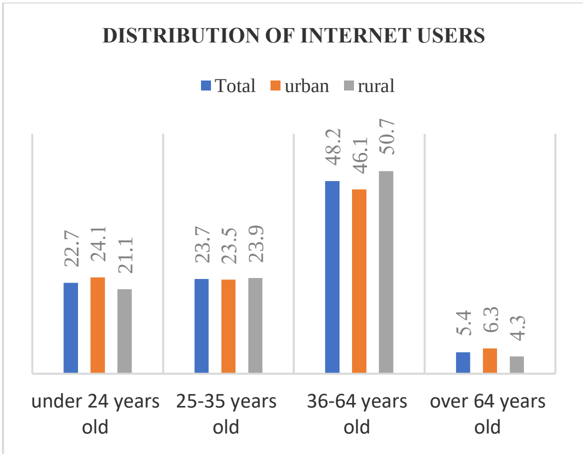

Fig. 3. Distribution of internet users by age groups as % to total, 2021
Source: official data of the State Statistics Committee of the Republic of Azerbaijan [20].

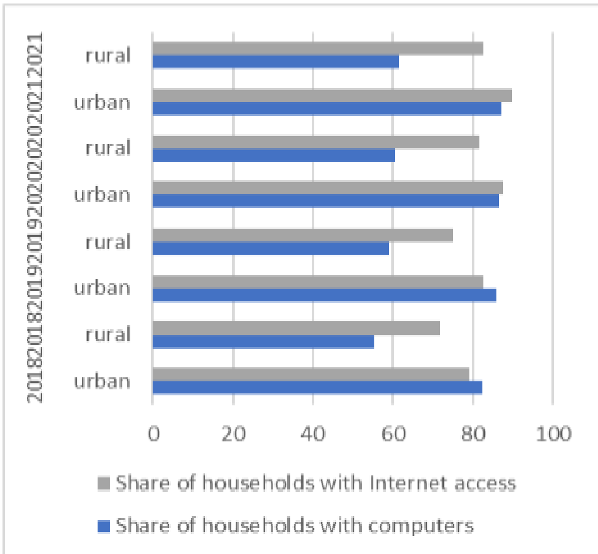

Fig. 4. Ratio of shares of households with computers and Internet access in urban and rural areas of Azerbaijan (%)
Source: official data of the State Statistics Committee of the Republic of Azerbaijan [20].

The study of the number of internet users across age groups and residential areas is reflected in Figure 3. As seen in the figure, the number of rural residents in two age groups, aged 25 to 64, using the internet is higher than that of urban residents. Undoubtedly, this is primarily associated with the demographic rejuvenation trends in rural areas.

Table 2. Distribution of equipment by type of wireless connection to the Internet, as a percentage of the total, 2021

Area	of which:					
	Via LTE	Via satellite	using a data card or USB modem	Via CDMA	via mobile internet	including using a 3G or 4G network
Total	1.6	1.7	2.1	1.7	92.9	71.3
urban	2.8	3.4	1.7	0.3	91.8	73.6
rural	1.0	0.9	2.3	0.8	87.5	67.4

Source: official data of the State Statistical Committee of the Republic of Azerbaijan [20].

The study of the urban-rural ratio in terms of household computer ownership and their Internet access yielded the following results, as presented in Figure 4. As evident from the diagram, the extent of coverage of rural areas in terms of telecommunication services significantly lags behind urban areas. A significant limitation to Internet access is the existing infrastructure, which relies on low-speed modem connections through the telephone network. Technologies such as digital subscriber lines, which transmit information at much higher speeds over existing infrastructure, are not always available in the country's cities, let alone its rural areas. An analysis of the proportion of rural households with computers showed that only about 60% of rural residents have computers on an approximate yearly basis. Consequently, rural residents rely more on accessing the World Wide Web (which is over 80% of them) not through computers, but through other digital communication means, primarily smartphones and tablets. Rural residents mostly connect to the Internet through data cards or USB modems, utilizing CDMA (Code Division Multiple Access) technology and mobile Internet. Subsequently, Table 2 examines the types of wireless Internet connections based on 2021 data.

During the investigation into Internet unavailability in households, the following reasons were identified: [20]

-"Internet is not needed" - expressed by 40.8% of urban residents and 46.5% of rural residents.

-"Access to the Internet is available elsewhere" stated by 13% of urban residents and 3.9% of rural residents.

-"Expensive equipment required for Internet connection" characterized by 12.4% of urban residents and 7.2% of rural residents.

- "High fees for usage" mentioned by 10.5% of urban residents and 11.3% of rural residents.

-"Feeling not confident about personal information security online" voiced by 2.2% of urban residents and 0.4% of rural residents.

-Expressed their opinion about lack of technical possibilities in this area - reported by 6.2% of urban population and 6.8% of rural population.

-Not satisfied with Internet speed and quality - mentioned by 1.4% of urban residents and 4.2% of rural residents.

-Consider the Internet harmful - expressed by 5.7% of urban residents and 7.5% of rural residents.

-Other reasons - identified by 7.8% of urban residents and 12.2% of rural residents.

Table 3. Distribution of computer, of internet users by educational attainments, as % to total, 2021

Population categories by residence	Primary education or lower	Lower secondary education	Upper secondary or postsecondary non-tertiary	Tertiary education
urban computer users	15.1	11.4	52.4	21.1
urban internet users	15.1	11.5	51.1	22.3
rural computer users	19.2	7.2	54.2	19.4
rural internet users	12.5	9.5	57.2	20.8

Source: official data of the State Statistical Committee of the Republic of Azerbaijan [20].

The category of "other reasons" for Internet unavailability in households includes digital illiteracy or lack of digital skills among the population. The modernization of digital technologies requires a progressive movement towards increasing the level of education. The users of computers and the Internet in 2021 were subjected to analysis based on their educational levels in Table 3.

In order to determine whether a significant difference exists between the education levels of urban and rural populations in terms of digital skills, a two-way analysis of variance (ANOVA) was conducted, and three hypotheses were formulated (accepted):

H1: Categories of population based on place of residence do not affect digital skills.

H2: Education levels do not affect digital skills.

H3: The combined interaction of population category and education levels does not affect digital skills.

Table 4. Two-factor analysis of variance with repetitions

Anova: Two-Factor With Replication					
SUMMARY	Primary education or lower	Lower secondary education	Upper secondary or postsecondary non-tertiary	Tertiary education	TOTAL
Urban computer internet users					
Count	2	2	2	2	8
Sum	30.2	22.9	103.5	43.4	200
Average	15.1	11.45	51.75	21.7	25
Variance	0	0.005	0.845	0.72	288.2429
Rural computer internet users					
Count	2	2	2	2	8
Sum	31.7	16.7	111.4	40.2	200
Average	15.85	8.35	55.7	20.1	25
Variance	22.445	2.645	4.5	0.98	383.6371
Total					
Count	4	4	4	4	
Sum	61.9	39.6	214.9	83.6	
Average	15.475	9.9	53.725	20.9	
Variance	7.669167	4.086667	6.9825	1.42	

ANOVA						
Source of Variation	***SS***	***df***	***MS***	***F***	***P-value***	***F crit***
Sample (urban, rural population)	9.0913	1	9.0913	2.2613	1	5.317655
Columns (levels of education)	4642.685	3	1547.562	385.2051	5.4809	4.066181
Interaction	28.335	3	9.445	2.350965	0.148451	4.066181
Within	32.14	8	4.0175			
Total	4703.16	15				

Source: systematized by the author on the basis of the data of the State Statistics Committee of the Republic of Azerbaijan [20].

While analyzing the collected data, it becomes evident that the value of the F-criterion for the population category factor based on place of residence (urban and rural) is F-observed = 2.26, while the critical F-value is F-critical = 5.32. If F-observed < F-critical, there is no basis to reject the null hypothesis: population categories based on place of residence do not have an impact on digital skills. This conclusion is further supported by the sample coefficient of determination for the population category factor: R^2=0.002, signifying that 0.2% of the total sample variance in the number of computer and internet users is attributed to the population category (urban or rural). Therefore, the acquisition, possession, and enhancement of digital skills are not dependent on the population category based on place of residence, provided that access to information and communication technologies is equal for both urban and rural residents. Azerbaijan has established nearly identical conditions for digital development across the country's territories based on the indicators of the first two sub-index groups of the IDI, as revealed in previous calculations. When analyzing the value of the F-criterion for the education level factor, it was found that F-observed > F-critical. Therefore, the null hypothesis should be rejected in favor of the alternative hypothesis. The sample coefficient of determination for the education level factor is R^2 =0.987, indicating that 98.7% of the total sample variance in the number of computer and internet users is attributed to the education level. Hence, education level influences the acquisition and utilization of digital skills. Additionally, in the analysis of the interaction between the two factors, population category and education level, the obtained values are as follows: F-observed = 2.35 and F-critical = 4.07. This implies that the combined interaction of population category and education level factors does not affect the number of users of both computers and the Internet. Consequently, digital skills are not influenced by this interaction. The indicator reflecting the number of purchased computers, smartphones, and other digital devices cannot accurately characterize the extent of digital skills possessed by urban or rural populations. It is also not reliably possible to determine the level of digital skills among individuals with degrees in relevant fields. In such cases, certification comes to the aid. Skills are acquired, and a certificate is obtained. However, there is a lack of statistical data on the number of certified professionals (or simply workers). In my opinion, companies that require certifications should maintain their own proprietary observation of the range of acquired and applied digital skills in their work. In other words, they should standardize skills, just as working hours were standardized in the recent past.

Here, readers might have objections, such as:

-When hiring for vacant positions, applicants are required to have not only educational credentials but also specific skills that match their future roles. In my view, company requirements can sometimes be narrowly focused. In many companies, employees often possess a limited set of skills. With the ever-growing volume of information that needs to be processed in real-time, employees might not meet the requirements that have evolved due to the changing nature of the digital era.

-There are situations where skills obtained through education are not fully utilized. These skills can become atrophied, like lifeless organs. In this case, there is a significant loss of an employee's qualitative abilities. To address this, it would be advisable to use qualitative indicators such as timely and high-quality document submission, teamwork, and the level of employee compliance with instructions from supervisors. Typically, qualitative indicators are assessed using a scoring system. However, an ill-considered approach to evaluating an employee's digital skills won't allow the identification of the degree of difference between alternative actions the employee could take. In most cases, deviations from established norms (scores) can only be indirectly assessed using an ordinal or rank scale. For instance, when evaluating digital skills based on the indicator of compliance with instructions while working on a computer, employees can be assigned scores ranging from 2 (low) to 5 (high), or more categorically, 0 points (not done) and 1 point (done) for the assigned task. If anything is not completed, it can be considered that the entire task has failed. It's similar to a mathematical problem: either the correct answer is obtained or it's incorrect.

Many experts, including marketers, share the view that it's not about creating but acquiring. Gaining a larger audience comes first, and then understanding the effectiveness of digital skills can come later. This approach makes sense from an economic standpoint: if there's an entry-interest, there will be an exit-skills. However, even this doesn't define the quality of the acquired skills and their effectiveness. To achieve the necessary scale of effectiveness, it requires self-acquisition of new skills and their implementation through specific methods suitable for different population groups. The advantage of this approach lies in the fact that such structured learning conditions will enhance the acquisition of all types of digital skills. Expert knowledge in a specific field is unquestionably important. It not only serves as the backbone or foundation of awareness about the availability of resources for skill acquisition, but it is also a resource itself. However, continuous self-refreshment of skills enhances employees' qualifications and simplifies life. Digital skills are defined by digital competencies. The digital transformation has the potential to enhance the economic efficiency of small and medium-sized enterprises, including those in the agricultural sector. Entrepreneurial digitalization enables companies to make decisions to improve agricultural business efficiency, modulate business processes, explore new markets, optimize and refine their operations, and adapt their approach to employees. Digitization helps companies integrate more easily into global value chains and expand their innovative activities. It can increase company efficiency: companies decide to invest in digital tools and practices for various reasons, and as a result, the technology implementation process should bring tangible benefits to companies undergoing digital transformation. Digitization also helps increase productivity, which, in turn, leads to higher wages due to improved digital skills and an improved standard of living in rural areas.

CONCLUSIONS

Summing up the study's findings, it can be concluded that digitization is multifaceted and typically involves the utilization of digital tools and technologies to address specific problems and enhance operations carried out by businesses. The application of digital technologies can improve the performance of small and medium-sized agribusinesses, increase company efficiency, and enhance the quality of life for rural residents. Individuals need to be prepared for the demands of the new digital era, which are related to processing large volumes of information and solving problems that machines cannot handle. This is achievable only by employees possessing digital skills. The level of employees with digital competencies holds significance in rural areas. Farming enterprises will only attain a competitive advantage through a high level of employees with digital skills. Further acceleration of the process of forming an information society in rural areas is possible by overcoming several objective challenges, such as: the shortage of computer science literature in Azerbaijani is due to rural Azerbaijan residents primarily speaking only their national language; the translation of educational programs in computer science, from basic levels providing only minimal proficiency in information and communication technologies, lacks progression toward deeper, diverse, and technical knowledge, to more profound, diverse, and technical knowledge. Ensuring information security, safeguarding personal and private information. Establishing and developing regional and local information and educational centers to expand the opportunities for all layers of the rural population to access information resources, creating conditions for providing free information services to underprivileged segments of the rural population. Educating rural populations about modern information and communication technology tools and their utilization.

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BIOLOGICAL FEATURES AND GENETIC VALUE OF THE LEBEDYN BREED IN THE NEED FOR ITS PRESERVATION ON THE TERRITORY OF UKRAINE

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Abstract

Research was conducted in the aspect of preservation the gene pool of aboriginal Lebedyn cattle in the Sumy region of Ukraine, which belongs to the brown breeds of the world. Cows of the Lebedyn breed are characterized by good indicators of milk productivity. Milk yield for 305 days of the first, third and highest lactation, respectively, amounted to 4,446, 5,281 and 5,292 kg of milk with a fat content of 3.82-3.87% and protein of 3.33-3.35%. The presence of lactose in the milk of Lebedyn cows ranged from 4.68-4.73%, and dry matter - 12.61-12.72%. A negative correlation was established between the amount of milk and the content of fat (r=-0.014...-0.367) and protein (r=-0.051...-0.212) depending on the estimated lactation. A fairly close and reliable positive correlation between protein and fat content was established (r=0.326...0.651), which allows effective indirect selection between these traits.

Key words**:** *Lebedyn breed, milk yield, fat, protein, correlation*

INTRODUCTION

It is a fact that few local breeds remain carriers of particularly valuable hereditary traits and allelic complexes, without which further breeding process would be one-sided. However, these breeds cannot compete with commercial specialized breeds in performance traits that determine their economic advantage. That is why there is a sharp decrease in the number of livestock and the network of breeding farms both in Ukraine and in Sumy region. Particularly acute is the problem of the gene pool preservation for small number of local animal species, whose disappearance decreases the biological diversity of the animal genetic resources and, even more lead to the loss of the national cultural heritage [4, 8, 17].

Large-scale breeding of the Holstein breed all over the world, as the best in milk production and conformation type, has led, according to D.T. Vinnichuk [19] to the fact that it actually became a world-class monobreed. Because of one-sided selection and the use of inbreeding, it loses important natural diversity value, especially reproductive ability, thereby reducing the duration of productive use [15, 18].

From the point of view of economic efficiency, there is no objective justification for the use of highly productive Holstein breed in the conditions of Ukraine. The reduction in cow lifetime leads to the need for intensive herd replacement (at least 30% annually). As a result of this, the enterprise is forced to maintain virtually the entire number of cows born over the last two to three years in order to ensure the preservation of achieved herd size.

From an economic point of view, significant costs for raising replacement heifers, annually introduced into the herd to replace retired cows, are included in the cost of produced milk. Thus, a decrease in the fertility of Holstein cows cannot ensure the expanded formation of a herd, since the goal is to at least preserve the existing number of cows [2]. The excessive physiological load on specialized highly productive breeds, which is the Holstein breed, contributes to a decrease in adaptive qualities and often leads to various diseases. It is also important to take into account that Holstein cattle have a number of hereditary defects that have a recessive type of inheritance [1, 9, 12, 17].

In terms of preserving the aboriginal breeds as carriers of various rare genetic blocks, which have important selection significance by the ability of these animals to be highly adaptable, resistance to common diseases, long period of productive use and the feature of excellent reproductive qualities. The same cannot be said about the Holstein monobreed, which has lost these properties that are important in breeding and economic values [5, 7, 14, 16].

Now in Ukraine, especially valuable, combined breeds of cattle productivity have almost disappeared, which, in the process of long-term selection, adapted to local feeding and housing conditions. These breeds include: gray Ukrainian, Ukrainian white-headed, brown Carpathian, red Polish, Lebedyn, and Pinzgau [11]. All of these listed breeds are included in the state gene pool conservation program. Among these breeds, especially brown ones, the most numerous is the Lebedyn, widespread in the Sumy region of Ukraine [10].

The process of intensification and specialization of the dairy cattle breeding industry with the widespread use of highly productive imported gene pool has necessitated the creation of new breeds of dairy livestock. They were formed by the method of absorptive crossbreeding of non-competitive aboriginal breeds with specialized dairy ones. With disappearance of aboriginal cattle, problem of preserving the gene pool of local breeds arose in many countries of the world, including Ukraine, which is only getting worse with time [11].

According to the current difficult situation, a set of selection and administrative measures aimed at protecting the Lebedyn breed is being developed. Her disappearance will lead to a depletion of genetic diversity and limited opportunities, including in the selection process to improve the newly created Ukrainian brown dairy breed. In this regard, scientists were tasked with an in-depth study of the genetic resources of brown cattle, monitoring the selection situation and, on their basis, developing methods for preserving the gene pool of the Lebedyn breed, especially in a closed population [9].

The productivity level of animals in gene pool herds should not be a major feature for breeding, because the vast majority of aboriginal breeds for its productive life give more production and of a higher quality than specialized breeds.

Recently, scientific studies have focused on the economically beneficial features of animal husbandry being a result of crossbreeding Lebedyn breed with the Swiss breed, at intermediate stages, in the process of selection of the Ukrainian brown dairy breed. That is why, not much attention was paid to the study of milk productivity and, in particular, the qualitative composition of milk from this cattle.

9.It caused, the deficiency of information in the scientific literature about the biological value and technological properties of milk at the present stage of breeding of the Lebedyn breed.

The question of the conservation and development of such important hereditary "Lebedyn" traits with increased fat and protein content in milk remains relevant. In connection, the staff of the Sumy NAU conducted a purposeful study of the dairy productivity features of cows in the gene pool herd of the Lebedyn breed.

MATERIALS AND METHODS

Studies have been conducted in the breeding farm ZAO "Sad" situated in Okhtyrsky district Sumy region. The main physicochemical parameters of milk - fat, protein, lactose and dry matter were determined by infrared diagnostics method on the automatic milk quality analyzer "Laktoscope" produced by "Deltainstruments" (Holland). Milk samples from each cow of the herd were taken once a month according to the recommendations of DSTU 4834:2007 of Ukraine [13].

The coefficient of linear correlation was calculated by formula of Pearson:

$$r_{xy} = \frac{\sum(x_i - \bar{x}) \times (y_i - \bar{y})}{\sqrt{\sum(x_i - \bar{x})^2 \times \sum(y_i - \bar{y})^2}}$$

where:
x_i– value for variable X;
y_i– value for variable $У$;
$\bar{x}$ – average value for X;
$\bar{y}$ – average value for $У$.

RESULTS AND DISCUSSIONS

The research of quantitative and qualitative indicators of milk from cows of the Lebedyn breed showed that the productivity background of dairy cattle in the region considering all forms of ownership, according to the last completed lactation yield was an average of 5,117 kg, according to the 2018 statistical data, and in experimental herd - 5,292 kg, proved the sufficient competitiveness of the animals of this unique breed (Table 1).
The average milk yield of first-lactation cows at the level of 4,446 kg meets the target standard for cows of Ukrainian brown dairy breed according to breeding program and points to the high potential of Lebedyn cattle, which is confirmed by the yield of the third lactation - 5,281 kg, which also meets the requirements of the target standard and proves its potential in the breeding process to further improvement of the Brown cattle population.
Since the quality of milk is an integral part of the milk productivity traits, the breeding value assessment of animals is impossible without determining the mass fraction of fat in the milk. Local combined breeds created as a result of long-term selection are usually characterized by a high fat content. Lebedyn cattle is no exception and also belongs to breeds that traditionally have high milk fat and milk protein content, as evidenced by reports from scientific sources [3].
The selection process of improving the milk productivity of the Lebedyn cows over the past three decades has not affected on significant variability the fat content in milk, as evidenced by our research results. Milk fat content varied from 3.82 % in the first to 3.87 % in the full-age third lactation. Values of these indicators exceed the fat content standard for milk of brown breeds by 0.12-0.17 %. The level of variability coefficients of fat content in the milk of experimental herd is significant, as for a selected trait (3.93-5.67 %), which creates the opportunity for effective selection of animals based on fat content.

Table 1. Indicators of dairy productivity and quality components content in the milk of Lebedyn breed on the farm ZAO "Sad"

Feature	n	x ± S.E.	Cv, %
First lactation: milk yield, kg	39	4.446±138.9	19.52
% fat		3.82±0.032	5.21
kgfat		169.7±5.25	19.31
% protein		3.33±0.025	4.61
Kg protein		147.9±4.49	18.95
% lactose		4.73±0.020	2.64
% dry matter		12.61±0.072	3.56
Second lactation: milk yield, kg	26	4,605±119.8	13.27
% fat		3.85±0.030	3.93
kgfat		177.1±4.19	12.06
% protein		3.34±0.033	4.97
Kg protein		153.8±3.97	13.15
% lactose		4.72±0.021	2.27
% dry matter		12.72±0.066	2.64
Third lactation: milk yield, kg	45	5,281±57.6	7.32
% fat		3.87±0.033	5.67
kgfat		204.8±2.87	9.41
% protein		3.34±0.023	4.57
Kg protein		176.5±2.22	8.43
% lactose		4.68±0.024	3.39
% dry matter		12.72±0.060	3.16
Total heard: milk yield, kg	171	5,292±78.2	19.34
% fat		3.83±0.015	5.27
kgfat		202.4±3.01	19.43
% protein		3.35±0.013	4.94
Kg protein		177.1±2.65	19.59
% lactose		4.70±0.010	2.82
% dry matter		12.66±0.029	3.01

Source: Own calculations.

The next, no less important indicator of milk quality is its protein content, which in terms of selection and economic significance is not inferior to fat content. In general, the most essential components of milk, such as protein, sugar and minerals, characterize the healthy properties of this product. The importance of milk protein is due not only to its high nutritional value, but also to its content of essential amino acids. In addition, protein is the main source of calcium and phosphorus, easily absorbed by the human. The protein level of milk is a useful component for the production of canned milk and cheese.

The content of protein in milk of the Lebedyn cows ranged from 3.33-3.35 %, depending on lactation, exceeding the breed standard for brown cattle by 0.03-0.05 %. Comparing the obtained protein level with indicators given by author of the Lebedyn breed A. E. Yatsenko [6], it decreased significantly (by 0.20% of its minimum value). In the future, it needs selective improvement using the method of rational, informed selection of animals with high values.

Lactose or milk sugar is not a constituent element that is massively assessed for milk selection and processing. However, the taste of milk depends on lactose, which is the main carbohydrate of the disaccharide group of milk. The structural elements of which are glucose and galactose. Lactose in milk is the most stable component. The lactose content remains almost unchanged during lactation. Lactose plays an important role in maintaining constant osmotic pressure in the blood-milk system. It determines the volume of water secreted in milk and is the main factor determining the level of milk yield, therefore its fluctuations in milk are much lower than fat and protein.

The average lactose content in the milk of Lebedyn breed cows was 4.68-4.73 % with the lowest level of variability in coefficients of variation – 2.27-3.39 %, when compared with fat content (3.93-5.67%) and protein (4.57-4.97%). The average level of dry matter in the milk of cows of the Lebedyn breed also does not vary significantly; it depends on the content of the dry matter components of skim milk and milk fat and varies within the calculated lactation from 12.61%, according to the first, to 12.72% of the data for the second and third lactations.

Selection of the cattle for several traits of milk productivity will be more effective if there is a close correlation between selected traits. Therefore, in the process of animal selection, it is important to monitor the level of correlation variability between the amount of milk yield and milk components, Table 2.

Long-term practice of breeding dairy cattle has proven that, as a rule, there is a negative relationship between the level of milk yield and fat content in milk, which complicates selection and breeding work on these two traits in the direction of their simultaneous growth. The results of our research were no exception to the rule, since the correlation between milk yield and fat content in the milk of the Lebedyn cows also turned out to be negative.

Its negative grade was highly variable and dependent on the estimated lactation. The lowest level of negative correlation was found according to the second lactation data (-0.367) with reliability at $P < 0.05$. The overall trend for negative correlation of milk yield-fat content is characterized by the total amount of cows in the whole herd ($r = -0.114$), although it is not reliable.

A similar situation was observed in the estimation of the correlation coefficients of milk yield – protein content in the milk of Lebedyn breed cows, the degree of which with a negative value varied within $r = -0.076 \ldots -0.212$.

The lactose content in milk, according to the unreliable values of the correlation coefficients, is almost independent of the milk yield as well as the dry matter content.

A sufficiently close and reliable positive correlation between protein and fat content ($r = 0.326 \ldots 0.651$), especially according to the first lactation and taken in a whole herd, proved the possibility of indirect breeding on any of these important selection traits.

The indicators of the degree of positive correlation coefficients between these traits show to what extent the percentage of dry matter in milk depends on other milk constituents - fat, protein and lactose, strongly show. The highest content of the dry matter content is affected by the fat content of milk, as proved by the highest correlation coefficients ($r = 0.680 \ldots 0.791$) and reliability ($P < 0.001$).

Table 2. Correlation between the traits of milk productivity in cows of the Lebedyn breed on the farm ZAO "Sad"

Lactation	feature	% fat	kgfat	% protein	Kg protein	% lactose	% dry matter
First (n=39)	Milk yield, kg	-0.152	0.963	-0.183	0.970	0.256	-0.085
	% fat	-	0.116	0.651	-0.002	0.030	0.791
	kgfat	-	-	-0.014	0.973	0.247	0.113
	% protein	-	-	-	0.057	-0.170	0.563
	Kg protein	-	-	-	-	0.201	0.040
	% lactose	-	-	-	-	-	0.334
Second (n=26)	Milk yield, kg	-0.367	0.950	-0.212	0.934	0.022	-0.253
	% fat	-	-0.062	0.437	-0.206	-0,044	0.717
	kgfat	-	-	-0.092	0.931	-0.004	-0.043
	% protein	-	-	-	0.149	0.119	0.740
	Kg protein	-	-	-	-	0.053	0.011
	% lactose	-	-	-	-	-	0.399
Third (n=45)	Milk yield, kg	-0.004	0.783	-0.051	0.846	0.039	0.034
	% fat	-	0.615	0.326	0.178	-0.118	0.680
	kgfat	-	-	0.162	0.777	-0.057	0.444
	% protein	-	-	-	0.488	0.115	0.666
	Kg protein	-	-	-	-	0.088	0.386
	% lactose	-	-	-	-	-	0.428
Total for the herd (n=171)	Milk yield, kg	-0.114	0.960	-0.076	0.967	-0.049	-0.066
	% fat	-	0.164	0.432	-0.002	0.001	0.730
	kgfat	-	-	0.044	0.959	-0.054	0.129
	% protein	-	-	-	0.178	-0.025	0.630
	Kg protein	-	-	-	-	-0.065	0.089
	% lactose	-	-	-	-	-	0.364

Source: Own calculations.

Almost at the same level, the dry matter content is influenced by the protein content with the corresponding coefficients ($r = 0.563… 0.740$; $P < 0.001$). The relatively lower correlation coefficients of lactose – dry matter, which variability varied somewhat within the accounted lactations ($r = 0.334… 0.428$) and their reliability ($P < 0.05–0.001$), also proved the dependence of milk dry matter on milk sugar content.

CONCLUSIONS

Generalized data of the milk samples analysis from cows of the Lebedyn breed for the content of fat, protein, lactose and dry matter indicate about general biological patterns of the dynamics of its quality indicators depending on heredity, physiological condition and paratypical factors.

The established tendency to a significant decrease in protein in milk of cows of the Lebedyn breed testifies to the necessity of taking under the careful control the breeding situation for the evaluation of milk constituents and selection of the sires with high breeding value for protein milk.

At the present stage, in the selection herds where in-depth breeding work is carried out, it is necessary to include the abovementioned indicators of milk quality in the complex assessment of breeding traits. It will enable to estimate the brown cattle animals on these very important grounds, to determine perfectly the influence of genotypic and paratypical factors on their content, to study the genetic parameters of the relationship and to develop specific breeding measures based on the obtained results, which will promote to increase fat and protein content in milk.

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ANALYSIS OF OPTIONAL QUALITY TERM (OQT): MOUNTAIN LABEL FROM PRODUCER'S PERSPECTIVE: STUDY OF MOUNTAINOUS COUNTIES SURROUNDING BRAȘOV, ROMANIA

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Abstract

Mountain products have been introduced in the EU supplemented with governing regulations to mainstream the products originating from mountain areas with adequate market facilities and use as a differentiating tool compared with conventional products. Since its formalisation and adoption of relevant laws in the national context in Romania, the adoption of the optional quality term Mountain Label among the producers has been astonishing. Considering the good market in Romania for quality and locally sourced products, mountain labels and their use among the producers were regarded as having a better impact on the economic and market status. The research intended to pursue an answer in the same direction to see if producers were able to fully exploit the EU optional quality term Mountain Label scheme at the national level in Romania or if there was dissatisfaction among the producers with the rules of utilizing the label. A general producer survey with questionnaires was planned, organized, and implemented on the three mountain massifs surrounding Brașov city to elicit the necessary findings. Due to continuous support from the relevant authorities in the registration of the label, the producers were interested in enlisting themselves in the quality scheme; however, poor marketing and promotional assistance were some of the problems identified as general problems that caused the producers to be disappointed in the labelling scheme. Although most of the producers had a good idea of the benefits associated with the label, only 50% of them were engaged in some way in highlighting the mountain label in their promotional activities. Different statistical tests like the U-test, correlation analysis, and chi-square tests were used in conjunction with the different findings visualisations to derive insightful findings. The findings of the research can be beneficial to comprehend existing scenarios of mountain labels and producers' perceptions of mountain labels post-registration, propose different systematic reformations for better efficiency of operations of mountain labels, and realize its initial objectives.

Key words: *mountain label, producer, perception, EU, Romania*

INTRODUCTION

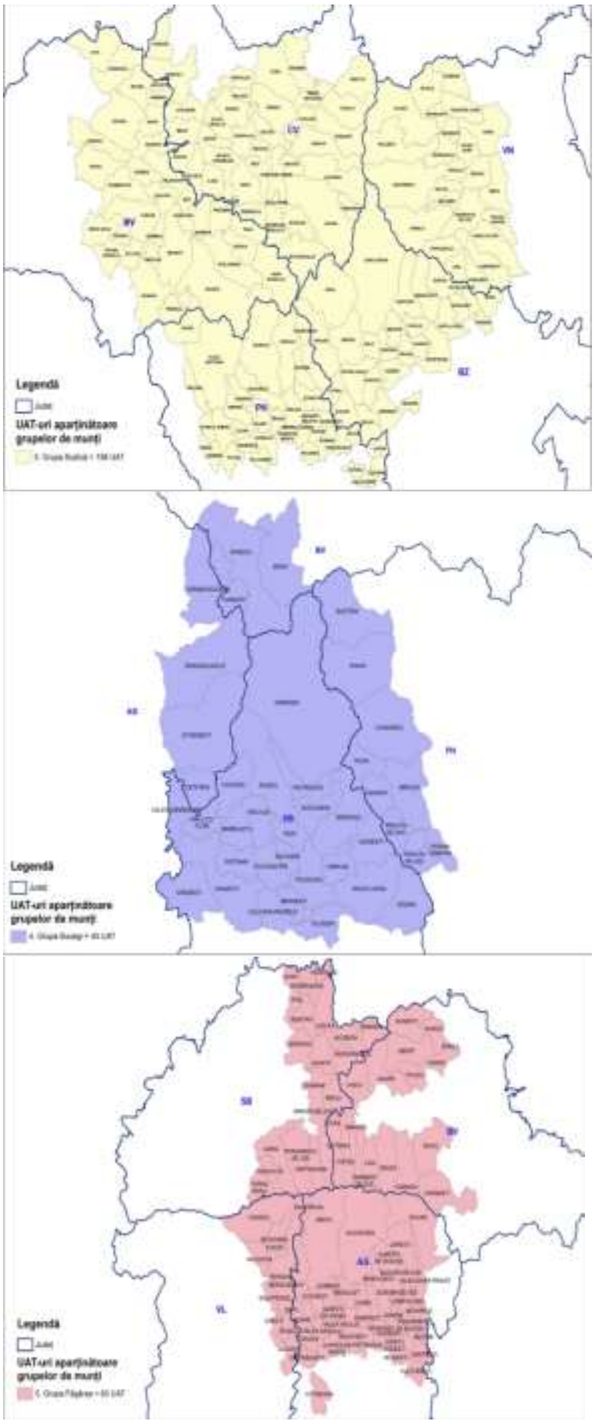
The Romanian mountains face myriad difficulties and challenges because of their mountainous landscape attributes like steep slopes, altitude, higher agriculture costs, and food production costs. The mountain regions in Romania are also highly characterized by rapid depopulation and lower productivity [1]. Also, contemporary consumers are willing to pay a higher price for a high-quality product with a well-known source of origin [8]. In attempt to compensate for the adversity faced by the mountain producers as a consequence of the geographical constraints and supply authentic mountain products to the consumers without misappropriation, mountain labels in the EU were effectuated to increase the competitiveness of the traditionally predominant mountain farming system. The use of mountain labels on mountain products can be an opportunity for mountain producers to enable them to receive premium prices for the products [20]. As there exists limitation on the research of the suitability of the labels from the producer's perspective, the relevance of the present study highlights the existing state of mountain labels execution in Romania taking a reference region of mountainous counties surrounding Brașov region.

According to EU Regulation No.1151/2012, the term ‘mountain product’ is established as an optional quality term [16]. This term is exclusively applicable to designate products meant for human consumption as outlined in the Treaty, under the conditions that:
(a) The raw materials and feedstuffs for farm animals primarily originate from mountain areas.
(b) For processed products, the processing itself occurs within mountainous areas.
In Romania, the specific legislation pertaining to the use of the Optional Quality Term "Mountain" label is validated by the following two regulations. [15].
-The Decision No. 506 of July 20, 2016 for the institutional framework and measures to apply the Commission Delegated Regulation (EU) No 665/March 11, 2014 [7] supplementing Regulation (EU) No 1151/2012 of the European Parliament and of the Council concerning to the conditions of using the optional quality term "mountain product," governing the framework for certification, verification, and control.
-The order of the Minister for Agriculture and Rural Development no. 52/2017 [11] for endorsing the procedure for verifying the conformity of data in the task book for acquiring the privilege to use the optional quality term "mountain product" and for assessing compliance with both European and national legislation by the economic operators granted the right to use this optional quality term, amended by the Order no. 321 of September 28, 2017.
Elementary and fundamental conditions that the producers and economic operators must satisfy before registering their products on the mountain registry are:
a) The geographical area must be a mountain area as specified as the delimited area according to the National Rural Development Program 2014-2020.
b) A mountain product must be designed for human consumption, under the following conditions:
-The primary source of raw materials, as well as fodder for farm animals, must originate predominantly from mountainous areas.
-For processed products, the processing must also occur within mountainous areas.
Romania is the sole country that does not implement derogations based on geographical location distance as specified in the European Commission Article 31(1)(b) of Regulation (EU) No 1151/2012 and Article 1(1) and (2) of Regulation (EU) No 665/2014.
As observed, there is high upward trend in the process of registration of mountain label certification by the producers in Romania. One such reason is due to the robust operationalization of the National Agency of the Mountain Areas (ANZM), which has been functioning in collaboration with producers, making them realize the mountain products' utilities and benefits, which has led to a better understanding of the scheme among the producers [6]. In order to completely capitalize on the locally available resources, the Romanian authorities needs to play crucial role in assisting the mountain producers facilitating in certification with national and international recognition like mountain labels [18].
The objective of the research is to pursue an answer in the same direction to see if producers were able to fully exploit the EU quality scheme Mountain Products at the national level in Romania or if there was dissatisfaction among the producers with the rules of utilizing the label.

MATERIALS AND METHODS

As the registration of mountain labels in Romania has been on steady rise through the years after the enactment of the legislation and all governing regulations, there has been limitation on research conducted to assess the perception of the producers post-registering to the optional quality scheme.
The elementary purpose of this analysis and research is to identify the existing state of the mountain label registration in Romania, observing the pattern of registration variation over the years, understand the more dominant product category registered and the counties which have shown been at the forefront in terms of registering in the optional quality scheme. Similarly, on the other hand, the

research had more comprehensive approach of assessing the impact of labels on the registered producers.



Map 1. Map of the study area: Făgăraş, Bucegi, and Sudică massifs
Source: [12].

The framework for the research to was adopted through different available study [19] and implemented to local context. For this, a study of producer was conducted on the nearby mountain massifs namely the registered producers in the three mountain massifs adjacent to Brașov – namely: Făgăraş, Bucegi, and Sudică massifs. An initial screening of the communes was done, to eliminate any superimposing communes with other mountain massifs. The screenshot of the mountain massif used in the analysis is represented in the Map 1.

The existing database of the mountain producers registered with the entitlement to use the optional quality term: Mountain label was retrieved and analyzed from the website of National Agency of the Mountain Areas (ANZM). The study employed descriptive and inferential statistics. There are mainly levels of precision (sampling error) and confidence to be considered while designing the sample size during quantitative research [7].

Therefore, attempts were made to minimize this error by selecting adequate number of producers as respondents to contribute in the research.

Excel was used for general data arrangement and visualization, while the R 4.3.0 binary software package was employed for the majority of data analysis, visualization, and computation of the statistical tests.

RESULTS AND DISCUSSIONS

Initial analysis of mountain areas and products in Romania

According to the Order of MADR and MRDPA No. 97/2019 (MADR and MRDPA, 2019), [10], 948 land administrative units (LAU) in Romania were included in the category "mountain townships" distributed across 27 counties Common Order MADR no. 97 and MDRAP no. 1332/2019 as shown in Figure 1 [9].

Statistically, among the 27 counties officially designated as having mountain areas, Hunedoara (69), Harghita (65), and Caraș Severin (55) record the highest number of mountainous townships, while Timișoara (5) and Gorj (12) have the lowest count of mountain townships within their counties. There are a total of 948 Local Administrative Units (LAUs), comprising 835 communes, 83 cities, and 29 municipalities. Additionally, there is one city compound recognized in the county of Sibiu.

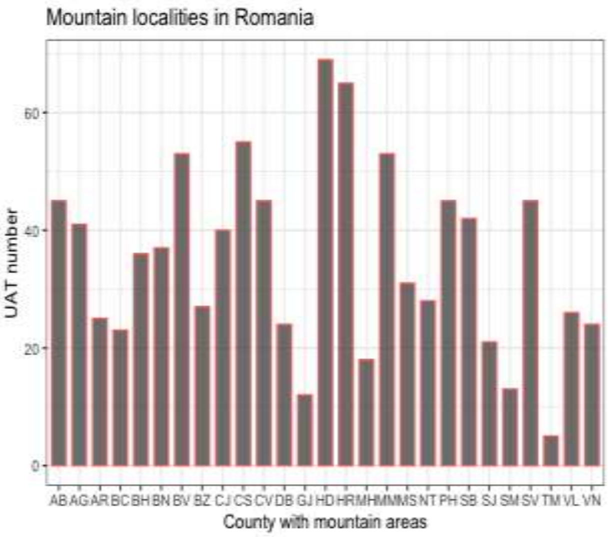


Fig. 2. Number of mountain localities by county in Romania
Source: Own determination based on the information from [13].

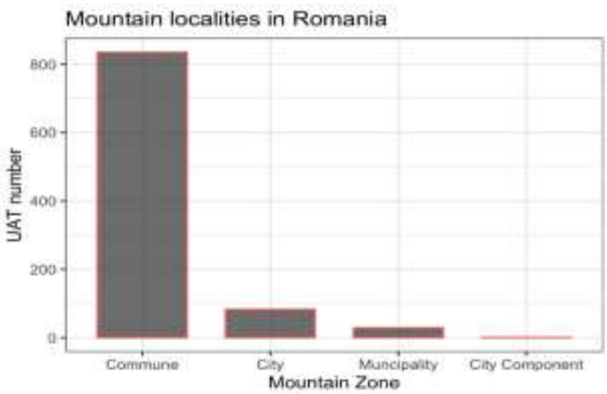


Fig. 3. Mountain localities by classification type
Source: Own Determination based on the information from [13].

The latest version (April 2023) accessible of the Excel sheet made available on the National Agency of the Mountain Area (ANZM) website was retrieved from the source for the underneath analysis conducted. As per the information retrieved from the analysis of the mountain product database made available by the ANZM, in the National Register of Mountain Products there are registered 3,703 products under 8 specific identified product categories.

The initiation of the process of registration of mountain products in the mountain registry commenced in 2017, with only a few producers (9) exhibiting their interest in the registration of 30 mountain products. Registration slowly picked up in 2018 as the adaptation of the Mountain Law was institutionalized.

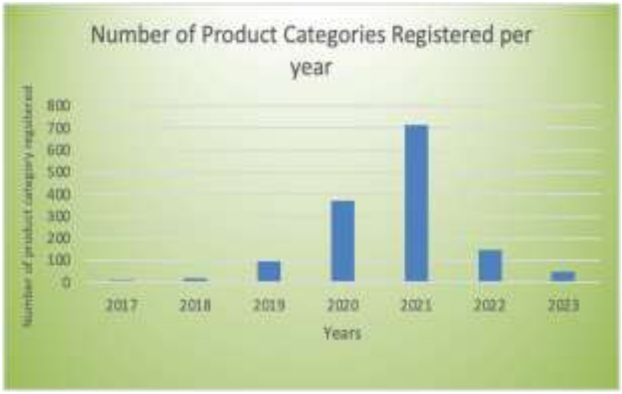


Fig. 4. Number of product categories registered in the period 2017-2023*
Source: Own determination based on the data from [14].

In the year 2018, the registration of mountain products almost doubled, with the total producers (17) registering almost 50 products under various product categories. In the year 2019, with a clear distinction of the mountain areas made as per the Order of MADR and MRDPA No. 97/2019, the registration of the products scaled new heights, with 97 producers onboard registering 379 more products in the year 2019, making the total cumulative number of 459 registrations at the end of the year 2019. The following year, 2020, saw exponential growth in the count of producers, with an additional 369 producers under different product categories, enlisting 1,084 products. The year 2021 has been the record year in terms of registration of mountain products with the right to use the optional quality term (OQT): mountain label, as a total of 714 individual product categories were registered by the producers, resulting in 1,608 new product registrations, increasing the cumulative registration of the product till 2021 to 3,151 products, as also indicated in the graph. From the year 2022 on, a sharp plunge in the total product categories and producers registered can be observed. In the year 2022, only 148 individual producers recorded their products on the registry, increasing the total number of products registered to 3,603. In the year 2023, till the data was analyzed and recorded, the progress of registration of mountain products has been on a declining trend, with a mere 47 new producers registering a total of 100 new products under different product categories, resulting in a total of 3,703 products registered.

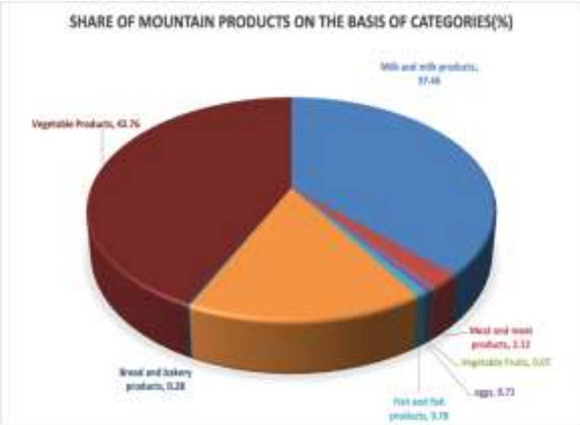


Fig. 5. Share of Mountain Products by category
Source: Own determination based on the data from [14].

On the basis of mountain product categories registered until the year 2023, as shown in Fig. 5, we may notice that vegetable products dominate the overall registration of mountain products in different counties in Romania. Following that, milk and milk products constitute 37.46%, with 530 producers registering the products. The least share of the mountain registration is attributed to vegetable and fruits (0.07%), bakery (0.28%), eggs (0.71%), and fish products (0.78%). Meat and meat-related products also have a low share (2.12%). The meat industry in the mountain region of Romania is import-dominated [17].

Meanwhile, Covasna County (20%) with the acronym CV as indicated in Figure 6 has the highest share of registration with 275 products recorded in the national registry, followed by Bistrița Năsăud (211).

Similarly, the least product category registered was noticed in four respective counties: Timiș (1), Bihor (7), Mehedinți (7), and Dâmbovița (8). Two counties, Arad and Sălaj, delimited as counties with mountain townships, had no products registered in the database at the moment when the data were retrieved and analyzed (Figure 6).

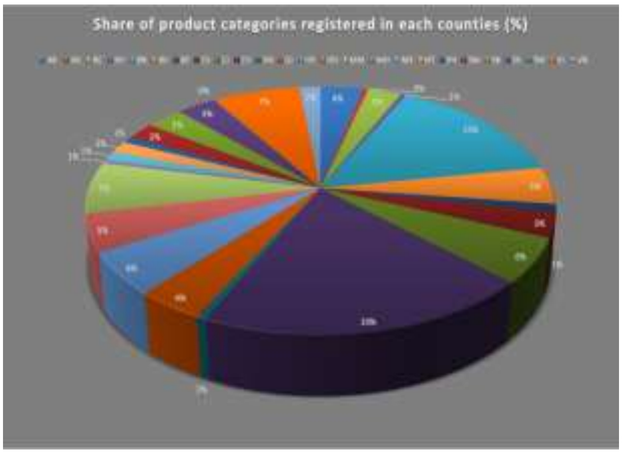


Fig. 6. Share of the registered mountain products registered by county till 2023
Source: Own determination based on the data from [14].

Producer Survey: To assess the impact of the mountain label in Romania

The producer survey research was planned, developed, and organized with the overall ambition to comprehend the producer's perception of the OQT term mountain label after being formally registered in Romania. Out of 1,400 producers registered in Romania, 216 producers were shortlisted and contacted as per the study area.

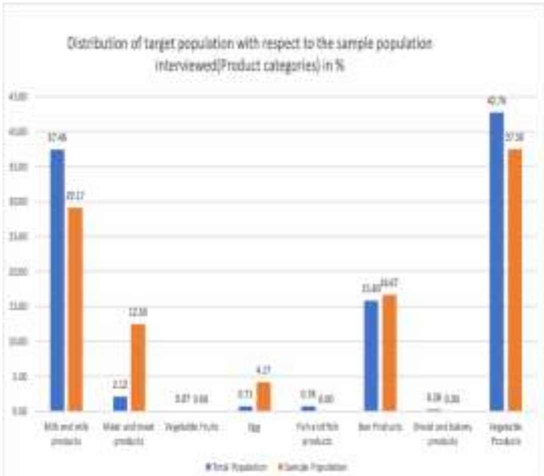


Fig. 7. Comparative representation of the total producers with the sample respondents by product category
Source: Own determination based on the data from National Agency of the Mountain Area.

Data from **24 producers** who responded were finally analyzed and reported. A general distribution of the producers who participated with the proportion of total registration is shown in Figure 7.

The data presented in Table 1 clearly indicated that the majority of the respondents were male (58.33%) followed by female (41.67%), distributed with an age range between 25 and over 65. The majority of the producers' respondents were in the age range of 35 to 44 (37.5%) of the sample population

Table 1. Summary Statistics of the socio-demographic and economic characteristics of the respondents

Gender	Frequency	Percentage (%)
Male	14	58.33%
Female	10	41.67%
Age	**Frequency**	**Percentage (%)**
18-24	0	0.0
25-34	6	25%
35-44	9	37.5%
45-54	4	16.7%
55-64	4	16.7%
65 +	1	4.2%
Production activity	**Frequency**	**Percentage (%)**
Production	12	50%
Processing	2	8.33%
Both production and processing	10	41.67%

Source: Own calculation based on field survey, 2023.

Concerning the production activity, 50% of the producers who responded were engaged in production activities, 41.67% related to both production and processing-related activities, and the rest, 8.33%, were processors who were handling raw materials originating from other producers.

Time Length of use of the OQT term: Mountain label in Romania

Most of the producers (66.7%) who took part in the survey were registered with the mountain label for a duration of 1-3 years, whereas 16.67% of the respondents who took part in the survey had been registered in the national mountain product registry recently (less than a year) (Figure 8).

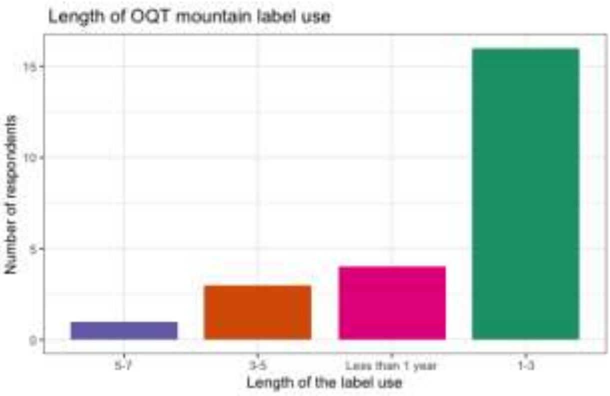


Fig. 8. Distribution of the sample respondents on the basis of length of OQT mountain label use (years)
Source: Own determination based on the field survey, 2023.

The other 12.5% (3-5 years) and 4.2% (5-7 years) of the sample respondents from the pool of producers had more experience working with the label as they had been registered in the database for a long time.

Producer's Motivation to join the Mountain label scheme in Romania

As the selection of more than one option was permitted in this question, most of the respondents (54.2%) mentioned increasing the sales of the products as their motivation to sign up for this voluntary certification. 41.7% of the responses were aimed at obtaining a competitive advantage from the market and increasing consumer confidence in the products by conveying clarity on the origin of the products. An interesting observation was made on the responses, as 20.8% of the producers were encouraged to register their product with the mountain label scheme in Romania to largely benefit from several rural development schemes, whereas 16.7% of the responses were motivated to increase the product quality and to use the label as a promotional and marketing medium to stimulate the sales of the mountain products. Other reasons mentioned by the producers were to avail themselves of the VAT reduction or fiscal benefits that are imposed on the trading of mountain-labelled products in Romania. Similarly, cheap label to acquire compare to other labels and easy regulations were other identified motivations.

Producer's satisfaction assessment with three essential criteria: Certification process, Rules related with utilization of

the label and promotional and marketing support of the mountain registered products in Romania

As shown in the consolidated bar chart displayed in Figure 9, most of the mountain producers were completely satisfied (87.5%) with the process of certification, whereas 4.17% were partially satisfied with the certification process and standard set up by the related government institutions. A strange point to observe in this case was that no dissatisfaction was expressed at all by the producer respondents. Most of the respondents mentioned the ease of the certification scheme with less paper work, and the support and assistance provided by the state competent authorities as some of the factors that made the process of acquiring the certification a more convenient and seamless experience. This result strongly coincides with the remarks made by [3], where it is pointed out that the support and assistance from the national agencies employed have resulted in an upward trend in the certification of mountain products in Romania.

Similarly, strong satisfaction (87.5%) was noticed in the producer's experience in terms of rules related to the regulations and utilization of the label, and the rest (12.5% of the producers who responded) preferred to be neutral. Easiness and relaxed rules were some of the reasons identified by the producers that can be attributed to the label being a voluntary certification mechanism. However, when the respondents were asked to evaluate their satisfaction level with the support they are receiving from the state or relevant authorities in the promotion or marketing of the mountain-labelled products, mixed responses were observed, with 25% of the producers completely satisfied and 16.67% partially satisfied with the efforts from the state supporting agencies. Almost 34% of the mountain producers who took part in the survey were dissatisfied partially or completely with the support they were receiving to market their mountain products, while the other 25% preferred to be neutral in this case. On asking the reasons for their dissatisfaction, some of the respondents pointed out that the centralized mountain label-related authorities need to be more active in promotional activities.

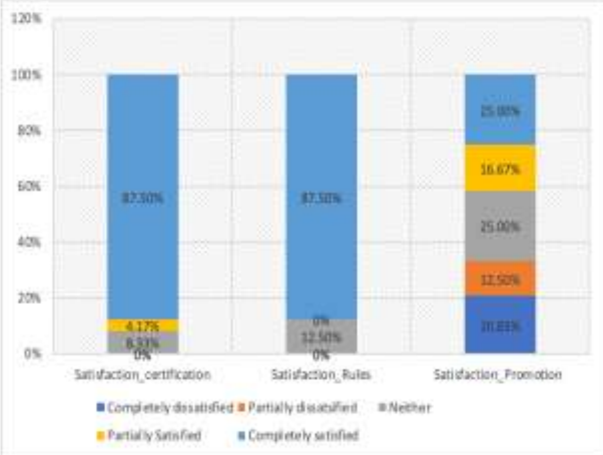


Fig. 9. Evaluation of the satisfaction from the mountain producers
Source: Own determination based on field survey, 2023.

From the stacked bar chart provided by Figure 10, it can be seen that the producers who were relatively new to using the label (i.e., less than 1 year or in between 1-3 years) were 50% satisfied (completely or partially) with the state marketing support on the registered mountain products, while the producers who had been using the label for 3-5 years of time duration were 66.67% completely dissatisfied with the support from the state on the promotional activities as shown in the figure. The producer with over 5 years of experience in the use of labels preferred to be neutral in this case.

A Fisher's Exact Test for Count Data was done to verify if there is any correlation between the length of use of the label and the marketing and promotional support rendered by the state institutions using a bivariate table. Here, a Fisher's exact test was done in the process of analyzing the dependence of the data, as some of the contingency tables of the expected frequencies were below 5, Fisher's exact test is highly recommended as a replacement for the chi-square test when at least one cell in the contingency table of the expected frequencies was below five [2]. A two-tailed test confirmed the rejection of the null hypothesis ($p = 0.4544$, >0.05), stating there is no correlation or dependence between the variables as reflected in the bivariate table.

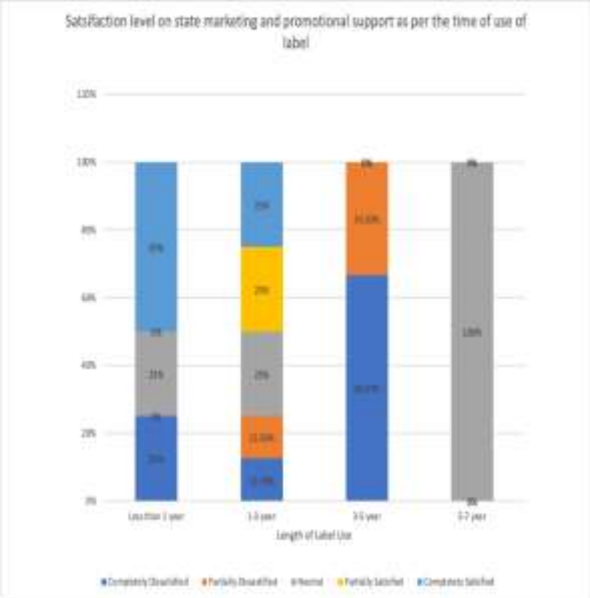


Fig. 10. Satisfaction level on state marketing and promotional support as per the time of use of label
Source: Own determination based on the field survey, 2023.

From the pool of respondents interviewed, only 50% of the respondents highlight mountain labels in their marketing and promotional activities, while the other 50% have registered in the mountain products database in Romania but have exhibited no interest in highlighting the labels on their products. When asked about some of the platforms or channels they usually use to promote their products with the mountain label, 33.33% of the total respondents said they use food fairs and exhibitions and the internet as their primary medium to promote their products with the mountain label. Similarly, only 12.5% of the respondents said they use the label clearly indicated on the label to promote and market their product on the market.

Producer perceived benefits/issues study

All the respondents who participated in the survey were asked to evaluate some of the pre-defined statements related to the OQT: Mountain label according to their experiences. A five-point Likert agreement scale (1 = completely disagreed, 2 = partially disagreed, 3 = neutral, 4 = partially agree, 5 = completely agree, 0 = cannot evaluate) was employed to draw out the responses from the producers on how they perceive the registration of OQT: Mountain Label in Romania has helped their cause. As most of the producers had never used the mountain label highlighted in their product, there are 0 values where they have not evaluated any of the statements. For uniformity and reliability in the data, the average value in this case for the statement was computed by purging the values with 0.

Table 2. Summary of the average value of the responses of perceived benefits/issues

Benefits/ issues	Average_ Total	Length of the label used				Highlighters	
		Less than 1 year	1-3 year	3-5 year	5-7 year	Yes	No
Strengthened your product identity	3.71	3	3.90	3	4	4.00	2.67
Increase in sales prices of the product	2.71	1	2.91	4	1	3.00	1.67
Increases in consumer assurance of the product	4.08	n/a	4.09	5	3	4.18	3.50
Increased awareness of the mountain products among consumers	4.31	n/a	4.36	5	3	4.36	4.00
Differentiation strategies from competitors in the market	3.62	n/a	3.55	5	3	3.91	2.00
Higher perceived costs than benefits	2.07	1	2.18	1	3	2.18	1.67

Source: Own calculation base on the responses given by the interviewees.

Here, the first five pre-defined statements were positively formulated, while the last sixth statement was negatively formulated. From the table presented above, it can be understood that most of the mountain producer respondents believed that the registration of the mountain label had enhanced the mountain product's identity in general. This finding aligns with the remarks of [21] where they feel mountain products symbolize traditional practices related to the cultural identity of local communities and specific cultural areas. However, while evaluating the contribution of the mountain label to increasing the sales of the products, the producers were not that sure and decided to place themselves in the middle section (neutral with an average value of 2.71). This clearly points out the need to expedite the promotion-related activities related to the mountain label, which were also earlier explained by the respondent producers. Nevertheless, producers firmly assert that the mountain label has played a significant role in fostering consumer confidence in their products. It has led to heightened awareness and served as a distinctive tool to compete effectively with other conventional products in the market. This aligns with the conclusions of [4], where they emphasize that the term "mountain product" facilitates trustworthy communication of the mountain origin of products, thereby enhancing assurance and awareness. For the sole negatively formulated statement, the producers rated it with a value of 2.07, which falls in the category of partially satisfied, which means that the producers believe that mountain-labelled products have more perceived benefits compared to costs in Romania if utilized properly.

In terms of analyzing the data on the basis of length of label use, most of the values of the responses were close to each other, where for the first five positively framed statements, most of the producers were in agreement with them, except for the criteria of increase in sales of the product, where most of the respondents except the one using the label for 3-5 years were in disagreement or preferred to stay neutral. Meanwhile, for the sole negatively formulated statement, the mountain producers were in disagreement, which alludes to the fact that mountain label products have higher benefits compared to the costs incurred. The free charge associated with the costs of registration of the mountain products can be attributed to this, as some of the respondents believe it is a cheaper label to acquire compared to others in Romania. Also, in regard to the highlighting of the mountain label, for the positively formulated statement, the highlighters had higher agreement in general than the non-highlighters, whereas on the contrary, for the negatively formulated statement, the condition was just the reverse, as shown in the table above.

Similarly, a correlation matrix was obtained with the help of the software, which showed the strong dependency between the relationships between all of the pre-defined statements. correspond with their responses in the case of these two statements. Except in all of the other statements (p values less than 0.05), a strong correlation was observed, which means a strong dependency between the variables as an alternative hypothesis is accepted.

A strong dependency between the statements means that if the mountain producers identify more with one set of statements, they also do similar responses with the other statement, and vice versa.

Furthermore, a correlation matrix with the values of the correlation coefficient derived from the software is presented in the figure below, which shows significance at different confidence levels (Figure 11).

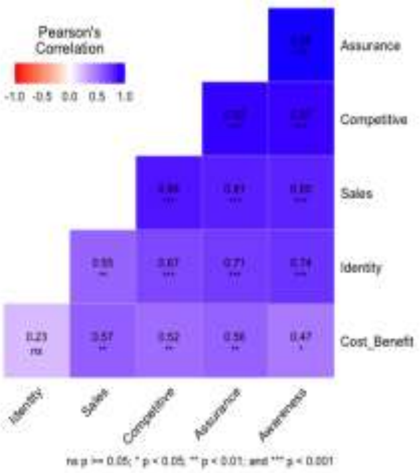


Fig. 11. Correlation coefficients matrix between the statement to check the dependences
Source: Own results based on the received responses.

Wilcoxon Mann Whitney U test to evaluate the difference in opinion between highlighters versus non-highlighters

As the mountain producer's respondents highlighting the mountain label and non-highlighters had different levels of agreement with the pre-defined six statements, it was therefore important to find out if the two independent groups, highlighters and non-highlighters of the mountain label, perceived the responses separately or not.

A consolidated table with the test of normality of the data, the Saphiro-Wilk test, was computed using the software and reported in Table 3.

Table 3. Test for normality of the data and Wilcoxon Man Whitney U-test

Benefits/Issues	Saphiro-Wilk test for normality of the data (p>0.05)		Wilcoxon rank sum test with continuity correction		
	W	p-Value	Value of W	Selected value of W	P-value
Strengthened your product identity	0.76908	0.004259	130	14	0.0004936
	0.56662	5.729e-05	14		
Increase in sales prices of the product	0.85134	0.03814	128	16	0.0007709
	0.54746	4.045e-05	16		
Increases in consumer assurance of the product	0.77335	0.004737	131.5	12.5	0.0002971
	0.48573	1.389e-05	12.5		
Increased awareness of the mountain products among consumers	0.64844	0.0002806	128.5	15.5	0.0004596
	0.48661	1.41e-05	15.5		
Differentiation strategies from competitors in the market	0.8148	0.01391	134.5	9.5	0.0001525
	0.45002	7.742e-06	9.5		
Higher perceived costs than benefits	0.81566	0.0142	122.5	21.5	0.002208
	0.54746	4.045e-05	21.5		

Source: Own calculation.

Initially, the normality of the data was checked to determine if the considered datasets were normally distributed or not. The null hypothesis states that the population is normally distributed, i.e., if the p-value is greater than 0.05, then the null hypothesis is accepted.

Nevertheless, in both iterations, for all six predefined statements, whether using highlighters or not, the p-value obtained from the test was consistently less than 0.05. This indicates the rejection of the null hypothesis and the acceptance of the alternative hypothesis for the dataset sample across all six predefined statements, implying a non-parametric distribution of the data.

Therefore, in this case, the relation between two independent groups (i.e., highlighters and non-highlighters) was determined by using the Wilcoxon rank sum test with continuity correction rather than the conventional comparison of means.

As the value of p for all six predefined statements (two-tailed) was significantly less than the threshold value of 0.05, the null hypothesis in this case was rejected, accepting the alternative hypothesis and inferring a significant relationship within the two independent groups compared. In each of the six cases, the individuals who used the OQT: Mountain label highlighters showed distinct agreement levels on the predefined statements compared to those who did not use highlighters. Put simply, highlighters were aligned in their belief that the mountain label enhances product identity, while non-highlighters held the opposite view and expressed disagreement.

Evaluation of the OQT: mountain label by the producers

Following their participation in the producer survey, mountain producers were subsequently asked to assess whether the overall use of the mountain label had met their expectations or not. Again, a five-point scale was used to understand their response to this question, with 1 being completely not fulfilled and 5 being completely fulfilled. The average value of this was quantified as 3.45, which can be used to construe that the producers' expectations were just partially fulfilled by adhering to the mountain label in Romania. Out of all the respondents, 37.5% decided to remain neutral in this case. 29.17% of the producer's expectations were completely fulfilled by the label, and the other 16.67% had their expectations partially fulfilled by registering themselves in this voluntary quality scheme. Almost 17% of the producers responding were not fulfilled by signing up with the OQT: Mountain Label scheme.

Similarly, when asked if the mountain producers were interested in extending the OQT: Mountain label by complying with EU and Romanian legislation, 55% were interested in extending their certification, and the other 16.67% preferred to be neutral. Almost 30% of the population was thinking of not extending the OQT: Mountain label further. Some of the reasons for continuing with the certification, as mentioned by the producers, were related to the simplified certification process. However, most of the producers just wanted to continue with the certification to take advantage of the government's VAT reduction scheme. On May 14, 2019, GO 31/2019 came into force, reducing the VAT from 9% to 5%, especially for the delivery of high-quality food, including mountain products approved by the Ministry of Agriculture and Rural Development [5].

Fisher's Exact Test for Count Data to check correlation between the highlighting of the mountain label and producers' expectation fulfilment and decision of extension

A Fisher's Exact Test for Count Data was done to verify if there exists any correlation between the highlighters and non-highlighters with the expectation fulfilment and possible decision of extension using a bivariate table. The reason for using Fisher's exact test is because the contingency table of the expected frequencies was below 5. The obtained p-value using Fisher's test was $p = 0.001248$, which is less than 0.05 at the 95% significance level, which means the null hypothesis in the case was rejected. That is, the decision to highlight the producers' mountain label was influenced by the producer's expectations (Figure 12).

Similarly, the other Fisher's exact test for count data between the highlighting decision of the mountain producer's and the possible decision of extension was also done to determine any dependence between the mentioned variables also shown in the bivariate table.

The obtained p-value in the case was 0.00585, which is also smaller than 0.05 at the 95% significance level, which means the null hypothesis in this case was also rejected, indicating a direct dependency between the producer's decision to highlight the label and their possible decision to extend the label certification.

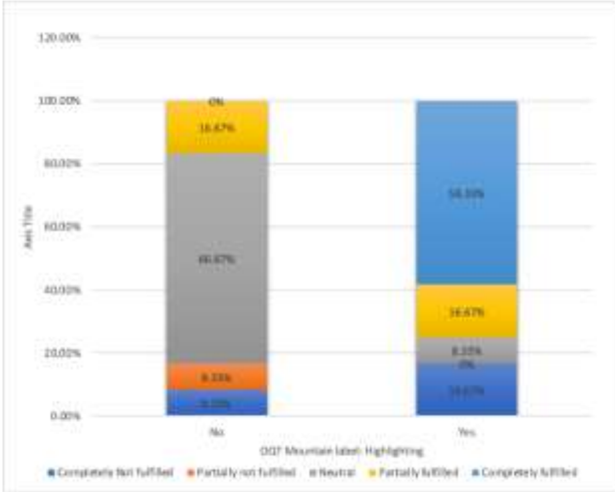


Fig. 12. Highlighting decision of the label with evaluation of producer's fulfilment (%)
Source: Own determination based on the data from field survey, 2023.

Below provided is the stacked bar chart (Figure 13) representing the distribution of the highlighting option of the mountain producers plotted against the agreement of the producers on their evaluation of the fulfilment and possible extension of the certification of the label expressed in percentage.

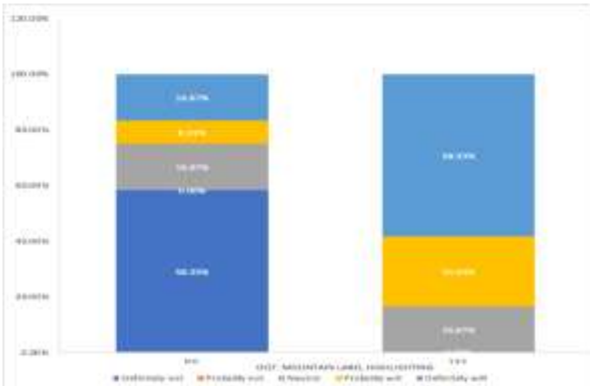


Fig. 13. Highlighting decision of the label with certification extension (%)
Source: Own determination based on the data from field survey, 2023.

CONCLUSIONS

Therefore, in this case, the relation between two independent groups (i.e., highlighters and non-highlighters) was determined by using the Wilcoxon rank sum test with continuity correction rather than the conventional comparison of means. this group perceive the benefits associated with the mountain products differently. The usual producers who highlight mountain product label believed to have benefitted from the use of mountain labels, however in contrast the ones who are not highlighting the mountain label to promote their products after official registration have completely different opinions than the usual highlighters where in a nutshell, they believe the use of the mountain label have not help them to enhance the product image, increase consumer confidence and served as an tool of competitive advantage compared with other labels available in the market.

The time of use of OQT: Mountain label in Romania has been effectuated and regulated for 7 years as of now, however, some of the producers' expectations from their initial intention by registering to these quality scheme has not been fulfilled as the research indicated, with many preferred to be neutral. Also, out of the group of respondents who contributed in the research, 30% were not seeking to extend their certification or be a regular part of highlighting the label in their mountain products, which hints at slow reluctance of the mountain producers in usage of the mountain label. In addition, only 50% of the producers were somewhat engaged in promoting their products with the registered label.

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CONSUMER UNDERSTANDING AND PERCEPTION OF MOUNTAIN LABEL IN THE CITY OF BRAȘOV, ROMANIA

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Abstract

The European Union introduced Regulation No. 1151/2012 to delineate the optional quality term "mountain product," aiming to preserve and promote the originality and authenticity of mountain foodstuffs. This research endeavors to delve into the comprehension and perception of the mountain label, considering awareness of the label and willingness to pay. With the remarkable increase in the adoption of the mountain label among producers in the mountain regions of Romania, this study seeks to investigate whether consumers purchasing the product in the market are cognizant of the provisions outlined by the National regulatory bodies and authorities for the mountain label. A general consumer survey with questionnaires was planned, organised, and implemented within Brașov city to elicit necessary findings. Although, the consumer was aware regarding the benefits associated with products with mountain label and also the places to easily find the mountain label, the consumers (50.77%) perceived mountain labelled product to be expensive. Similarly, only 47% of the respondents were interested in paying more for the products with mountain labels and 50% were completely unsure about their purchasing decisions, which indicates a clear unsurety in the mind of the consumers. The consumers (70%) seemed unaware about the mountain label although they had general idea regarding mountain products and the categories of products that are made available in the market verified by the agencies. The findings of this research can be beneficial to initiate different promotional campaigns launched at consumers to better educate them regarding mountain labels and to avoid misleading the consumer with any use of terms related with mountains and assist in overall mountain sustainability.

Key words: *mountain label, consumer, understanding, mountain product, awareness, Romania*

INTRODUCTION

Mountain labels are the labels that assure the origin of the products that originate from mountain areas. Agricultural and food-related activities in mountainous regions contribute to the sustainability of these areas and foster the development of supply chains for mountain foods. [16]. On the European stage, the initial endeavor to formalize the Optional Quality Term (OQT) "mountain label" was initiated in 2012 through the specific regulations EU 1151/2012, addressing the quality scheme for agricultural and food products. Subsequently, more comprehensive regulations detailing the conditions for using the optional quality term "Mountain product" were set forth by EU 665/2014, supplementing the aforementioned earlier regulation.

The robust operationalization of the National Agency of the Mountain Areas (ANZM), which has been functioning in collaboration with producers, making them realize the mountain products' utilities and benefits, which has led to a better understanding of the scheme among the producers [5]. Also, the growing interest shown by consumers in local and mountain products is motivated not only by the quality of these products but also by a rediscovery of local cultures with psychological benefits for consumers [8]. As the uptake of mountain label among the producers has been on rise, the interest of present study highlights the consumer awareness and understanding of mountain labels in Romania as eventually the market of the mountain labelled products is balanced by consumers through their purchases.

Consumers demonstrate a keen interest in purchasing mountain food products and are willing to pay premium prices for these items, provided they adhere to traditions, reflect the essence of the territory, prioritize environmental considerations, and uphold ethical standards [15]. The mountain product label can be a resource to support the mountain economy especially addressed to people sensitive to environmental concerns [9].

In Romania, consumer perceptions of food prices indicate a high degree of annoyance as most high-quality foods are not always affordable in terms of quality and price [2]. Like in other EU Member States, also in Romania the impact of food quality on consumer choices is mostly stimulated by behavioural predisposition. This impulsive decision-making while purchasing food products also corroborates the findings presented by [4], which indicate that price points are decisive factors for consumers making purchasing decisions while purchasing traditional food products in Romania. However, despite the additional cost-levying factors for consumers in Romania, it is believed that qualitative products are of higher monetary value than conventional products by virtue of their taste, health aspects, and quality aspect [4]. Romanian people are more and more selective concerning food, preferring to search for traditional fair goods as being natural and friendly to the environment [12].

MATERIALS AND METHODS

The introduction of the mountain labels within the EU legislation was to inform consumers regarding the mountain origin of the products and thus enable the producers representing the mountain areas to fetch better prices for their products in a competitive market. Specifically, leveraging the use of mountain products to promote mountain agri-food products is envisioned to yield several positive outcomes. These include bolstering the mountain agri-food sector, diversifying local economies, offering quality assurances to consumers, safeguarding the environment, and preserving territorial biodiversity [1]. In particular the primary purpose of this research is to understand to what degree the consumers based in Brașov, which is one of the populated mountainous cities in Romania are aware of the mountain label which has been put into operation by the concerned authorities.

The consumer research study area was selectively conducted in and around Brașov City located in the Brașov County in Romania. According to the 2021 census, it has a population of 237,589 inhabitants with a total surface area extending to 267 square kilometres and located at an altitude of 600m from the mean sea level. A total of **65 respondents** participated in the consumer research whose responses were analyzed to derive certain conclusions on the existing understanding of mountain products and labels in Brașov, Romania.

The study employed descriptive and inferential statistics and econometric models like ordinal logistic regression to analyze the data. Descriptive statistics like mean, frequency, and standard deviation and data visualization like bar charts and pie charts were used to present the summary statistics of socio-demographics, and consumer understanding of the mountain labels. Excel was used for general data arrangement and visualization, while the R 4.3.0 binary software package was employed for the majority of data analysis, visualization, and computation of the statistical tests.

In order to understand the relationship between different independent variables (age, gender, education, net income, profession, marital status, and responsibility in purchasing) and the willingness to pay for the mountain-labelled product, an ordinal logistic regression was employed.

The equation for the ordinal logistics regression model is given by the equation:

$$logit\ [P\ (Y \leq j)] = \alpha_j + \beta_i x \quad ....(1)$$

where:

P= Probability of score

Y= Ordinal Outcomes with J categories

α= Constant associated with the j^{th} distinct response category

β= Vector of coefficients associated with the predictors
x= Vector of predictor variables
j=1,…, J−1 and i = 1,.......m.
Alternatively, here, j is the level of an ordered category with J levels, and i corresponds to independent variables [13].
For our case, j represents the willingness to pay (No, May be, Yes), and i represents all the other independent variables as mentioned above.

Table 1. Description of variables used in ordinal binary logistics regression (willingness to Pay)

Variable	Type	Description	Value
Independent variable (Y)			
Willingness to pay	Dummy	Consumer are willing to pay or not for products with mountain labels	No = 0, Maybe = 1, Yes = 2.
Dependent variable (x_i)			
Age	Dummy (as factor)	Age group of the respondents	18-24 = 1 25-34= 2 35-44 = 3 45-54 = 4 55-64 = 5 64 or above = 6
Gender	Dummy (as factor)	Gender of the respondents	Female = 1 Male = 2
Education	Dummy (as factor)	Education of the respondents	Secondary school = 1 Vocational school = 2 Undergraduate studies= 3 Postgraduate studies = 4
Profession	Dummy (as factor)	Professional status of the respondents	Employed = 1 Retired = 2 Student = 3 Freelancer = 4
Income	Dummy (as factor)	Income level of the respondents	<1,250 RON = 1 1,250-1,500 RON =2 1,501-2,550 RON =3 2,551-3,500 RON = 4 3,501-6,000 RON = 5 6,001-7,500 RON = 6 7,501-10,000 RON = 7 >10,000 RON = 8
Marital status	Dummy (as factor)	Marital status of the respondents	Married = 1 Single = 2 Divorced = 3
Responsibility in Purchasing	Dummy (as factor)	Respondents' role in purchase of food products	Yes = 1 Partially = 2 No = 3

Source: Own determination.

RESULTS AND DISCUSSIONS

The consumer survey restricted to Brașov was planned, developed, organized, and distributed with the intention of getting insights on the consumer's understanding of the mountain products, labels, and their perception of the price points and willingness to pay for the mountain products**.** Table 2 provides a comprehensive tabulated summary of the socio-demographic characteristics of the respondents, showcasing their participation frequencies and percentages.

Table 2. Socio-Demographic Characteristics of the Respondents

	Frequency (n) 65)	Percentage (%)
Gender		
Male	25	38.46%
Female	40	61.54%
Age		
18-24	7	10.8%
25-34	17	26.2%
35-44	19	29.2%
45-54	16	24.6%
55-64	5	7.7%
65 +	1	1.5%
Monthly net income (RON)		
<1,249	0	0
1,250-1,500	2	3.08
1,501-2,550	2	3.08
2,551-3,500	12	18.46
3,501-6,000	21	32.31
6,001-7,500	15	23.08
7,501-10,000	9	13.85
Level of Education		
Secondary School	0	0
High School	4	6.15
Vocational School	1	1.54
Undergraduate studies	29	44.62
Postgraduate studies	21	47.69
Professional status		
Employed	50	76.92
Seasonal worker	0	0
Pension	1	1.54
Student	3	4.62
Unemployed	0	0
Freelancers	8	12.31
Others	3	4.62
Marital Status		
Married	34	52.31
Single	28	43.08
Divorced	3	4.62
Widowed	0	0

Source: Own calculation base on the data from field survey, 2023.

As clearly indicated in Table 2, among the respondents who participated, the majority of the consumer respondents were female (61.54%), whereas the other (38.46%) of the respondents identified themselves as male. The age of the respondents was majorly distributed within the age group between 25 and 54, almost equalling 80% of the total respondents who attended the survey; meanwhile, 10.8% of the population were considerably young within the limit of 18–24, and the other 9.2% were older, exceeding the age limit of 55. Most of the respondents who took part in the consumer survey were employed (76.92%), while there were a few other participants who identified themselves according to different professional statuses, namely pensioners (1.54%), students (4.62%), freelancers (12.31%), and others (4.62%). Considering most of the sample respondents to be engaged, the amount of monthly net income they earn was also in the middle level, with 3,501–6,000 RON being the most dominant one, with 32.31% of those falling in these strata of income level.

There were only a few of the respondents who earned between 1,250 and 2,550 RON (6.16%), and similarly, the respondents who earned above the average salary (>7,500 RON) were also fewer (20%) of the sample respondents.

All of the sample respondents who contributed to the consumer research were skilled and educated, with almost 94% of the respondents having an undergraduate or postgraduate degree with them. Concerning the sample respondent's marital status, 52.31% of them were married, 43.08% were single, and the rest 4.62% identified themselves as divorced, with no widow participating in the survey.

Responsibility of food purchases: Segmented by gender of the respondents

Upon querying the sample respondents about their involvement in procuring agricultural and food products for their households, a significant majority (58%) affirmed their active engagement and elaborated on their roles.

Conversely, 37% indicated partial involvement in the purchasing of such products, while 5% stated no investment at all in this household procurement process.

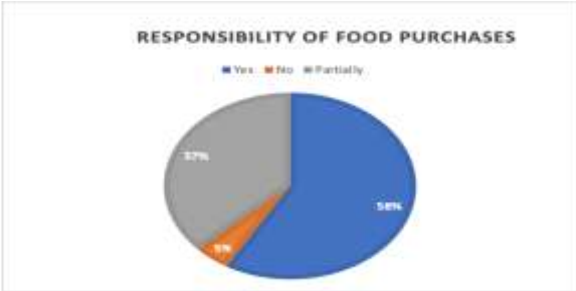

Fig. 1. Distribution of purchasing responsibilities
Source: Own determination based on the data from field survey, 2023.

The active participation of females in purchasing more quality-oriented food products (namely organic) [11], a Fisher's exact test was done here to evaluate if the purchase of food and agriculture products is largely impacted by gender, with the null hypothesis indicating no significant dependencies between the gender of the respondents and the responsibility of food purchases.

A two-sided test done failed to reject the null hypothesis ($p = 0.6821$, >0.05), stating there is no correlation or dependence between the gender of the respondents and their responsibility in the purchase of the food products. In simple words, both gender groups were equally involved in the process of purchasing food products for their households.

A stacked bar chart between these two variables has been drawn and is represented in Figure 2.

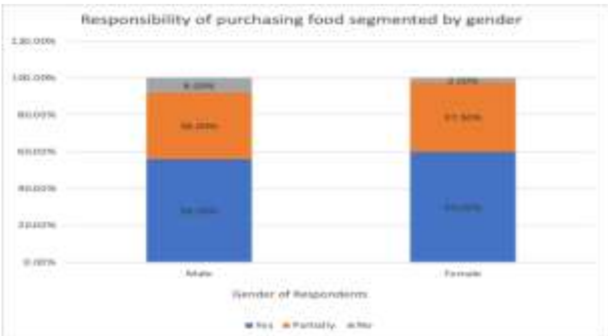

Fig. 2. Stacked bar-chart between gender of the respondents with their responsibility
Source: Own determination based on the data from field survey, 2023.

Description of the purchase decisions and preferred product

A multi-choice question was then asked to the pool of respondents to understand the major

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factors behind their purchase decisions of food products and what kind of product they usually prefer for their purchase. From the selected sample of respondents reached during the consumer survey, the respondents were asked to motivate their answers. Out of the responses received, 83.08% of the respondents shared that origin and place of production are the main reasons behind their purchase decision, which also corresponds to the research results of [6], stating 80% of the Romanian population opts for Romanian local products and brands during their purchases. Similarly, 53.85% and 43.08% of the respondents, respectively, stated that the price and reputation of the brand of the product they are purchasing are other factors impacting their purchasing decision. A handful of participants (13.85%) mentioned packaging as one of the crucial factors behind their purchase, and a few of the 4.62% said the ingredients of the product were the other motivating factors that drove their purchasing decision (Figure 3).

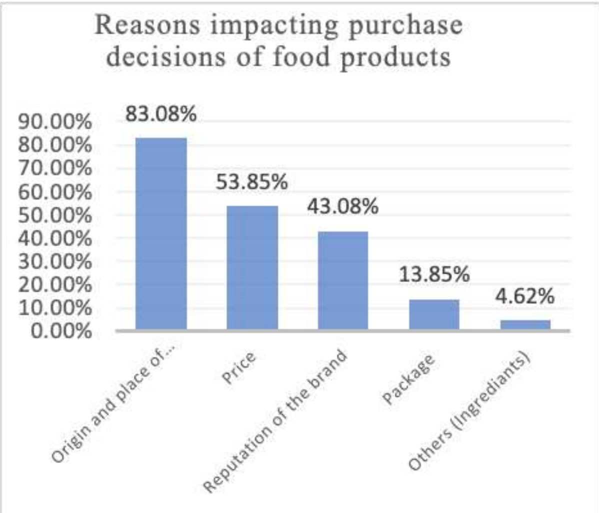

Fig. 3. Respondent's reasons that impact their food purchases
Source: Own determination based on the data from field survey, 2023.

Similarly, as shown in Figure 4, the respondents were further asked about the category of product they usually select during their purchases. Most of the survey participants pointed out local products (72.31%) as their primary choice of selection, followed by national products (58.46%) and regional products (53.85%). Some of the respondents also preferred EU products (16.92%) and foreign products (6.15%) during their shopping for food products.

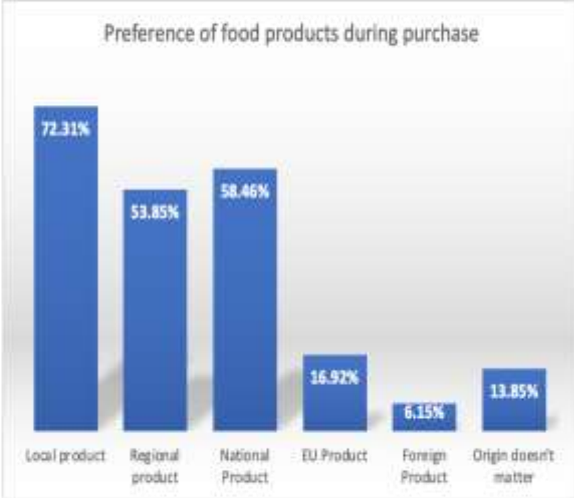

Fig. 4. Respondent's preferences during food purchase
Source: Own determination based on the data from field survey, 2023.

Attention to quality Labels during Purchasing: Compared by age of the respondents

The responses to the attention provided to the quality label when purchasing the food product were then analysed and represented as shown in the figure. 62% of the sample respondents indicated their agreement with looking at the quality labels during their food purchases, whereas 31% of the respondents mentioned that they only check the labels occasionally. 1% of the sample respondents never checked the quality label during their purchase, and 6% of them are attentive to the quality labels associated with the food products (Figure 5).

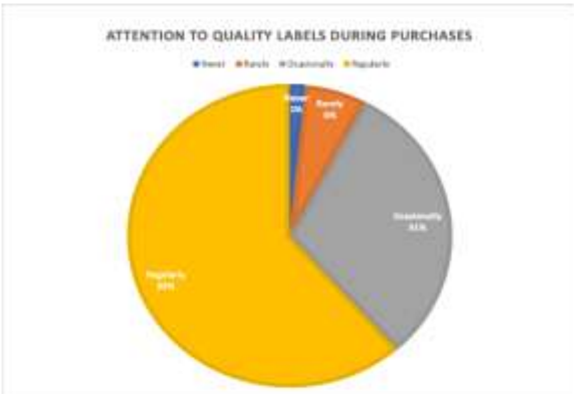

Fig. 5. Attention given to quality label
Source: Own determination based on the data from field survey, 2023.

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[17] concluded that as age increases, the probability of using food labels decreases. Subsequently, a chi-square test was conducted to examine whether the respondents' attentiveness during food purchases was contingent on the age of the sample respondents. A null hypothesis was formulated for this analysis (H_0 = Respondent attentiveness during food purchase is independent of the age group of the sample respondents, and an alternative hypothesis was created explaining the inverse). Upon computation of the chi-squared tests **(X-squared = 32.692, df = 15, p-value = 0.005177)**, as the obtained value of p was less than the allowed level of 0.05, the null hypothesis in this case was rejected, which means the alternative hypothesis was accepted, indicating a clear dependency between the age of the respondents and the focus or attention they give during the purchase of food with quality labels. The distribution of income and attentiveness during the purchase of food quality labels is also further expressed in Figure 6.

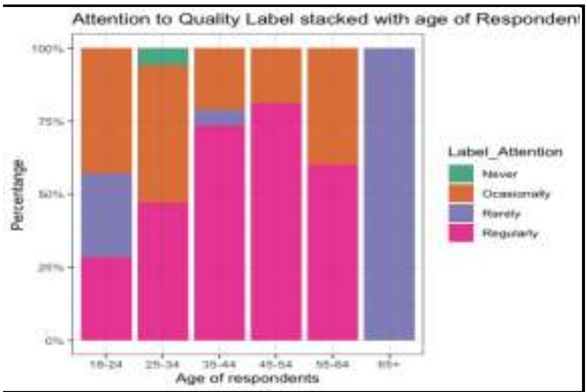

Fig. 6. Stacked bar chart between label attention and age of respondents
Source: Own determination based on the data from field survey, 2023.

A study conducted in 38 countries, reported that 18% of European respondents claimed that they "always" check the nutrition information on the package [10]. Therefore, when the consumer respondents were asked regarding the primary reasons of theirs to give attention to the quality labels, most of them (64.6%) replied that their intentions to have a healthier diet were the essential reasons; similarly, 47.6% of them answered that tracking the origin of the product was the reason behind giving attention to the label during their food purchases, and 46.2% of them had the motivation of supporting the local and national producers behind their rationale for being attentive to the food label details. On this multiple option selection questionnaire, 15.4% of them answered curiosity as another purpose for checking the food labels.

Frequency of purchase of quality labelled products: Categorized by professional affiliations

When the respondents were asked about their frequency of purchases related to quality labelled foods, most of them answered that they were somewhat responsible for purchasing quality labelled food products. 49% of the sample respondents were occasionally engaged in the purchase of food with quality labels, and 48% of them were regularly buying such products to fulfil their household requirements. The rest of the 3%, as shown in the figure, replied that they rarely buy food with quality labels.

Fig. 7. Frequency of purchase of quality labelled foods
Source: Own determination based on the data from field survey, 2023.

According to [14] the socio-economic status of the consumers has little implication on the reading of the food labels; therefore, to understand more about this in the present study, a chi-square test was planned and done to check the dependency between the frequency of purchase of the quality-labelled product and the professional status of the respondents. A null hypothesis for this was prepared (H_0 = Respondent purchase of quality food labels is independent of the

professional status of the sample respondents, and an alternative hypothesis was created explaining the inverse). Upon computation of the chi-squared tests (X-squared = 8.6672, df = 8, p-value = 0.3711), was obtained.
As the obtained value of p was greater than the allowed level of 0.05, we fail to reject the null hypothesis, which indicates no clear dependency between professional status and their frequency of purchase of quality labelled products.
That means professional status has no role in consumers buying quality-labelled products. The distribution of professional status with the frequency of purchase of quality labelled food is also further expressed in the stacked bar chart (Figure 8).

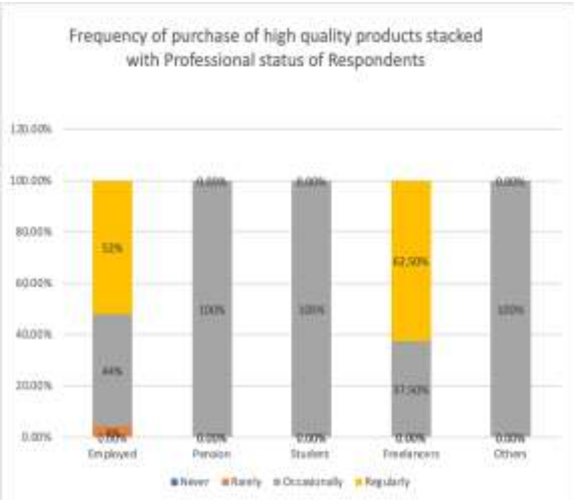

Fig. 8. Stacked bar chart between frequency of purchase and profession of respondents
Source: Own determination based on the data from field survey, 2023.

Awareness Study: Mountain products and Mountain labels

Participants in the consumer survey were then queried about their awareness of both mountain products and the mountain label, as illustrated in Figure 9.
78.46% of the respondents had earlier heard of mountain products, and only 21.54% had no clear idea related to mountain products.
However, on the contrary, 69.23% of the same respondents interviewed had no idea regarding the national labels related to mountain products, as authenticated by the decision of the Ministry of Agriculture and Rural Development, MADR No. 5/2017.

A Pearson's correlation test was then done to evaluate if there was a significant correlation between these two responses.

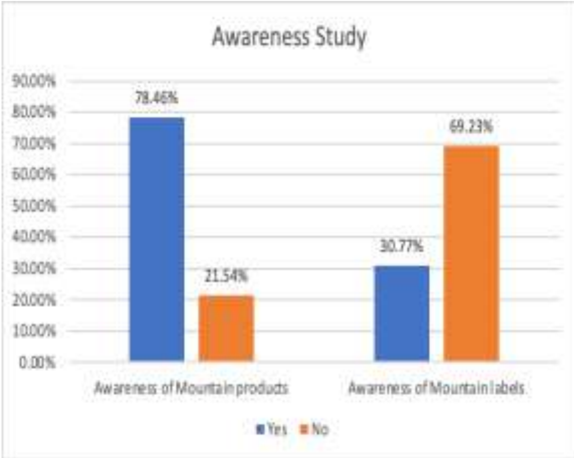

Fig. 9. Awareness Study
Source: Own determination based on the data from field survey, 2023.

Upon calculation, a correlation coefficient of 0.34 was obtained, which indicated a positive correlation between the two sets of questions. However, when a correlation test was computed **(t = 2.9588, df = 63, p-value = 0.004347, 95 percent confidence interval: 0.1152068 0.5466226)**, the p-value obtained was less than the significance level (0.05), indicating acceptance of the alterative hypothesis, which means there is a significant difference between the awareness of the mountain product and the mountain label. In simple words, the consumers are aware of the mountain products; however, they know very little about the mountain label logo that has been authorized by the government.

Definition and Categorization of Mountain Products

Among the pool of respondents who participated in the survey questionnaires, as reflected in Figure 10, only 69.23% of the respondents had a complete idea of the definition of a mountain product and the locality where the product needs to be produced and processed, and almost the same proportion of people (70.77%) had an understanding of the categories of products that can be labelled as mountain products as per the national regulation. Almost 30% of the respondents in both cases lacked proper knowledge and understanding of the mountain

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products and mountain product categories, which also hints at less effective marketing and promotional campaigns concerning the label both at the local and national level.

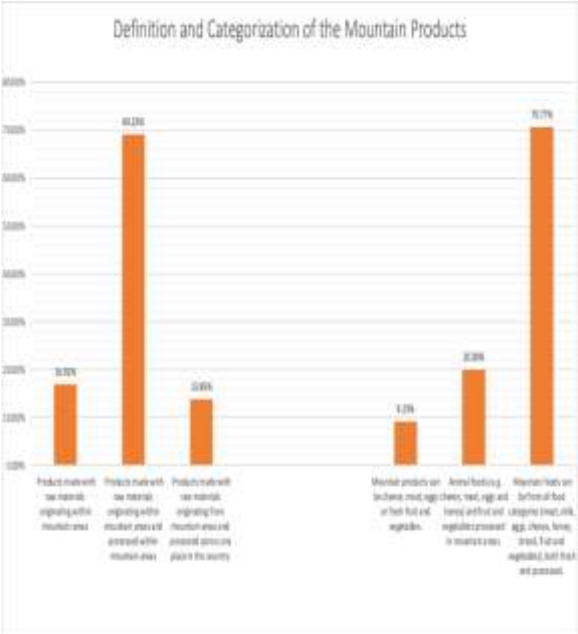

Fig. 10. Understanding of Definition and Categorization of the Mountain Product
Source: Own determination based on the data from field survey, 2023.

Chi-Square tests between awareness of the mountain labels and education

As the research of [18] analysed the use of food label information by urban consumers, they found a significant relationship between the respondents' education and their inclination to check the food quality labels. Therefore, to understand more about this in the present study, a chi-square test was planned and done to check the dependency between awareness of the mountain label and education of the sample respondents. A null hypothesis for this was prepared (H_0 = Awareness of the mountain labels is independent of the educational qualification of the sample respondents, and an alternative hypothesis was created explaining the inverse). Upon computation of the chi-squared tests **(X-squared = 1.1838, df = 3, p-value = 0.7569)**. As the calculated p-value exceeded the accepted threshold of 0.05, we retain the null hypothesis, suggesting no significant dependence between professional status and the frequency of purchasing quality-labelled products. In other words, the educational qualifications of the respondents do not play a role in their awareness of mountain labels. In other words, the consumer awareness of the mountain labels is independent of the educational qualification, insinuating that all the categories of respondents, irrespective of their educational qualification, had a minimal idea of the mountain label. Figure 11 visually represents the distribution of educational qualifications along with the awareness of the mountain label through a stacked bar chart.

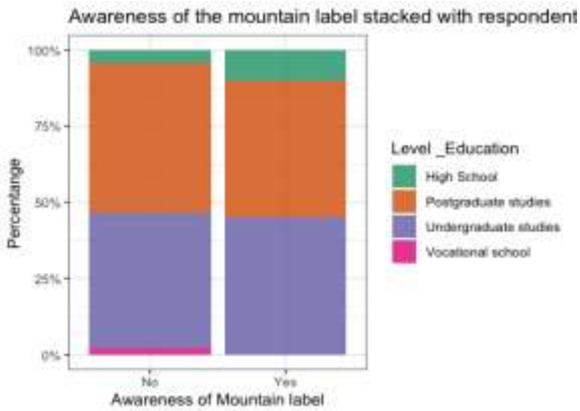

Fig. 11. Awareness of the mountain label stacked with education
Source: Own determination based on the data from field survey, 2023.

Benefits of purchasing mountain labelled and point of sales

When respondents in the consumer survey were questioned about the various benefits associated with purchasing mountain products, a majority (53.8%) promptly linked it to the promotion of local identity and products. This aligns with the conclusions of [19], where a similar finding was reported, indicating that mountain products are characterized by traditional practices connected to the cultural identity of local communities and specific cultural areas.

Similarly, Figure 12 shows that 47.7% respondents believed that purchase of the mountain labeled product would ensure better sensory and health benefits implicit in the consumption of the products, as indicated in the research of [3]. 41.5% commented that the mountain labeled products are better than the conventionally and industrially produced products, and 32.3% had similar thoughts, as they thought it added assurance to consumers during the purchase of these products.

Confoundingly, only 1.5% of the respondents believed that the purchase of mountain-label products boosts the local economy (Fig. 12).

Fig. 12. Benefits perceived by consumers through mountain labeled products.
Source: Own determination based on the data from field survey, 2023.

Likewise, when the consumer respondents were asked regarding **the point of purchase of mountain-label products**, 73.85% of them thought direct sales points like farms were the most common purchasing points for mountain-label products. 61.54% and 58.46% of the respondents mentioned local products, specialty products, and farmer’s markets as other crucial centers to purchase the mountain labeled products.

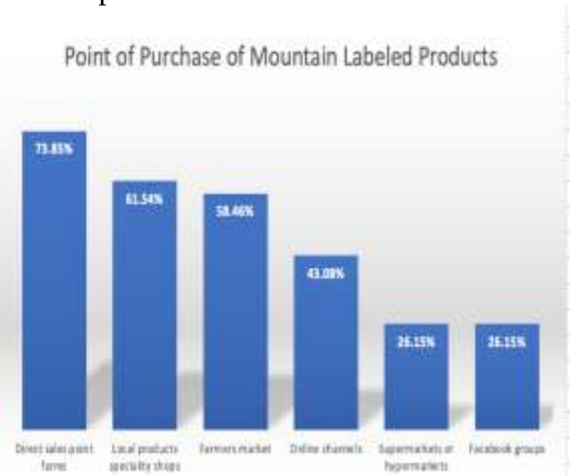

Fig. 13. Point of purchase of mountain labeled foods
Source: Own determination based on the data from field survey, 2023.

In the age of digital marketing, 43.08% and 26.15% of consumers thought that mountain-label products could be get through online or Facebook groups.

On the other end, only 26.15% of the consumers thought they could easily buy the mountain products from the super or hypermarkets in their vicinity.

Perception of price of mountain labelled products: Categorized as per income

The communication strategies aimed at promoting mountain products have guaranteed better positioning and higher market prices for them and are fundamental for the sustainable development of mountain companies and adequate remuneration for high-quality products [7].

Therefore, it was essential to understand how the sample respondents from Brașov perceive the prices of the mountain labelled quality products. 50.77% of the respondents believed that the mountain products are highly priced and are expensive compared to other conventional food products, and the other 49.33% mentioned that they find parity on the prices of the mountain products with other conventional products (Figure 14).

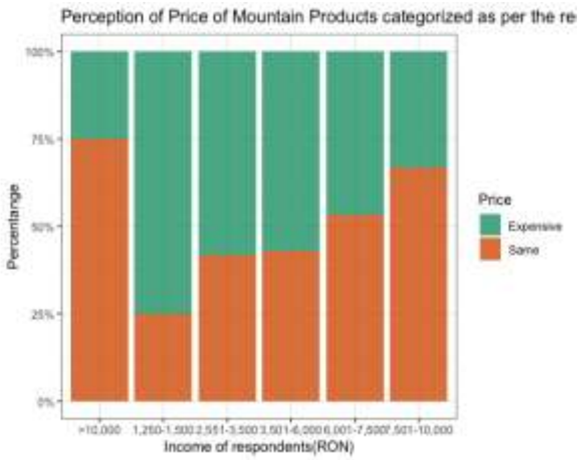

Fig. 14. Stacked bar chart between perception of price and income of respondents
Source: Own determination based on the data from field survey, 2023.

To further explore this in depth, a chi-square test was planned and done to check the dependency between awareness of the income level of the respondents and their perception of the price of mountain products. A null hypothesis for this was prepared (H_0 =

independence between the perception of price and income of the sample respondents), and an alternative hypothesis was created explaining the inverse.

Upon computation of the chi-squared tests **(X-squared = 3.8141, df = 5, p-value = 0.5765)**, As the obtained value of p was greater than the allowed level of 0.05, we fail to reject the null hypothesis, indicating no clear dependency between the two variables.

The stacked bar-chart distribution of income with the perception of the price of mountain products is also further expressed in Figure 14.

Ordinal logistic regression was executed using R programming, and the results of the mathematical computation are represented below in Table 3.

Table 3. Output Summary of the Logistics Regression

Variables	Value	Standard error	T value	P value
Age				
25-34	1.022	1.62	0.630	0.528
35-44	1.109	1.63	0.676	0.498
45-54	1.645	1.667	0.986	0.323
55-64	2.225	2.12	1.046	0.295
65+	-17.26	0.000	-906	0.000*
Gender **Male**	-0.962	0.750	-1.283	0.199
Education				
Postgraduate studies	-0.948	2.10	-0.450	0.652
Undergraduate studies	-0.895	2.064	-0.433	0.664
Vocational school	35.76	0.000	2.3e+08	0.000*
Income				
1,250-1,500	-17.02	1.60	-10.63	0.000*
2,551-3,500	-16.93	0.911	-18.58	0.000*
3,501-6,000	-16.90	0.693	-24.38	0.000*
6,001-7,500	-17.11	0.697	-24.55	0.000*
7,501-10,000	-17.54	0.963	-18.21	0.000*
Profession				
Freelancer	0.524	1.12	0.464	0.641
Others	-34.36	0.000	3.47e+08	0.000*
Student	1.780	1.952	0.911	0.361
Marital status				
Married	-17.40	0.704	-24.70	0.000*
Single	-17.66	0.635	-27.78	0.000*
Responsibility				
Partially	19.35	0.661	29.24	0.000*
Yes	18.40	0.592	31.10	0.000*
No||Maybe	-15.87	0.981	-16.17	0.000
Maybe|Yes	-15.78	0.983	-16.03	0.000
Residual Deviance: 71.70414 log Lik.' -35.85207 (df=23) McFadden R2 = 0.27 AIC: 117.7041 * Significance at 95%				

Source: Own calculation.

Among all the independent variables that were used to run the ordinal logistics regression analysis, the variables with p-values less than 0.05 at the 95% significance level, also indicated by * in Table 3, were considered to be statistically significant and had an influence on the willingness to pay for mountain labels. Also, the McFadden R2 suggests the model was a good fit.

General Statistical Overview of the reasons of not buying mountain products

The group of respondents were then asked about the impediments to their purchase decision of mountain labeled products.

Table 4. Reasons for non buying mountain labeled products

Pre-Defined formulated Statements	Mean (M)	Variance (V)	Standard Deviation (S.D)
-Mountain products don't meet the criteria of a safe and healthy product.	1.68	1.28	1.13
-I don't understand the meaning of the mountain labels and their associated benefits.	2.19	1.95	1.40
-I don't know of any food quality labels.	2.32	1.94	1.39
-Significant differences between price and quality ratios	2.54	2.37	1.54
-Mountain labels are not easily accessible in my shopping area preferences	2.93	2.74	1.66
-Mountain products don't have any potential benefits compared with other conventional foods.	1.74	1.07	1.03

Source: Own Calculation.

They evaluated six statements, all formulated negatively, using a 5-point scale of agreement (1: absolutely disagree, 5: absolutely agree) (Table 4). As most of the producers had been regularly purchasing mountain related products, there are 0 values where they have not evaluated any of the statements. For uniformity and reliability in the data, the average value in this case for the statement was computed by purging the values 0.

As can be clearly observed from the table above, for the first pre-defined statement, the respondents completely disagree, which means they regard mountain products as safe and healthy products, although they are not frequent in their purchases. Similarly, on the second, third, and fourth statements, the consumers convey their partial disagreement, which means they believe they have adequate or minimal knowledge of mountain labels and food quality labels and believe mountain products offer marginal price-to-quality ratios. Similarly, for the fifth statement, the consumers decided to be neutral, which indicates their doubtfulness about the availability of mountain products nearby their localities. Furthermore, on the last statement, the group of respondents in average disagrees with the fact that mountain products don't have any potential benefits, indicating good knowledge of the social, environmental, and economic benefits associated with mountain labels, although they are not frequent in the purchase of mountain labeled products. Similarly, a correlation matrix was obtained with the help of the software, which helped in verifying any dependency between the relationships between all of the pre-defined statements (Table 5).

Table 5. p-values for the correlation coefficients

Reasons for not buying analysis	Safe / Healthy	Meaning	Don't know	Price / Quality	Non-availability	No benefits
Safe, Healthy	0.0000	0.0040	0.9590	0.0000	0.1620	0.0000
Meaning	0.4110	0.0000	0.0000	0.0150	0.0980	0.0150
Don't know	0.9590	0.0000	0.0000	0.1350	0.0100	0.0630
Price-Quality	0.0000	0.0155	0.1350	0.0000	0.0120	0.0000
Non-availability	0.1610	0.0980	0.0100	0.1210	0.0000	0.0020
No benefits	0.0000	0.0150	0.0630	0.0000	0.0020	0.0000

Source: Own Calculation.

It can be clearly observed from the p-values of the correlation test between all the predefined statements and the correlation chart, as shown in the figure 38 below. There are six p values that are greater than the threshold significance level ($p > 0.05$), which means in those cases the null hypothesis cannot be rejected. The way consumers have responded in this case doesn't correspond with their responses in the case of these two statements. Apart from that, in nine other correlation computations between the pre-defined variables, the obtained p-values are less than 0.05, which gives us enough confidence to reject the null hypothesis, indicating a strong correlation between the responses of the consumers between these two pre-defined statements. Also, this analysis gives us the general idea that because of the lack of dependency or correlation between the pre-defined statements, respondents have different opinions on their reasons for not purchasing the mountain labeled products.

CONCLUSIONS

According to our results, the mountain product brand needs to be communicated in a widespread manner, since 70% of respondents affirmed, they had never seen the brand before the survey.

A strong communication strategy thus needs to be prepared by the concerned authorities with the group of stakeholders involved, like producers, to educate consumers regarding the mountain label.

Promotional strategies aimed at the consumer need to be launched to support mountain agriculture, the economy, and the producer. The consumers will then have a clear image of mountain products so that they can be direct contributors and take maximum benefits from purchasing such products that have been directly endorsed by the government by fulfilling certain sanitary and origin conditions.

Only 47% of the respondents were interested in paying more for products with mountain labels, and 50% were completely unsure about their purchasing decisions, which indicates a clear unsurety in the minds of the consumers. Similarly, one of the reasons for their disinterest in purchasing mountain labeled products, as per the research, can be a higher perception of the prices of the products, as most of the consumers felt that mountain products are usually more expensive for them to include in their purchasing decisions. Therefore, a more simplified marketing approach is anticipated from all the concerned stakeholders to ameliorate the status marketing and promotional gap that was prevalent in the study.

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APPLICATION OF ARTIFICIAL INTELLIGENCE TECHNOLOGIES IN VITICULTURE

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Abstract

Currently, artificial intelligence (AI) is widely used in many areas in industry, agriculture, health and even in our everyday life. In agriculture, AI is used for smart farming and is a crucial tool to create sustainable food systems. A particular area of interest in agriculture where AI is being used successfully is viticulture, for example to reduce workload and allow focus on winemaking efficiency, productivity, and vineyard yield. The present review aims to provide an overview on the current uses of precision viticulture techniques and in particular geographic information system (GIS) in viticulture and winemaking, with a detailed focus on the production of high-quality wines.

Key words**:** *artificial intelligence, agriculture, GIS, viticulture, winemaking*

INTRODUCTION

Agriculture is one of the oldest and most important occupations in the world, with a history that began thousands of years ago. It is the science and art of cultivating plants and raising animals.

The different techniques and technologies used in agriculture have improved over time. Modern agronomy technologies, technological developments in plant growth, agrochemicals such as pesticides and fertilisers have increased yields while causing environmental damage. With the increase in global population and the expansion of inhabited areas, the areas used as agricultural land have become smaller. At the same time, the interest shown in agriculture today is much lower than it used to be. With the migration of people from village to city, the interest in agriculture has decreased; people increasingly prefer to buy ready-made products instead of cultivating them in their own garden the way they used to.

Geographical Information System

The Geographic Information System (GIS) proves to be an intuitive and valuable tool for digitally modelling agricultural fields. Through GIS technology, AI contributes to increasing the efficiency of the wine industry by facilitating the production of healthier grapes, pest detection and control, plant disease identifications, the monitoring of plant (vine) growth and soil assessment, the provision of weather forecasts, the characterization of wine quality, and even the manufacture of storage barrels.

The generally accepted definition of GIS is a computer system that analyses and displays geo-referenced information using data attached to a single location.

GIS is a system that creates, manages, analyses, and localises different types of information, connecting them to a map and integrating the location data with all sorts of thematic data. The process establishes a basis for different layers, analysing the content for use in science and other domains, such as telecommunications, health, education, insurance, public safety, sustainability, transportation, government, retail, water, natural resources, real estate, petroleum, public safety, etc.

GIS facilitates better understanding of geographic patterns, relationships, and context. Among the benefits of using GIS are improvements in communication, management, and decision making.

GIS allows its users to visualise many and different types of data on one map, such as streets, buildings, fauna and, in this case, vineyards and crops. With the help of GIS and AI, it is possible to monitor each vineyard in quasi-real time, oversee the behaviour of employees, or identify vegetative problems (leaf diseases, pests), keep track of the vineyard's history regarding pests, diseases, the type, quantity, and location of applied fertiliser, and assess whether some portions of the vineyard need more water than others. AI can even help in forecasting.

Artificial Intelligence

"Artificial life" is the name given to the new discipline that studies "life" by trying to recreate biological phenomena from inside computers or other "artificial" environments [52]. This new discipline combines the analytical approach of traditional biology with a synthetic view that seeks to organise systems that behave similarly to living organisms rather than to study biological phenomena separately to observe their behaviour. The advances in neurology in recent decades have been spectacular, especially those related to the properties of neurons. In the psychology field, new behavioural data have appeared that have revealed many aspects and characteristics of psychological abilities, such as visual perception and memory [6]. Thus, by understanding more about the nature of the brain and the principles that govern its activity, we can also understand different mental functions, such as perception or learning. By understanding the functioning of the human brain and its central nervous system, we can also understand how artificial neural networks (neural networks) appeared and were developed. The idea behind the founding of the artificial intelligence field claims that intelligence can be described and defined so precisely that it can even be simulated by a computer. Most specialty books define artificial intelligence as "the study and design of intelligent agents" (an intelligent agent is defined as a system that perceives the environment and/or acts in such a way as to increase its chances of success) [68]. AI subdomains are based on issues such as reason, knowledge, perception of objects and feelings, learning, communication, etc. In 1955, the most convenient/accepted definition of artificial intelligence was given by John McCarthy [39]: "a machine that behaves in a way that could be considered intelligent, if it were human." One of the main features of artificial intelligence is the ability to constantly improve and learn with or even without help. Alan Turing claimed that artificial intelligence will be achieved when in a conversation we will not be able to tell the difference between a machine/robot and a real person. In 1950, he created the Turing test, which involves two persons and a robot/machine. The first person asks a series of identical questions to both the second person and the robot. Based on the answers, the questioner must figure out who the robot is. If the questioner cannot tell the difference between the person and the robot, then the robot has passed the test and can be said to think.

Edourad Claparede [64] considered intelligence as the ability to adapt quickly to new situations. Being considered intelligent in the living world means one has the ability to communicate with other individuals, to process the information received, to make plans, to establish "smart" relationships and contacts, etc. It is believed that "the essence of life lies in its intelligence," expressed by the ability to discern and process information. Intelligence should not be mistaken for human intellectual capacity, which involves abstract thinking, elaboration of concepts, planning, etc., using verbal symbols. There are numerous techniques that are relevant to AI, such as neural networks, genetic algorithms, logic programming, fuzzy logic, qualitative reasoning, expert system, etc.

According to the *Encyclopedia Britannica* (1997) [40] (McGraw Hill, also in 1995 [14]), there are several perspectives on this concept, among which include:

-From the perspective of intelligence—AI is the capacity of computers and/or robots to perform tasks that are usually associated with humans, such as reasoning, discovering, generalising, adapting, and learning from previous experience;

-From the perspective of the philosophy of reason—there have been remarkable advances in the speed of electronic computers; therefore, many philosophers have concluded that a proper program and memory can think intelligently; thus, the term artificial intelligence indicates the area of investigation that seeks to develop computers gifted with such capabilities;

-From the perspective of computer science—robots, whose construction requires the collaboration of specialists in several fields. As many robots are designed to perform functions often performed by humans, many aspects of building robots fall into the realm of artificial intelligence. Example: AI is used to design robot programs that can “react” to unforeseen situations (for example, a robot used on an automatic assembly line must “know” how to pick up incorrectly oriented products or recognise defective ones).

-From the perspective of computer science—expert systems, such as error diagnosis systems [31], meaning all the steps from diagnosing human diseases to diagnosing malfunctions in a space shuttle that are built on the principle of expert systems. The knowledge of human experts is stored and represented as basic knowledge with rules that can be applied to solve possible problems. An interface allows the user to name the symptoms and clarify the problem by answering questions asked by the system. The main goal is for the user to discover the solution to the problem.

Expert systems are the biggest success of artificial intelligence and are expected to increase their area of applicability in the future. There are modernists who are against the use of AI, claiming that it will transcend the limits of progress and transform humanity in such a way that will eventually capture and dominate it, ultimately “swallowing” it completely. One purpose of the artificial neural network (ANN) is to copy the human brain’s ability to recognise shapes and patterns. The field of use for ANNs is very wide: identifying fingerprints, faces, and signatures [37], forecasting in medical diagnosis [10] and the economy [46], and predicting human behaviour [36]. An ANN has the ability to learn and to abstract [50], which are very important skills if the abstraction rules of the process of recognition are unknown to the user [56]. ANNs are also used to determine different (wine) aromas. The human brain has the ability to extract information from complex olfactory impressions. Technologies, including robotics, computer vision, and machine learning, have been developed to assess beverages such as beer and sparkling wine [11,60].

Machine Learning

Machine learning is the study of computer algorithms that can improve automatically through experience and the use of data [43, 45]. Research in the fields of artificial intelligence, machine learning, and deep learning is ongoing and progressing rapidly. These are concepts that have been around for decades, but we have only been hearing of them lately because of increasingly powerful computers and the mounting demands that people are making of their accessories and gadgets. Artificial intelligence is the technology for creating computer systems that are considered “smart”. Machine learning is a more restrictive discipline that involves creating systems capable of learning from the examples and data they receive. There is common ground between these two concepts; machine learning is the part of AI that refers to the machine’s ability to learn on its own. Machine learning-based programs can learn to recognise various trends and make predictions based on stored information [53]. IBM, Microsoft, Amazon, and Google are companies with complex machine learning platforms that operate with mathematical algorithms and are able to manage large amounts of data, learn on their own, and refine their actions. Machine learning differs from AI namely in that AI should act completely independently, whereas machine learning-based systems are under human control and run within well-established parameters. Deep learning was developed as an extension of machine learning and thus artificial intelligence, and it is based on a large amount of data introduced into a computer system through neural networks.

Deep learning can analyse information in greater detail. It also has the ability to remember its past actions and to learn from its own behaviour. Examples of deep learning applications include self-driving car navigation systems, the Google DeepMind system, fraud detection, spam, voice and handwriting recognition, image search, and translation.

Viticulture

Viticulture is the science of vine agrobiological characteristics and their study in which the goal is to continuously develop and improve cultivation technologies to obtain large amounts of high-quality crops. It deals with the cultivation of vines to obtain grapes. Viticulture has spread widely throughout the world, and many countries today are producing wine. The viticulture industry is one of the most important industries in countries that own land designated for wine production, such as Spain, Italy, France, Chile, and Romania, among others.

Economic impact and benefit of the use of GIS technology and AI in viticulture

The intelligence of machines, together with data received from sensors and images, allows winegrowers to improve many aspects involved in vineyard management. For example, AI is used in the vineyards to provide relevant information such as yield and size as quantifiable aspects, as well as in the wineries and distribution.

AI technology, if properly combined with other technologies such as sensing, can bring many economic benefits. It can gather, interpret and learn from the data collected, helping farmers make fact-based and predictive decisions. In wineries, AI collects data from sensors and is used to improve the wine quality and production.

AI can detect plant diseases, pests, insects, and chemical fertilizers, identify plots of land which need to be irrigated, vine voids in plots, and determine the urgency of fertilizer or pesticide treatment [13].

GIS enables the reduction of inputs to the vineyard (pesticides, fertilizers and herbicides) through an optimized spreading of the final products.

New technologies and data sources include satellite and drone remote sensing, field sensors and automated weather stations, which are increasingly deployed and used to improve decision-making due to their enhanced availability, affordability and reliability [44].

The paper aimed to explore various means by which the artificial intelligence (AI) is integrated into viticulture, in particular through the geographic information systems (GIS), as well as to point out the importance of precision viticulture techniques and their practical applications in viticulture and winemaking, having as main objectives the improving of efficiency in grape cultivation and obtaining high quality wines.

MATERIALS AND METHODS

The current review was restricted to articles with English full-text availability. MDPI, Eurostat Regional Yearbook, European Commission, DG Agriculture and Rural Development, Google Scholar, Springer Link, Springer Nature, Elsevier, Encyclopedia Britannica, and Journal of USAMVB (Scientific Papers Series Management) were among the most used information sources. The most common search keywords were used: artificial intelligence technologies in viticulture, GYS, wine, machine learning, winemaking, and detection methods. Additionally, searches were conducted using each term in turn. We also looked for additional references in the bibliographies of the included papers. In our review of the literature, we discovered a sizable number of studies that mostly discussed the GIS technology and AI in viticulture. The results of the thorough search are sorted into categories and listed according to the best techniques discovered. We only included the more than 60 research articles and review papers that were discovered after 1974 because that is when the authors study the growth of the aerial vegetative growth of the vine until 2023 when some concrete examples of the application of AI technology in the wine industry were presented.

RESULTS AND DISCUSSIONS

Brief presentation of viticulture state in the EU and in Romania

According to *Eurostat Regional Yearbook*, 2018 edition, approximately 3.2 million ha of EU land was occupied by vines in the year 2015, both in and not yet in production. The area included 17 EU state members.

This reflects the fact that the northern European expansion of the Roman Empire is linked with the northern limit of the wine plants' presence. More than three-quarters (78.1%) of the area was used to produce quality wines, PDO wines (61.7%) or PGI wines (16.4%) [26].

The evolution of areas under vine in the EU is presented in Figure 1.

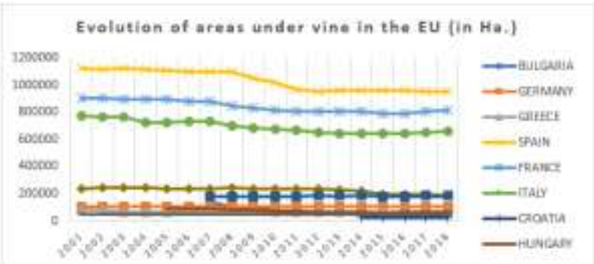

Fig.1. Evolution of areas under vine in the EU (ha). Source: [20].

The evolution of areas under vine in Romania, for example, is presented in Figure 2.

The integration of AI in viticultural agriculture in Romania stands to yield numerous positive impacts. AI technologies can elevate precision farming practices, optimize resource allocation, and enhance overall efficiency in grape cultivation.

Fig. 2. Evolution of areas under vine in Romania.
Source: [21].

By analyzing data from diverse sources, including weather patterns and soil conditions, AI systems can offer valuable insights for informed decision-making. AI-driven applications hold the potential to predict disease outbreaks, optimize irrigation schedules, and streamline vineyard operations, thereby contributing to increased yield, enhanced grape quality, and resource conservation. Furthermore, the incorporation of AI in viticulture can promote sustainability by reducing reliance on pesticides and minimizing environmental impact. Despite these potential benefits, challenges such as initial implementation costs, the need for a skilled workforce, and concerns related to data privacy necessitate careful consideration. The advantages of incorporating artificial intelligence into viticultural cultivation in Romania are diverse, encompassing the potential to significantly reshape grape cultivation by bolstering efficiency, sustainability, and technological advancement. In terms of winemaking, AI algorithms enable the simultaneous analysis of tens of thousands of wines, unveiling correlations between sensory components, classification, and price. Such analyses can also explore the influence of regional soil variations, weather conditions, and other natural factors on wine characteristics. The future trajectory involves integrating sensory reviews from diverse sources with chemical analysis data to unveil connections between different methods of wine evaluation. In Romania, the National Office of Vine and Wine Products (ONVPV) has implemented a control system since 2008, utilizing a certification mark with a unique alpha-numeric series. This system was subsequently replaced in 2014 by the QR code system, ensuring traceability and certifying the origin and authenticity of the marked wine [13].

Figure 3 [26] presents the vine distribution areas, with distribution heavily distorted in favour of the southern EU regions.

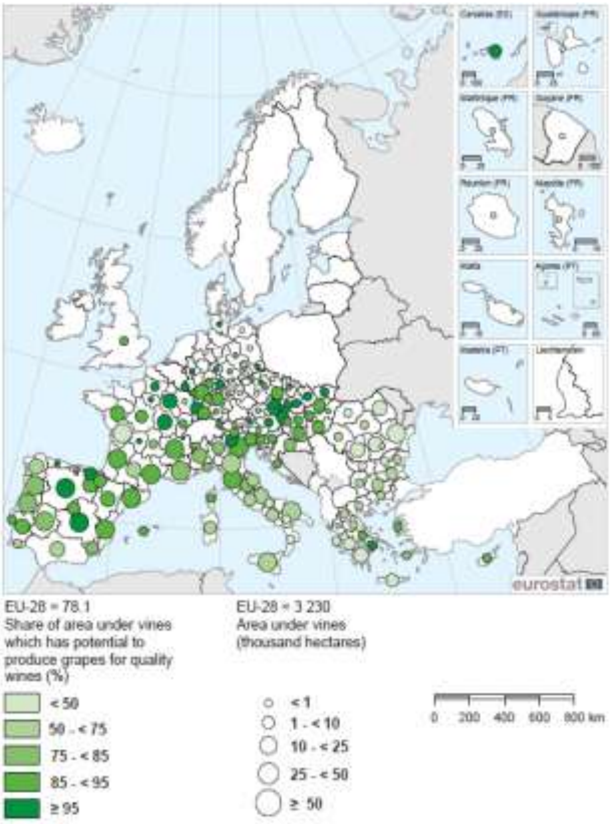

Fig. 3. Vine areas for quality wines, NUTS 2 regions, 2015 (thousand hectares under vines and share of area under vines which is used to produce grapes for quality wine.
Source: [26].

The size of each circle represents the total vine area for each NUTS (Nomenclature of Territorial Units for Statistics) level 2 region. In accordance with the map legend, the colours provide data on the tendency to produce quality wines; darker shades mean a greater share of the total vine area is committed to producing quality wines.

The four regions in the EU that have more than 100,000 ha of vines are Puglia, Castilla-la Mancha, Aquitaine, and Languedoc-Roussillon. According to the 2018 edition of the *Eurostat Regional Yearbook*, there were 18 NUTS level 2 regions in the EU in 2015 where the total area under vines was larger than 50 thousand hectares.

These 18 regions together represented 61% of the total vine area in the EU.

Wine Market Situation and Trade Developments

The transformation of grapes into wine is called vinification. Oenology (also called wine technology) is the science that deals with the study, methods of preparation, conditioning, and storage of wines and products derived from grapes, must, or wine [57]. The generally accepted European definition of wine states that wine is produced exclusively by alcoholic fermentation, in whole or in part, from fresh grapes, crushed or not crushed, or from grape must, with at least 8.5% alcohol by volume. Over the years, wine has undergone different studies aimed at demonstrating its benefits. Producing high-quality wine can be considered an art, and although interest in agriculture has declined, the interest in wine is as intense as ever. Wine is one of the most popular drinks worldwide, and its market is constantly growing. It is believed to be an effective elixir and therefore good for health in moderate quantities. To be considered of quality, a wine must fulfil some requirements that help the buyer to more easily choose, such as a European food/beverage label with guaranteed geographical origin with Recognised know-how (and grapes exclusively from the area in question) [21]:

-An indication of the PDO status, which refers to its connection with an area that is recognised by official rules to produce special foods with special characteristics related to the location [38];

-An indication of PGI status, which is a label for European quality food due to its close relation with a specific region (with at least 85% of the grapes coming from the area in question).

Geographical indication (GI)-recognised products or products that are under consideration can be found on geographical indications registers, which include data regarding the production and geographical specifications for each product. The intellectual properties rights (IPR) for

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products with qualities related to the production area can be established with the help of geographical indications. The geographical indications for food, wine, and spirits include the following aspects [24]:

-Protected designation of origin (PDO) for food and wine;

-Protected geographical indication (PGI) for food and wine;

-Geographical indication (GI) for spirit drinks.

The main differences between PDO and PGI are the ratios of raw materials in the product that should come from a specific area or the proportion of the production process taking place in a specific area. The wine market has become important even in countries without a tradition of consumption [25].

According to fortunebusinessnights.com, the wine market is predicted to grow from USD 340.23 billion in 2021 to USD 456.76 billion between 2021 and 2028, corresponding to a CAGR (compound annual growth rate) of 4.30% [18]. Europe is the biggest wine producer, responsible for more than half of the world's wine output.

In 2019, the EU exported over 7 bn. litres of wine. About 43% of the total wine production, or 3.1 bn. litres, was exported to non-European countries. From this, approximately 0.69 bn. litres were sent to the United Kingdom (around 22% of extra-European wine exports) and 0.65 bn. to the United States (21% of exports). The country that imported the third-largest volume of wine from the EU was Russia, with 0.28 bn. litres (approx. 9% of exports), and the fourth was China, with 0.25 bn. litres of wine (8%). With 1.1 bn. litres or 34% of the EU member states' extra-EU exports of wine, Italy was the number one exporter of wine in 2019. The second place was held by France, with 0.8 bn. Litres or 25%, and the third place belonged to Spain, with 0.7 bn. litres or 22%. Conversely, the top importer was Germany. According to the 2019 import charts, the quantity of wine imported by the EU member states was 4.8 bn. litres, among which only 16% came from non-EU countries such as Chile, with 0.17 bn. litres or 23% of imports and South Africa with 0.16 bn. litres or 21% of total imports. Germany was the largest EU member state wine importer, with 30% of total EU member states' extra-EU imports, amounting to 0.23 bn. litres, and the Netherlands followed in the ranking with 0.11 bn. litres or 15% of imports, Denmark with 0.07 bn. litres or 9% of imports, and Sweden with 0.06 bn. litres or 8% of total imports. Both Belgium and France imported 0.05 bn. litres, which was 7% of total imports. Ireland was ranked sixth place with almost 0.05 bn. litres or 6% of total imports. Figure 4 presents the situation regarding wine trade from 2021 to 2022.

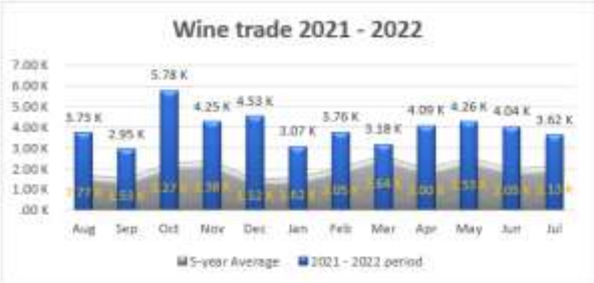

Fig. 4. Wine trade.
Source: [22].

According to the EU Wine Market Observatory, the 2021/2022 wine + must production was 159 million hectolitres (Mio Hl) +7% compared with the forecasted value (148 Mio Hl). The overall production decrease was half of that estimated the previous October (from −13% in October 21 to −7% in March 22), with a decline of −7% compared to the 2020/21 production (170 Mio HL in 2020/21 <-> 159 Mio HL in 2021/22 = −11 Mio Hl = −7%) [16]. The first three wine producers in the EU were Italy, Spain, and France. Italy was the largest EU and world producer, with 50.4 Mio Hl, representing 32% of total production in the Union, followed by Spain (39.4 Mio Hl), which produced 25% of the volume [23]. For the second consecutive year, France took third place (37.2 Mio Hl) with 23% of the produced volume. Two-thirds of produced wines were quality wines (this proportion remained stable: 45% were PDOs and 21% were PGIs) [19]. During the last decade, a slight upward trend in the production of PDO and varietal wines, stability in the level of PGI production, and a downward trend in the production of wines without appellations were observed (Figure 5) [23].

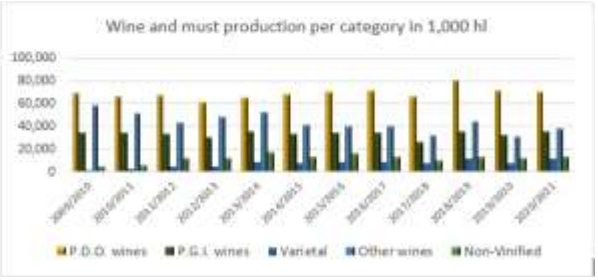

Fig. 5. Evolution of EU-27 wine and must production per category, April 2022 (1,000 hl).
Source: [23].

Figures 6 and 7 present the wine market situation and trade developments in 2022.

According to Kantar, in 2021, household wine consumption decreased by −5.5% in volume vs. −0.8% in volume in 2020 and −6.3% in 2018–2020. The consumption decreased by −1.5% in value compared to 2020.

Unlike other years, consumers tended to buy more expensive wines.

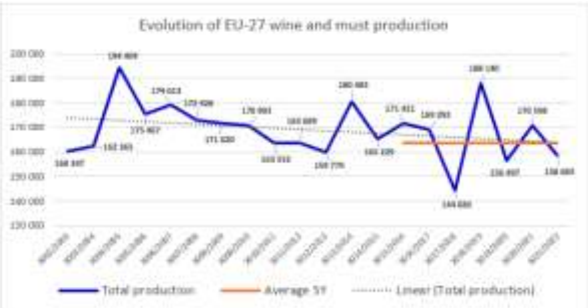

Fig. 6. Evolution of EU-27 wine and must production.
Source: [23].

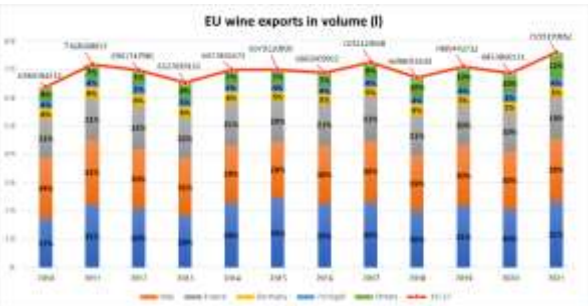

Fig. 7. EU wine exports (2010–2021)
Source: [16, 23].

The average price was EUR 4.91 per litre, up 4.2% from 2020 and +4.9% from 2018–2020, on average. Regarding the colour, only white wine purchases increased in 2021 (+3.2% in volume and +8.5% in value). Sales of still wines decreased by 10% in volume in Q1 2022 compared with Q1 2021 (−10% compared with the 2019/21 average) and 10% in value (−6% compared with the 2018/20 average). In contrast, the price paid was EUR 4.66/l, which remained stable when comparing with 2021 (+4% compared with the 2019/21 average) [17].

AI technologies in viticulture

Among the most relevant uses of AI in viticulture can be mentioned the following: robotics and human assistance technologies with AI capabilities for vineyards with the harvest intended for winemaking; VR (virtual reality) headsets for training; headset with human assistance Augmented Reality (AR), which helps to determine the cut points on a vine trunk so that people can make the cuts correctly; autonomous tractors and combines; robots that dig and plant cuttings; robots that monitor certain factors in the vineyard such as their harvesting yield, vegetative growth, production level and the physicochemical composition of grapes; planting, monitoring, pruning and fertilizing vines, as well as harvesting grapes can be automated; intelligent storage (warehouse automation through robotics and AI); more efficient distribution and marketing with the help of automation; digitalization of certifications (electronic label (e-labelling), electronic certificate (E-Certificate) etc.); automated storage of barrels, wine bottles [13].

The great variety of wines in the world is explained by differences between territories (soil, rainfall, exposition, etc.), grape varieties, winemaking methods, and types of ageing: there are white, red, or rosé wines as well as wines with different residual sugar levels (i.e., dry or sweet wines) or effervescent wines (Figure 8).

Owing to the progression of wine consumption culture assimilation and expansion in the world, the use of digital technologies has affected the domain. As in many other areas, artificial intelligence has been used to reduce workload (humans have been replaced by robots) and allow focusing on crop winemaking efficiency, productivity, and yield, in order to obtain high-quality wines.

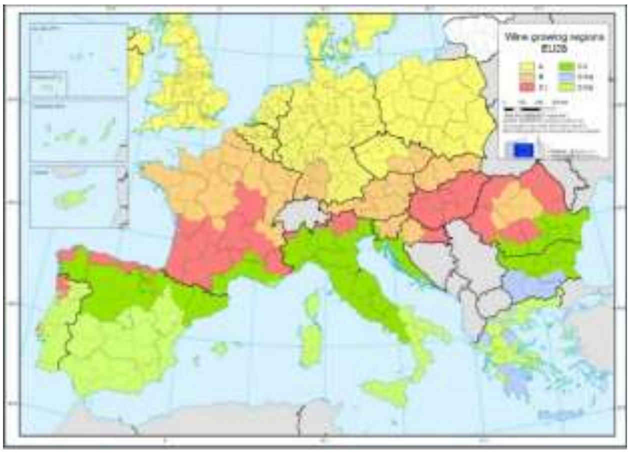

Fig. 8. Wine-growing regions EU28.
Source: [32].

Through GIS, artificial intelligence algorithms contribute to the wine industry efficiency by facilitating production of healthier crops, pest detection and control, plant disease identification, monitoring of soil and plant growth (cultivation, maintenance, and harvesting) and the degree of soil fertility, provision of weather forecasts, wine quality identification, traceability, and even manufacture of storage barrels. Since vineyards are mostly located in dry areas, special hardy varieties and/or a sufficient supply of water at key stages of development in case of severe drought are necessary. Support tools are therefore needed for the optimisation of water use in order to adapt agronomic practices.

Laroche-Pinel E. et al. (2021) presented a solution to this problem in their work, involving large-scale monitoring of the vine water status using Sentinel-2 images [34], which provide spatialised and temporal information. Six plots were observed over three years (2018–2020) of field measurements to determine the water status of vines that were measured from pea size until the ripening stage based on stem water. The images offered by Sentinel-2 were downloaded and analysed in order to extract band reflectance values and compute vegetation indices. Five supervised regression machine learning algorithms were tested in order to determine if there were any relationships between the stem water potential and data provided by Sentinel-2 images (band reflectance values and vegetation indices). In conclusion, promising results for the prediction of stem water potential (R2 = 0.40, RMSE = 0.26) were obtained through the regression model using Red, Red-Edge, NIR, or SWIR bands.

Bahat I. et al. (2021) [3], in their study of a commercial *Vitis vinifera* ‘Cabernet Sauvignon’ vineyard in Israel covering 2.5 ha, approached the effect of the terrain as a compound of the micro-terroir factor. In that study, the topographic wetness index (TWI) was used as an integrative, steady-state hydrologic measure to delineate the management zones (MZs) within a vineyard and study the interactions between vine vigour, water status, and the grape and wine quality. The relationships between soil water availability, vine vigour, and water stress are very important, as they can be used to allow appropriate decisions to made involving irrigation.

The decametric resolution satellite and UAV (unmanned aerial vehicle) platforms of low altitude were applied by Khaliq A. et al. (2019) [32] for a comprehensive analysis including a comparison of vineyard multispectral imagery. Spectral indices are considered valuable tools for describing crop spatial and temporal variability. The relationship between the crop vigour and the normalised difference vegetation index (NDVI) was used to evaluate the Sentinel-2 images and high-resolution UAV aerial images. The unbundled spectral contributions of the different elements (i.e., the inter-row terrain, the whole cropland surface, and only the vine canopies) in the vineyard environment were analysed through UAV data processing, which was compared with the satellite imagery by computing three different NDVI indices. The conclusion of the study regarding the maps computed from UAV imagery using only the pixels that represented crop canopies was that these were more reliable than satellite imagery for in-field assessment. Meanwhile, it was concluded that the raw resolution satellite imagery could not reliably describe the vineyard variability because the NDVI computation can be influenced by the inter-row surfaces and their contribution to the sensed dataset, thereby leading to unclear crop descriptors. Cogato A. et al. (2019) [12] assessed the feasibility of using images provided by Sentinel-2 in quantifying the impact that heatwaves have on irrigated vineyards. The study is mostly useful for countries such as Australia, where heatwaves are common in many viticultural areas. During the period of two seasons (2016–2017 and 2017–2018) of the study, the authors investigated the possibility of satellite-based remote sensing to evaluate the effects of high temperatures on grapevines in a South Australian vineyard and investigated the feasibility of assessing the effects of heat stress on grapevines through the utilisation of Sentinel-2 data.

The following steps were undertaken in that study:

- Comparison of the NDVI from medium- and high-resolution satellite images;
- Determination of the correlations between the vegetation indices (VIs) and the environmental conditions [45].
- Identification of the VIs that best indicated heatwave effects.

Although the authors concluded that the results of the study needed confirmation through further investigation, the spectrum regions and the VIs were found to be more suited to heat stress detection based on the analysis of spectral features of vineyards affected by multiple heatwaves. The high correlation of spectral bands and VIs with environmental conditions is an observation that resonates with the results of other studies on water stress using high-resolution imagery.

In the article *Development of Spectral Disease Indices for 'Flavescence Dorée' Grapevine Disease Identification* [1] the authors aimed to develop spectral disease indices (SDIs) for the detection of FD disease in grapevines. The application of SDIs in precision agriculture is demonstrated to improve disease detection, identification, and monitoring. The spectral signatures of the diseased and healthy grapevine leaves were measured using a non-imaging spectroradiometer for two different levels of infection, and the most discriminating wavelengths were selected with the help of a genetic algorithm (GA). Finally, the spatial data enabled the addition of advanced image processing algorithms for more robust FD detection. In order to obtain a certain style of wine of a certain quality, adequate environmental conditions and proper cultural practices are required. The harvest and, by default, the obtained wine can vary from one year to another owing to climate, disease, soil, pests, and other factors. There are vineyards where traditional practices are still used, even though they are more time-consuming and, in the long run, lead to physical and mental stress and fatigue. Over the last decades, new technologies have been implemented to allow machines to take on many tasks and relieve humans of their burden. Examples of such technologies include robotics, wireless sensor network technologies (WSN, useful for real-time monitoring), GPS, and sensors. Examples of robot prototypes and commercial solutions for viticulture [52]: VineRobot [65], VINBOT [49], Wall-Ye [63], VRC Robot [62], Vitirover [62], and Forge Robotic Platform [3]. Precision viticulture is a scientific technique that assists wineries with the management of large areas, maintaining variability, improving their performance, and maximising the grape quality and yield by decreasing risks and environmental impact. This technique depends on new technologies such as Global Navigation Satellite Systems (GNSS), meteorological sensors, and other remote sensing equipment and satellites, as well as GIS for assessing and responding to variability. Through the use of precision viticulture technologies, it becomes easier for vineyard owners and winemakers to control the variability in their vineyards and the factors influencing grapevine performance.

AI technologies in the assessment of technological indicators in grape processing and wine production

Must is unfermented sweet grape juice that is obtained by crushing and pressing grapes. For choosing the moment to start harvesting, the most important parameter is the degree of ripening of the grapes, expressed by the sugar content (in g/l) of the must.

Huglin (1986) [29] considers there to be four fundamental categories among the intrinsic factors of wine quality: sugars, acids, the constituents of the "nose", and phenolic compounds. Thus, quality is a complex concept in which sugar content is only one element [48]. Pierre Huglin developed a bioclimatic heat index for vineyards, called the Huglin heat sum index (thereafter being referred to as the Huglin warmth index or, in short form, the Huglin index). The index works as follows: the temperature sum over the temperature threshold of 10°C is calculated and then summed for all days from the beginning of April until the end of September using the daily average temperatures and the maximum temperatures. The calculated total shows almost no variation according to latitude. For each grape variety, a different amount of heat is needed for successful long-term cultivation in a given area. In general, the obtained heat sums are lower than the actual values in vineyards based on data from different weather stations or climate models. Huglin stated that: "for cool wine-growing possibility, the sugar content is general whenever the grape varieties used are on average at the limit of their growing possibility, the sugar content is the primordial element of quality. In hot regions, on the other hand, the maintenance of sufficient acidity is often the dominating concern" [29].

In his paper, Champagnol (1984) [10] agreed and noted that "in the south of France, with a vintage of a sugar content lower than 10° probable alcohol, *Carignan* or *Grenache* can only give mediocre or passable wine. This wine can become acceptable on average for 11° and often excellent for 12° or 13° with more aromatic varieties, in northern regions, a good wine can be obtained with lower sugar contents. This is however not as good (even after artificial enrichment) as that obtained from a vintage richer in sugar" [48]. One of the main objectives when it comes to the quality of wine in the northern regions is obtaining an optimum (maximum) sugar content. It can be said that quality is a complex concept, the result of the interaction of many components. The sugar content is considered a good indicator of the quality level, as it presents good evidence of the ripening stage together with the parallel evolution of other relevant components. The ripening period plays an important role in the accumulation of sugars [10]. Grape ripening represents the last physiological process in the chain of biochemical transformation. The climate during the ripening period also plays an important role [48]. Ripening of grape is usually considered to have begun when the skin begins to change its colour. This can easily be observed in the case of red grapes, but when it comes to white grapes, there is not only an observable change of colour but also a change in firmness, with grapes becoming softer. The artificial increase in sugar content affects thus only one aspect of quality, being more disturbed by poor grape ripening. The procedure leading to the cartography of sugar content should proceed in stages. First, it must be specified how the grape's sugar content will be determined, followed by translation of the obtained knowledge into area limits of the given sugar content. Both stages have their own characteristics, such as [48]:

-Using the knowledge of the scientific literature;

-Statistically processing relationships between sugar content and explanatory variables;

-Owning a sufficiently dense and representative measurement network of the explanatory variables;

-Comparing different grape varieties regarding a reference value.

There are many causes of the variation in sugar content: climate, yield, nature of the grape varieties, soil, plot topoclimate, and vine-growing methods [48]. In 1979 S. Meriaux, H. Rollin, and P. Rutten studied vineyards in Languedoc [42]. They concluded that drought could have a very different effect depending on the period in which it occurs, being able to reduce the yield and/or sugar content (i.e., without changing the yield) depending on the case [48]. As it can combine experience with progress, AI is, therefore, used in many areas related to agriculture and, implicitly, viticulture and winemaking, in order to combat problems and concerns such as climate change, pests, diseases, insects, vine well-being, and the assessment of wine and must quality (such as through bubble and foam-related parameters). Artificial intelligence techniques can therefore be used as reliable tools by winemakers in formulating their decisions. For example, ANNs are used to determine different (wine) aromas. In the following, some concrete examples of the application of AI in the wine industry are presented. The group data treatment method (GDTM) is suitable for processes that are non-linear, complex, or little known [11, 28]. According to Cleran [11], who compared the GDTM method with neural networks in predicting alcoholic fermentation kinetics, neural networks are provide more accurate predictions than GDTM. On the other hand, GDTM is more robust when applied to atypical fermentation samples. In his paper, Bouyer (1991) [8] evaluated the potential of neural networks for simulating alcoholic fermentations. The experimental values were estimated in laboratory scale fermenters with online monitoring of kinetics [30]. Another experiment was developed with the aim of forecasting the risks at the beginning or in the middle of the fermentation process. This consisted of the combination of statistical and neural networks for predicting the risks of sluggish and stuck fermentations [28, 51]. Moreover, the experiment aimed to compensate for the lack of analytical information with accurate kinetics information (instantaneous CO_2 production rate) and by testing quantities of several types of must. There are networks that can process data regarding fermentation defects [28].

I. Alvarez [2] used the NeuroAgent (IntelliSphère) software, which allows knowledge originating from learning and knowledge extracted from the expert to be visualised in a similar way. Other well-known programs used for neural networks and artificial intelligence are MATLAB and NeuroSolutions.

AI technologies economic impact in viticulture

AI can determine or predict wine quality based on the distribution of its components, track the aging process in barrels, and perform a sensory analysis of the wine. This can directly affect the productivity of the winery, with clear financial advantages and economy of time [13].

Artificial intelligence algorithms allow to analyze and search for interactions in large amounts of data, resulting from many sensors and observing many processes. To maximize the benefits, high-quality data from robust, reliable, low-maintenance, low-cost sensors should be available and collected, and efforts should be made to specify the required data quality [55].

These benefits can generate resource cost savings, improved product quality, faster actions with lower risks, and increased production [47, 59].

According to the research of Burks, Schmouldt and Steiner (2008) [9], the introduction of robotics in agriculture can create more jobs in the general economy than it could initially destroy. It is not realistic to consider just replacing workers with machines because there are many crops for the production of which there is not much skilled labour available, such as pruning in French vineyards.

The requirements for AI advancement in agricultural operations should include a deeper sector-targeted evaluation of the risks, compared to the benefits that AI's restrictive requirements may bring to society [10, 28].

Finally, AI should be considered as a valuable tool for a sustainable viticulture, which is defined as the "global strategy at the scale of grape production and processing systems, incorporating at the same time the economic sustainability of structures and territories, which produce quality products, taking into account the precision requirements in sustainable viticulture, the risks for the environment, product safety and consumer health [41].

Among the most relevant uses of AI and projects implemented in the Romanian viticulture and winemaking the following initiatives can be mentioned: 1) the BIT Software solutions for viticulture, which are specialized and comprehensive applications for wine producers, managing all processes from land and crop management, planning and production of grapes and wine, bottling and labeling to distribution [67]; (2) iOla or the "virtual engineer" is a network of sensors, which collects information, interprets it with the help of AI, and the generated data then helps to make predictions about the environment so that it can be more easily controlled. iOla Agritel is a dedicated solution for agriculture that combines sensors, drone/satellite imagery and data from devices that scan the chemical composition of soil and water for irrigation from groundwater and rivers. All this information is processed by a system based on artificial intelligence that helps the farmer in improving the crops, namely by optimizing irrigation and chemical treatments (for example: NPK, pesticides, etc.), protecting the environment and soil degradation [66]; 3) Jidvei, a renowned Romanian wine producer, in collaboration with Orange and Teraseya, opted for intelligent agriculture through a series of technologies and equipment such as LoRa WAN network, Live Objects solution and different types of sensors of the highest quality. The Teraseya platform designs maps of variable application for areas or parcels with risks of disease or frost, determines the type of soil and the most suitable grape variety for it. It also shows exactly where fertilizers should be used and where irrigation is needed, for a maximum harvest yield [69].

CONCLUSIONS

Most researchers agree that AI is unlikely to develop and display human emotions, such as love or hate and that there is no reason to expect AI to become deliberately benevolent or malicious. AI promotes decentralized information in open-data environments and can help the viticulture and wine production to develop in a more efficient way. Among the fields in the viticulture and wine industry where AI technologies can be successfully applied the following can be mentioned the recognition of different types of wine; the recognition of yeast strain; the recognition of must variety; the forecasting of wine aroma, the prediction of the evolution of the parameters in fermentation processes; the prediction of the acidity content; the wine fermentation control; the wine blending optimisation; the artificial wine taster; the disease detection in different crops; the precision pesticide sprays; the crop yield predictions; the construction of wine barrels; the control of the oxygen transmission rate from within the barrels; the prediction of alcoholic fermentations; the overall mapping (GIS). Finally, integrating data analyses from sensors and other data-retrieving devices, AI machines can supervise the whole wine-making process and recommend measures for improvement that are based on the obtained information.

Although currently in Romania the wine sector is not at a very technologically advanced stage, digitization presents a huge potential, having major benefits for improving productivity, the yield of vineyards, and finally to improve the overall efficiency in the entire wine sector. In addition, AI increases and improves the ability to take decisions and solve problems and can contribute to a healthier diet by minimizing the use of fertilizers and pesticides, as well as to a more sustainable agriculture, for example through the reduction of the impact of the overall activity on the environment.

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BIBLIOMETRIC STUDY ON THE IMPORTANCE OF USING CREATIVE ACCOUNTING IN FINANCIAL REPORTING

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Abstract

The current research aimed to analyze scientific production, using bibliometric analysis as a research method, with the aim of understanding the current structure of studies and future research directions related to creative accounting, how to use creative accounting practices and the role or in financial reporting. 13,463 documents published between 1999-2023 were identified in the Web of Science database and 24,461 researches in the Scopus database, which were refined according to 2 more terms: "user perception" and "impact on financial results" . 80 articles were retained for the last stage of research, whose scientific content was analyzed with the help of VOSviewer software, performing both descriptive analysis and performance analysis, as well as scientific mapping from the perspective of the conceptual, intellectual and social structure. In order to determine research gaps, the 10 most relevant and influential papers were analyzed, these being established in relation to the number of citations, which was between 32 and 168. The research results highlighted the fact that half of the analyzed articles are reviews of specialized literature, which highlights gaps in primary research on creative accounting. What is worth noting is the fact that case studies or empirical studies based on questionnaires or the analysis of data sets related to financial reporting, address both aspects related to large companies listed on the stock exchange, as well as those related to medium and small companies. The studies followed the techniques of creative accounting and the way of financial reporting, both for private and state companies, both companies that benefited from external and internal financing, demonstrating the complex interest in the issue of using creative accounting. The gaps identified in this study will constitute future research directions in the field.

Key words: *creative accounting, financial engineering, accounting reporting, ethics*

INTRODUCTION

In an era in which information ciculate vrey fast and they are time subject to the phenomenon of globalization, which makes the competition to become stringer and strnger, and decision-making is essential as a result of the complexity of economic phenomena, it is important that information to be of high quality and permanently aligned to legislative changes. At the same time, the correct use of accounting information allows decisions to be made that lead to a decrease in the fiscal pressure to which economic entities are subjected, with a direct impact on the results obtained. In this context, creative accounting is the one that correlates an important amount of data with the aim of optimizing financial reports and results [14].

The tendency to apply some creative accounting means has existed since the appearance of economic phenomena, but the awareness of the use of such methods or the recognition of such phenomena appeared much later. In 1993, Naser K. states that since 1920 there has been a tendency to manipulate accounts [17]. The first work identified in the Web of Science database regarding the use of the term creativity and accounts appeared in 1976 and belongs to Scandura J.M., a mathematician who explains the way in which mathematics can be used creatively to optimize some results [19]. In 1953, however, Hepworth, even if he did not clearly define creativity, found that in business management there has always been a tendency related to the possibility of manipulating the value of taxes and fees, this being started from the need to increase the confidence of shareholders regarding the performance of management and the increase of own incomes [10].

In 1968, Copeland considered that the repetitive use of some rules, both accounting measurement and financial reporting, which results in the reporting of revenues, which, although they have a small variation, can constitute financial engineering techniques or in other words creative accounting [8].

In 1978, however, Kamin and Ronen noted that there is a difference in motivation in the application of these tools, which is given by the profile of a company. Thus, in the case of owner-managed companies, as opposed to those controlled by employee management, it is found that there is much less interest in the use of financial engineering techniques [11].

In the last period, however, the concept of creative accounting is more and more often brought into discussion, being identified with the process of manipulating accounting information by professionals in the field, both accountants and managers with the aim of increasing earnings [3, 9, 21].

Some authors consider that the application of creative accounting can affect the business in the long term, being only a form of manipulation used at a given time [15]. The negative impact is due to other authors, the fact that it is based on the exploitation of legislative deficiencies or normative ambiguities, which are not always considered honest [20, 23].

Raileanu et al. al. considers that the early identification of creative accounting techniques could have contributed to avoiding the major financial scandals that have affected the world in recent decades, proposing to limit their use [18].

On the other hand, most authors recognize the fact that creativity does not always have a negative connotation, that the use of means and procedures to minimize or maximize results has always existed, but the reason is different, depending on the users (investors, creditors, state, etc) [24], and that these decisions appeared due to the accelerated development of markets and the proliferation of financial products.

Recently, however, the research on creative accounting has intensified and although there is still no consensus on the definition of the concept, there are various approaches. That is why, in this article, we propose to analyze both the procedures, policies and techniques identified by various authors regarding creative accounting, as well as the purpose pursued and its effects on companies and on the entire economy.

From the analysis of the specialized literature, it emerged that creative accounting has always been used, although the term under which it appears differs from one country to another: Fabricated numbers or earnings management in America, Accounting for profits or Window-dressing in England, Balance sheet manipulation or heisse Luft in Switzerland, Winstegalisatie, Creatieve jaarverslaggeving or Windstflattering in the Netherlands, Fabricated accounts or Bricolage in France, Manipulative accounting or Feral accounting in Australia, Furyo Kessan, Funshoku or Mae-da-oshi in Japan [1].

In this context, the goal of this study was to analyze scientific literature in the field, using bibliometric method, tfor a better understanding of the current structure of studies and future research directions related to creative accounting, how to use creative accounting practices and the role or in financial reporting

MATERIALS AND METHODS

The choice of bibliometric analysis as a research tool was determined by the fact that it is a research method that involves the inventory of the activity of publishing scientific articles at the global level, being used in the comparative analysis of productivity in the scientific field [13]. It also evaluates the performance of the research centers, which is a complement to the standard evaluation procedures, representing reference points for the concerns in the field, considering the fact that longitudinal studies of scientific interests contribute to the determination of research areas, which they can evolve or regress.

The current research followed the analysis of the relevance that the concept of creative accounting has within the specialized literature. To identify the most relevant scientific articles, the Web of Science and Scopus databases were used, some of the most popular platforms in the scientific world, which contain relevant publications, being used at an international level and within which articles published yet can be found from the beginning of the 19th century until now.

At the same time, the purpose of the research was to provide a critical picture regarding previous studies and to identify the main challenges and opportunities related to the use of creative accounting in financial reporting. Achieving these objectives was based on the following research questions (RQ):

RQ1: What are the research groups on the topic of using creative accounting techniques?

RQ2: What does the distribution of scientific research production look like regarding creative accounting?

RQ3: What are the main research gaps in creative accounting and future research avenues in this field?

Therefore, the bibliometric analysis was the quantitative research model that could answer these questions.

The date on which the two databases were consulted was November 29, 2023. To carry out the bibliometric analysis, we started from a first keyword "financial engineering", being identified a number of 23,543 articles and works within the Scopus database. The same search was performed in the WOS database. Further, the research was refined by using an alternative word, much more current for the current period, "creative accounting" with a number of 13,463 researches identified in the WOS database and a number of 24,461 researches in the Scopus database. The refinement was achieved by using 2 other terms, namely: "user perception", obtaining 7,989 articles from the WOS database and 885 articles from the Scopus database, respectively "impact on financial results", thus reaching a number of 80 representative articles in the Scopus database, articles that have been analyzed in the present article, with the help of the VOSviewer software. In the interpretation of the data, the size of the nodes in the generated network indicates its relevance in the research, and the thickness of the curves, but also the distance between the nodes represents the connection between the analyzed elements.

RESULTS AND DISCUSSIONS

As can be seen from Figure 1, starting with the year 1954, the subject of creative accounting techniques and how they influence the results of a company, begins to attract the attention of researchers, the number of articles published on this topic increasing from 27 in 1970 to 1,322 in 2021. In 2023, the number of articles published until November 29, 2023 was 1,098.

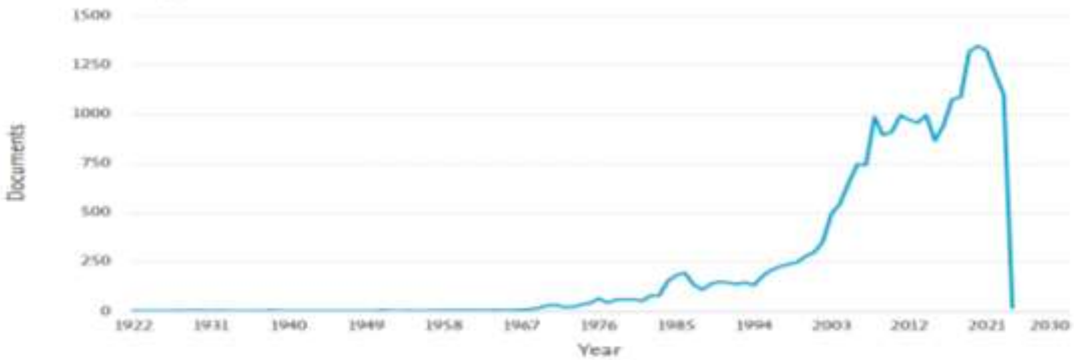

Fig. 1. Evolution of the number of articles published in the field of creative accounting
Source: WOS [28].

From the analysis of the relationship established between the first 100 co-authors of the articles with creative accounting as their theme and who published a minimum number of 5 articles on this theme, it emerged that they are grouped in 7 clusters, among which a number was established total 673 links. The highest number of links established with other authors belongs to Wang I. with a number of 37 links.

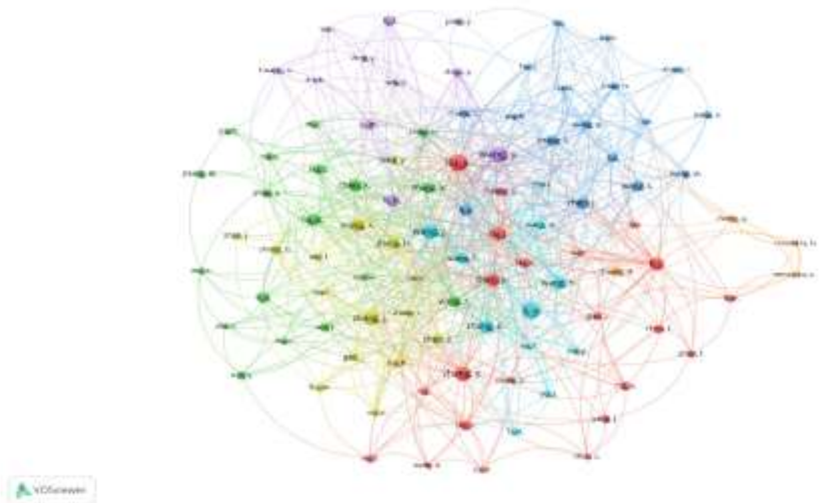

Fig. 2. Distribution of scientific research according to co-authors
Source: VOSviewer own processing.

Analyzing the links established between the first 30 key terms used in the 80 analyzed articles, and starting from a minimum number of 5 key words used simultaneously within an article, it was found that the most important terms were: risk perception (with a a number of 48 occurrences and with 212 established connections); risk assessment (with a number of 27 occurrences and 159 established links); risk management (with a number of 18 occurrences and 106 established links); risk analysis (with a number of 14 occurrences and 88 established links); value engineering (with a number of 16 occurrences and 87 established links).

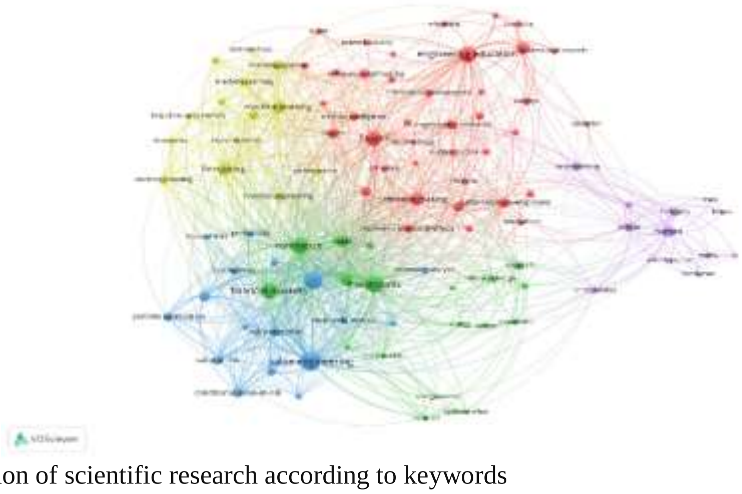

Fig. 3. Distribution of scientific research according to keywords
Source: VOSviewer own processing.

This proves the fact that creative accounting techniques have always been analyzed in close correlation with their financial effects and their risks. Following other key words, we find that not only the incomes, but also the costs, but also their effect on the obtained results were the basis of the use of creative accounting, looking every time for the most effective solutions, but also calculation algorithms with the aim of making decisions more efficient taken.The 30 keywords were grouped into 4 clusters between which 220 links were established, which highlight, as we show, the relationship between risks and the economic and social effects that the decisions made produce.

Analyzing the authors' concerns regarding the perception that users of accounting information have regarding the use of creative accounting techniques and their effect on the results obtained, and setting as conditions: the publication of a number greater than 5 articles/country and a greater number of 5 citations per article, it resulted that the analyzed articles belong to a number of 152 countries, of which only 52 met the established criteria. The 52 countries were grouped into 8 clusters, between which a number of 273 links were established.

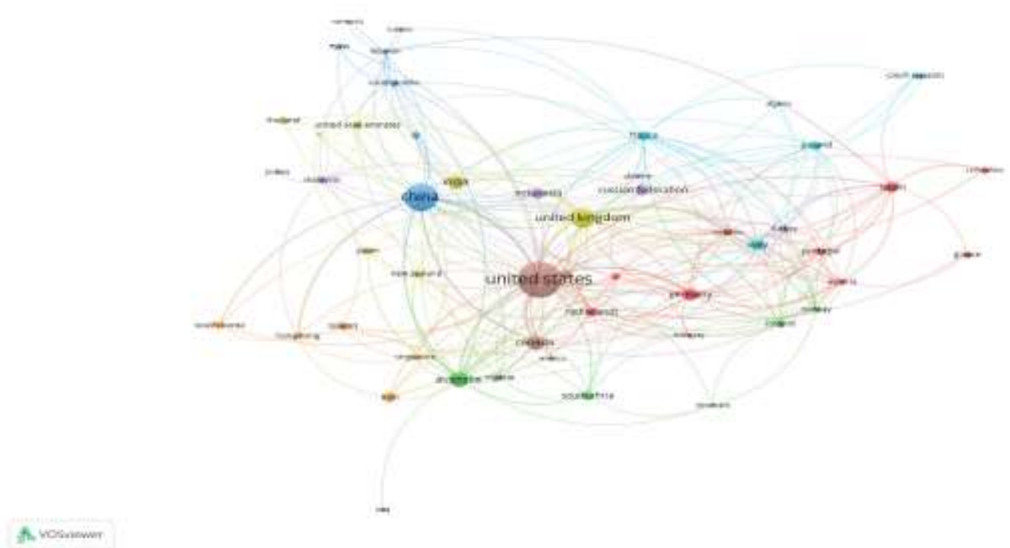

Fig. 4. Distribution of scientific research by country
Source: VOSviewer own processing.

Among the top 10 countries are America, England, China, Australia, France, Canada, Germany, Italy, Spain and Sweden. Romania is on the 50th place with 5 articles published on this topic, which highlights the fact that the subject is one that should be debated, considering the fact that among the countries of the European Union, Romania is in 2023 on the last place in terms of revenue VAT and in the penultimate place in terms of tax evasion.

Or the relationship between the correct application of creative accounting techniques and tax evasion is a direct one, and the awareness of the use of these techniques and their application method can contribute both to improving the results obtained by companies, to improving their relations with the state, but also to increasing the degree of collection which in turn has a direct impact on the budget.

Analyzing the main research groups in the field of creative accounting techniques (RQ1) it is found that in the first 10 there are centers of some universities or research institutes from Europe and America.

The largest share of articles (22.07%), from the total of 743 articles, belongs to the University of London (164 articles), followed by the Ministry of Education Science of Ukraine with 14.67% (104 articles) and the University of California System with 14.00% (104 items).

The other research centers have published their concerns related to "creative accounting" in a number of between 39 - 58 articles (University of California System - 58; Center National de la Recherché Scientifique CNRS -

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53; Russian Academy of Sciences - 49; Harvard University – 44; University of Texas System – 40; University of Leeds – 39; University of Oxford - 39) (Fig. 5).

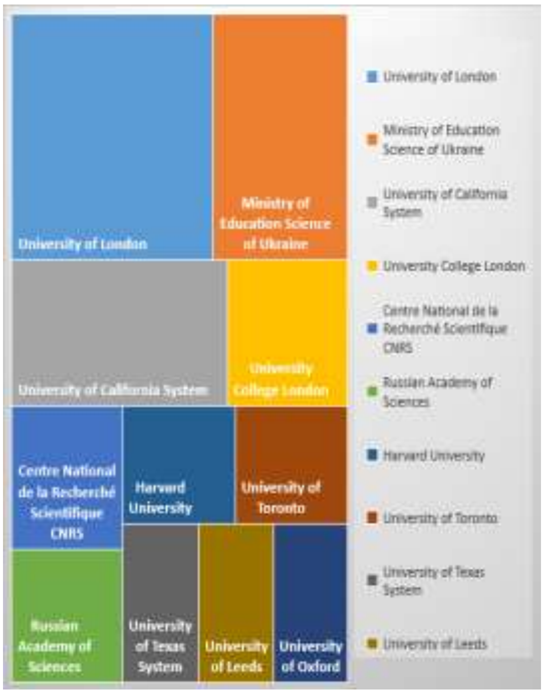

Fig. 5. The main research groups in the field of "creative accounting"
Source: own processing according to Scopus [22].

Analyzing the countries with the largest number of articles and scientific research in the field of creative accounting, we find that in descending order, on the first 5 places, the following are ranked: USA, Australia, China, Indonesia and Brazil (Fig. 6).

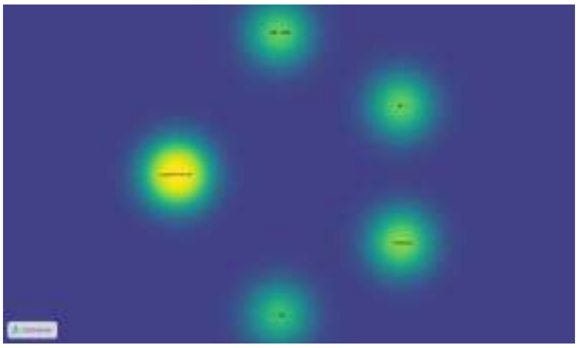

Fig. 6. Distribution of scientific articles, by country
Source: VOSviewer own processing.

The analysis of the distribution of scientific production in the field of creative accounting, namely the number of citations analyzed compared to the number of publications (RQ2), starting from the WOS database, highlights the fact that the number of citations increased in the period 1999-2022. In 2022, their highest level was reached (620 citations) (Fig. 7).

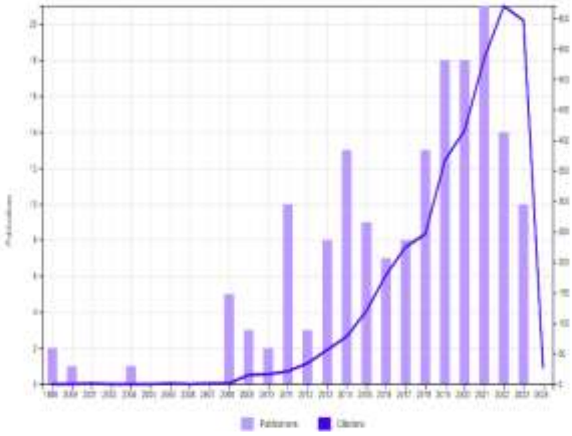

Fig. 7. Evolution of the number of works and citations from the period 1999-2023
Source: own processing according to WOS [28].

Regarding the number of articles, they reached the highest number in 2021. It is noted that the subject began to have interest in the scientific environment once the economic crisis of 2008, a turning point in the economic environment, when it began to be discussed the subject of "manipulation" of accounting information and the role it had in the presentation of financial statements and in triggering the global crisis.

In order to determine research gaps and to develop research paths in the field of creative accounting (RQ3), the most relevant works in the field were analyzed. 118 articles resulted from the application of the filters, but only the first 10 were retained, the number of citations being the criterion used. The main findings of the analysis undertaken are presented in Table 1.

What the analysis of the 10 most cited articles in the field of "creative accounting" highlights is the need for empirical studies and primary sources, which can thus evaluate the impact of the application of these techniques in an environment that is in continuous change, as a result of countless tax changes which tries to ensure the transparency of financial reporting in the conditions of globalization.

Table 1. Summary of research results in the field of "creative accounting"

Author(s)	Year of publication	Scopus Category	Number of citations	Main findings
Beneish, M.D.	2001	Managerial Finance	168	The research analyzes how widespread the earnings management procedure is, reducing or increasing revenues in relation to the financial interests of companies. At the same time, the earnings management incentives are also analyzed, proposing the expansion of future research. The paper also presents the specialists' perspective regarding the analyzed phenomena, which in fact constitute elements of "creative accounting" and "financial engineering" [4].
Milesi-Ferretti, G.M.	2004	Journal of Public Economics	153	The current research highlights the fact that the "relaxed" fiscal regulations are what lead companies to resort to fiscal optimization and the use of "creative accounting". At the same time, it shows that the detection of "creative accounting" tools is difficult to achieve, this depends on several factors, including the degree of use of financial engineering and the transparency of financial reporting [16].
Tsalavoutas, I., André, P., Evans, L.	2012	British Accounting Review	85	This paper analyzes aspects related to the application of IFRS in Greece, compared to the previous regulations, through a case study made for a number of companies listed on the stock exchange. The accounting value of own capital and that of net income are analyzed, elements that express the value of a company. The method of management and accounting reporting of these indicators can be seen as a way of fiscal optimization, therefore the perspective of the users is followed, being the reconciliation between the national accounting regulations and IFRS, under the conditions that the value is important both for shareholders and and for other categories of investors [26].
Vinnari, E.M., Näsi, S.	2008	Scottish Journal of Political Economy	55	The paper analyzes the role of accrual accounting and its application in the public sector, following the perception of its use both from the point of view of practitioners and from the point of view of academic specialists. The research highlights the fact that the accrual accounting of the public sector, in turn, offers opportunities for the application of creative accounting and earnings management tools. However, it is shown that this system is much less permissive when reporting is done according to international regulations, and not national norms [27].
Bernoth, K., Wolff, G.B.	2008	Scottish Journal of Political Economy	55	The paper analyzes the effects of applying "creative accounting" on bond yields. The case study is carried out at the level of the European Union, a constant spread of these techniques that result in an increase in the risk premium. However, considering that fiscal transparency leads to a decrease in risk, this is proposed as a measure to reduce the negative effects of interest management in the case of bonds [6].
Baralexis, S.	2004	Managerial Auditing Journal	48	Noticing the inefficiency of applying the same analysis models of capital markets both in the case of large and small countries, the author investigates the perception of the application of "creative accounting" practices in Greece. Stating that these are quite widespread, he identifies the methods of use and the reasons for resorting to such practices, showing that in the case of large companies it is an overestimation of profits, and in the case of small companies it is an underestimation. The purpose of overvaluation is to increase external financing, and that of undervaluation is to reduce taxes. At the same time, the author also identifies solutions, emphasizing the fact that the reporting mode is important both for internal users and for those external

				to the companies [2].
Maltritz, D., Wüste, S.	2015	Economic Modelling	43	The paper approaches a panel research with the aim of identifying fiscal rules and their impact on the way of accounting reporting. It is also analyzed, the specialized literature following the "creative" ways of interpreting and applying the accounting legislation at the level of the EU countries. The study thus establishes the significant influence of fiscal rules on stock-flow adjustments, which influence accounting reporting decisions [12].
Benito, B., Montesinos, V., Bastida, F.	2008	Critical Perspectives on Accounting	42	The research analyzes the method of accounting recognition of private financing, based on a case study carried out in Spain, as well as the mode of their transfer in the financial statements, considering them as an example of the use of "creative accounting". Thus, we find that the current research also addresses particular aspects related to the application of "creative accounting" tools [5].
Tassadaq, F., Malik, Q.A.	2015	International Journal of Economics and Financial Issues	33	The research empirically investigates the issue of applying "creative accounting" in financial reporting. It is one of the works that brings into discussion the issue of ethical responsibility of creative accounting, and the role that financial auditors, legislative regulations, etc. they have it on its practical application. The research is both documentary and applied, based on a case study based on the collection of information. The study recommends the cautious use of "creative accounting" tools, because although they do not contravene the law, it can be associated with manipulative behavior, with a negative impact on the image of any company [25].
Carlin, T.M., Finch, N.	2011	Pacific Accounting Review	32	The research has an empirical character, based on the results of the audit of a number of 200 companies listed on the Australian stock exchange, regarding the determination and registration of goodwill, one of the elements that allow the manipulation of accounting information. The work highlights the level of difficulty regarding financial reporting, due to the accounting rules (IFRS). What adds to the work, compared to the previous researches, is the complex perspective regarding the depreciation of the goodwill, thus testing the quality of IFRS compliance [7].

Source: Own precessing.

Regarding the research methodology, it is found that half of the papers are based mainly on the review of specialized literature, the others are based on other secondary research methodologies and on case studies, which analyze both the public and the private domain, both the case of listed entities, such as small companies. The obtained results are aimed at improving the way of accounting reporting and ensuring transparency.

CONCLUSIONS

The present research, based on the bibliometric analysis of scientific research works in the field of creative accounting, had as its goal the development of research in this field, starting from the fact that longitudinal studies are the ones that contribute to the clarification of research directions. The results obtained allowed us to create an objective scientific mapping of how scientific production evolved in the analyzed period (1999-2023) and allowed us to create a map of the knowledge that was disseminated through the research conducted.

There is a growing interest in the subject of creative accounting in recent years, but especially since 2008, the year the global economic crisis started. The non-existence of a sustained pace of researchers, considering the fact that the maximum number of works/author/authors who addressed this topic is 4. Analyzing the most relevant and influential articles, from the point of view of citations, we find that for the first ten articles, the number of citations varies from 32 to 168 citations. On the other hand, only half of them are based on case studies, the rest being bibliographic analyses, which highlight the need to publish more case studies, which help to understand creative accounting practices and the way of accounting reporting.

We consider that the contributions of this research are the following:

• the work offers a major contribution in the scientific field of understanding the use of creative accounting as a result of the systematization of existing knowledge

• identifying research gaps, which requires the realization of empirical and primary studies in the field of creative accounting

• the research identifies both the aspects not covered, but also their limits, thus offering opportunities regarding the expansion of scientific research in the field of creative accounting

In turn, the research carried out has some limitations that can nevertheless be considered as a foundation for conducting future studies.

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ANALYSIS OF THE PERCEPTION OF ROMANIAN CONSUMERS REGARDING THE PRACTICE OF CREATIVE TOURISM AND ITS ROLE IN SUSTAINABLE LOCAL DEVELOPMENT

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Abstract

Tourism, as a form of spending free time, has undergone numerous transformations in the last period of time, this is due both to globalization that contributed to the internationalization of tourist experiences, but also to recent events (such as the Covid-19 pandemic, economic crises, etc), but also changing the perception of tourism consumers regarding how they can spend their free time. Traditional or well-known destinations have started to face overcrowding, which is starting to be felt negatively by both residents and visitors who are starting to change their consumption habits regarding the locations they choose as tourist destinations. On the other hand, the challenges of the modern world regarding the effects of global warming, the sharp increase in the population, the depletion of planetary resources, but also the much greater concerns of the current generations regarding these aspects, make the choices we make regarding the choice leisure destinations to change and become more responsible. In this context, creative tourism as an increasingly sought-after option, among a growing category of consumers. In this paper, we set out to analyze the perception that tourism consumers in Romania have regarding this form of tourism. The research assumed, on the one hand, a bibliographic analysis regarding the term creative tourism and how this notion has evolved from the moment of its definition as a form of tourism in the 2000s until now, as well as from a study of case based on the application of a questionnaire to measure the perception of consumers regarding this form of tourism, but especially on the awareness of its existence. The questionnaire had 16 questions answered by 124 respondents. The data were centralized and interpreted with the help of the Excel program, the results highlighting the fact that although some of the respondents practice creative tourism, it is quite little known as a concept. The answers given by the study participants highlighted the fact that they are interested in practicing activities integrated into creative tourism, considering that there are many advantages both regarding the experiences they create, with the interactions they establish with the locals or with the other participants. At the same time, the impact that creative tourism practices have at the local level (both economic and social) is recognized. We consider that these results are useful not only at the micro level, but also at the macro level, under the conditions that the development strategies of the field of hospitality will be thought in such a way as to promote, integrate and develop this form of contemporary tourism.

Key words: *creative tourism, local development, density, sustainability*

INTRODUCTION

Like any business, tourism is an activity that, in order to meet the increasingly high demands of consumers, must reinvent itself and identify new solutions to attract them. The inclination of tourists to return to their origins, their desire to spend free time in nature, but also the desire to protect it, make creative tourism, as a form of tourism practice brought into discussion at the beginning of the 2000s in an OECD report, to represent one of the solutions of these searches [3, 20].

The report considers that the relationship established between tourism and culture has led to its development, and the creativity associated with it has contributed to the development of conventional tourism models and their transformation into innovative, creative products, much more adapted to the modern world, constantly looking for new challenges [4, 12]. In this way, creative tourism can contribute to increasing the attractiveness of tourist destinations, as well as to the local development of those areas, considering that it can develop both in well-known areas, but especially in areas that are less known or with less notoriety. Although initially creative tourism was related to big, cosmopolitan cities, its development possibilities are multiple. To an equally great extent, creative tourism can also be developed in smaller localities whose potential can be exploited by creating new experiences for the tourist due to participation in practical activities carried out with the community or unknown persons, and which also have a durable character. In the same way, you can rely on local gastronomy, on the creation of emotions, memories, experiences, traditions, customs, from which emotional links established between the tourist and the destination can result.

In this respect, creative tourism has been intensified during the Covid-19 pandemic [10].

Although the first definition given to creative tourism belonged to Richard Greg according to which it offers a way of redesigning cultural tourism, a non-interactive way that can create captivating and unforgettable experiences for visitors attracted to cultural activities, and not only that, with a positive effect on both parties [15, 16], we can consider that a reference to this concept was made by Pearce and Butler, in 1993 [22].

UNESCO is the organization that started the discussions regarding the identification of new forms of tourism, defining in 2006 creative tourism which was understood as a way of spending free time that can lead to authentic experiences (cultural, heritage, etc.), as a result of the participatory learning of the tourist and his connection with the inhabitants, with their customs and experiences [24].

That being the case, creative tourism cannot be reduced only to rural areas, because it can equally be developed in urban areas.

The UNWTO definition includes in the category of creative tourism art, architecture, music, literature, cultural traditions, culinary traditions, etc. i.e. all categories of industries that are creative, that participate in the realization of a lifestyle, that imprint a system of values or beliefs [25].

However, the definitions and appreciations, the identified characteristics of cultural tourism are diverse and expressed by different authors.

Tan et al. considers that creative experiences in tourism refer to novelty and usefulness, to existential experiences and activities, but also to the application of a controlled risk related to the loss of cultural identity [21].

What distinguishes cultural tourism from creative tourism is the reduction of the experience that tourists have and that is due to its transformation into a tourism rather than mass tourism, in which tourists concerned with the exchange of experiences with the locals, adopting their objections and traditions, are removed [14, 17, 19]. However, many authors show that most forms of manifestation of creative tourism had cultural tourism as their starting point [5, 7]

Chugh considers that creative tourism is participative in nature, which involves the development of emotional bonds between participants and which makes tourists return to that destination, as a result of their emotional attachment to that destination [1].

Cloke, for his part, considers that in order to achieve a creative tourism, one can resort to the combination of different elements, in different ways, resorting to feelings, experiences, replacement or modernization of traditional forms of tourism [2].

Markusen et al. considers that by creating some spaces, some creative activities contribute directly to the animating of public and private spaces, to the architectural revitalization and streetscapes (a good example and model of Uramt being the cultural capitals - Sibiu - 2004, Timisoara - 2023), to increase the viability and visibility of some local businesses and, last but not least, to increase public safety [8].

Ricards considers that creative tourism cannot be a form of mass tourism, but a small-scale one, which involves a small number of visitors, who have a responsible attitude towards the environment and community and who want to determine economic, social and cultural, and not just attracting tourists [13, 15, 18].

However, there are also authors who consider that the use of forms of creative tourism should be approached with reluctance or perhaps only critically when the question arises of the application of the ways of encouraging and supporting this form of tourism. This aspect is related both to the understanding and application of the concept of creativity and, on the other hand, the quality of the programs offered and which have a strong financial impact on the national and local budgets [6, 11, 23].

The adoption of a creative tourism, like any other form of tourism, must balance its advantages and disadvantages.

As far as local communities are concerned, they develop by increasing the population's income, by increasing social cohesion, by increasing equal opportunities, by integrating different complementary activity sectors, by showing a less aggressive tourism with the environment [9]. On the other hand, there is more and more talk about overtourism, about the fact that the residents no longer want to share their space with tourists looking for a perfect photo (protest of the residents of Hallstatt, 2023), a unique experience, visiting some places consecrated (Venice, Barcelona, etc.), of the invasion of some localities that still retain their local charm (Viscri, Romania).

However, this form of tourism is one that relies on creativity, modernity, open-mindedness, education, so that the negative effects of its practice can be much more easily understood and reduced, and its advantages can be turned into success.

MATERIALS AND METHODS

Our research started from the analysis of the specialized literature, as a documentation stage, which had as its purpose both the definition and the identification of the main characteristics of the concept to be analyzed, as well as the identification of the strong points and the weak points related to its practice. The second stage consisted of completing the questionnaire composed of 16 questions. And the third stage, which took place between September and November 2023, involved uploading the questionnaire to collect respondents' answers regarding creative tourism. 124 questionnaires were thus collected. The questions that were the basis of this research had the aim of providing, on the one hand, demographic information about the respondents, and on the other hand, information about the concept of creative tourism. At the beginning of the questionnaire, information was provided regarding the definition of the concept.

The concrete questions refered to tourism were the following:

(*5) Before completing this form, did you advance the term creative tourism?*

(6) What are the forms of tourism that you have practiced so far?

(7) Have you practiced a form of creative tourism until now, even if you don't know the concept?

(8) If you practiced creative tourism, did it take place in Romania or in another country?

(9) What kind of accommodation do you prefer?

(10) How do you travel or go on vacation?

(11) What are the aspects that determine you to choose a certain tourist destination?

(12) What was the form of booking the destination?

(13) Do you prefer to go to new locations or do you return to a location that you liked?

(14) Do you consider that creative tourism is a form of tourism that you want to experience?

(15) What are the reasons for choosing creative tourism as a way of spending free time?

(16) What do you think is the impact of creative tourism on the environment, compared to traditional tourism?

The questions that formed the basis of the questionnaire were closed questions.

The limits of the research were given by:

• the information collected on the basis of the questionnaire is at the level of the perceptions of those surveyed

• there is a certain difficulty in attributing the effects identified by the respondents

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• data analysis using descriptive statistical methods, not duplicated by other categories of methods
• lack of control groups

The group of respondents

A number of 147 respondents answered the questionnaire, of which only 124 provided complete answers.

Statistical methods were used to process the data, which were later presented in the form of tables or graphs. Based on these, opinions were formulated regarding the creative tourism, as well as conclusions and recommendations.

RESULTS AND DISCUSSIONS

The answers obtained based on the questionnaires applied online through the Google Forms application were centralized and processed with the help of the Excel program.

Table 1. The socio-demographic characteristics of the respondents

	Frequency	Percentage
Gender		
Female	72	58.06
Man	52	41.94
Age		
20-35	27	21.77
36-45	41	33.06
46-55	34	27.42
56-65	17	13.71
over 65	5	4.03
Education level		
High school	41	33.06
University	59	47.58
Master	21	16.94
Doctoral studies	3	2.42
Residence environment		
Urban	86	69.35
Rural	38	30.65

Source: Own calculation.

Of the 16 questions in the questionnaire, the first four had a demographic character. Thus, of the 124 people surveyed, 58% were female and 42% male. Of their total, 69% live in urban areas and 31% in rural areas. Regarding the segmentation by age category, it was found that 22% of the respondents were between 30-35 years old, 33% between 36-45 years old, 27% between 46-55 years old, 14% between 56-65 years old and 4% older than 65 years. Among the 124 respondents, most have university (42%) and high school (33%) degrees. The share of those with master's studies was 17%, and of those with doctoral studies 2%.

To question no. 5: *Before completing this form, did you know what creative tourism is?* the answers provided highlighted the fact that the concept is little known among the respondents, this resulting from the 89% share of negative answers, compared to the 11% who had affirmative answers.

From the answers to question no. 6: *What are the main forms of tourism that you practice?* question with multiple answer options, it was found that 82% of respondents are those who travel during vacations or vacations, 33% participate in concerts, sports, cultural events, etc. and 29% also travel for business purposes. A rather small share, of only 6%, are those who volunteer during the holidays. Young people up to 35 years of age belong to this category. It is found that 58% of the respondents practice other forms of tourism (adventure, religious, etc.) (Fig. 1).

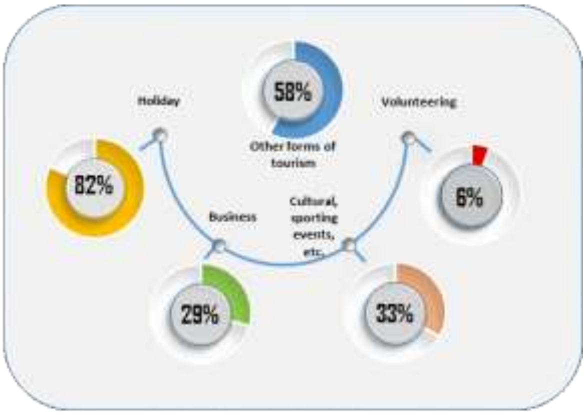

Fig. 1. Share of the main forms of tourism practiced by the respondents
Source: own processing

To question no. 7: *Have you practiced a form of creative tourism until now, even if you don't know the concept?* The respondents appreciated in a weight of 27% that they practiced it, and it consisted of carrying out activities specific to the visited area, together with the locals or by participating in different customs or traditions.

To question no. 8: *If you practiced creative tourism, did it take place in Romania or in another country?* of the 33 respondents who answered affirmatively to the previous question, 41% stated that they were involved in creative tourism activities in Romania, 32% in trips they made to other countries, and 27% contacted with creative tourism both in Romania and in other countries. What we could find is that the number of Romanian tourists who are interested in practicing creative tourism is quite low, this is due to the fact that they do not know this concept well enough and they have not encountered enough activities of this kind during their trips made to spend their holidays, vacations or free timer (Fig. 2).

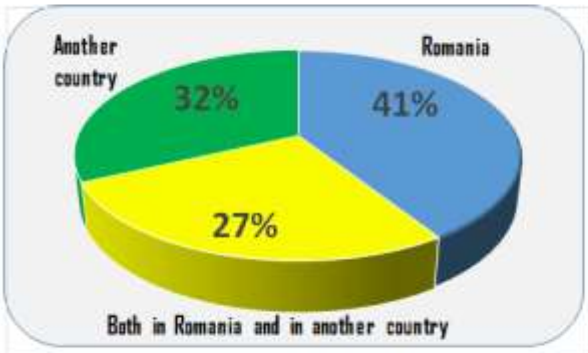

Fig. 2. Share of creative activities in which the respondents participated, in relation to the venue
Source: own processing.

Thus, we find that creative tourism has a niche character, that it has a lower visibility, which is a reason why it also needs a stronger promotion.

In this way, both tourists, hosts and local communities will become much more interested in practicing this form of tourism and will try together to identify solutions, "creative ideas", ways to increase the number of those who practice it and who can thus contributing to the increase of income for the hosts and the community.

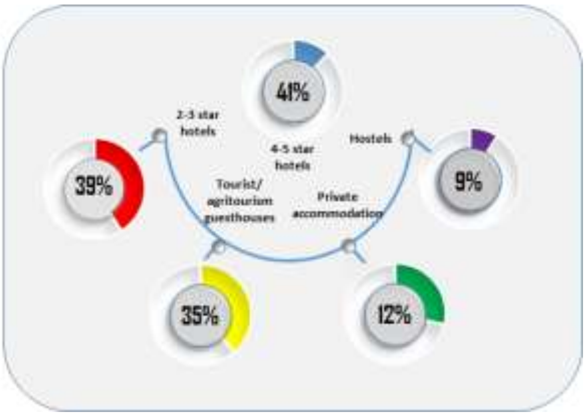

Fig. 3. Share of the type of accommodation preferred by the respondents
Source: own processing.

To question no. 9: *What kind of accommodation do you choose when you go on vacation?* The answer options were multiple, and the survey participants highlighted the fact that they usually prefer hotels; both on 4 and 5 stars (41%), but also on 2 and 3 stars (39%); 35% of the respondents also stay in agro-tourism or tourist guesthouses, and 12% prefer accommodation with private individuals. Only 9% of the respondents stay in hostels, they are generally young (Fig. 3).

The answers given to question no. 10: *How do you travel or go on vacation?*, which also had multiple answer options, highlighted the fact that most of the respondents go on vacation or spend their free time with their family (63%), as a couple (57%), with friends (42%) or in organized groups (39%). Also, 35% of the respondents travel alone, but this is due to the fact that some of them declare that they travel for business purposes. Whatever form is chosen for practicing creative tourism activities, it becomes a way of relaxing or sharing experiences (with friends, with strangers in the group, with locals, etc.).

Moreover, **to question no. 11**: *What are the aspects that determine you to choose a certain tourist destination?* the respondents, who had a choice between five answer options, appreciated that all of them contribute to the choice of the places they visit, the order being the following: the purpose of the trip, i.e. relaxation, visiting some tourist attractions, adventure tourism, etc. (76%), travel costs

(62%), distance (41%), attractiveness (53%) and other considerations (47%). Thus, we find that although tourists pursue quite precise objectives in their trips, a high percentage of them also take into account the costs of the trip, as well as the distance.

To question no. 12: *What was the form of booking the tourist destination?*, the answers provided highlight the fact that the majority of respondents prefer online platforms (67%), but also travel agencies (26%) or booking through the reception unit (34%). Only 6% of respondents go without a reservation.

Digitization, but also the development of digital skills, are an important factor in making reservations. Also, the scores and reviews on the platforms' pages are elements that tourists take into account in the choices they make when choosing an accommodation unit and a tourist destination.

Question no. 13: *Do you prefer to go to new locations or do you return to a location you liked?*, question that had three answer options, highlighted the fact that, in general, tourists choose both well-known locations, to which they return several times , but also new locations (94%). Only 9% of the respondents look for new locations every time and 7% of them prefer only known locations. Since creative tourism is based on establishing connections with the natives, this will result in the tourist returning to those locations, causing him to recommend them to his acquaintances or to express his opinion online. Creative tourism is ultimately a form of experiential tourism, which will lead the tourist to either look for new, unknown locations, but also locations to return to precisely because of the pleasant experiences he experienced.

The answers to question no. 14: *Do you consider that creative tourism is a form of tourism that you want to experience?*, showed that more than half of the respondents would like to experience the activities related to creative tourism, while 18% consider that these activities do not interest them, and 21% do not know if they want to do this (Fig. 4).

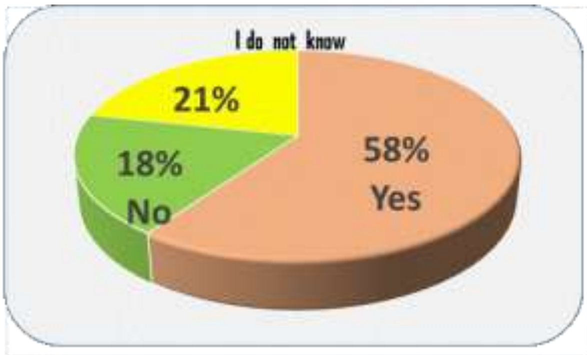

Fig. 4. Structura respondentilor interesati de practicarea turismului creativ
Source: own processing.

Thus, we find that there is a rather high interest among the respondents related to this form of tourism that should be promoted, but this does not depend only on the development of those public policies that I mentioned earlier, but also on the involvement of entrepreneurs, of the local population in thinking of creative activities and developing programs to attract tourists, both Romanian and foreign. According to the Emirati data, the interest of foreign tourists is higher in relation to creative tourism in Romania, compared to Romanian tourists.

By applying question no. 15 we wanted to find out from the respondents: *What are the reasons for choosing creative tourism as a way of spending free time?* The question was a closed one, with multiple answer options, which highlighted the fact that tourists who would like to practice this form of tourism are interested in its sustainability (43%), as well as the fact that it is a pleasant form of leisure (41%) (Fig. 5).

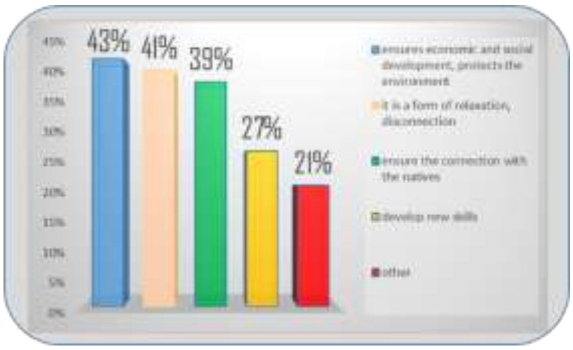

Fig. 5. Hierarchy of reasons for practicing creative tourism
Source: own processing.

At the same time, 31% of the respondents are interested in connecting with the natives and understanding their way of life, while 27% believe that it would be a way to acquire new skills; 21% of the people who answered the questionnaire considered that there are other reasons for choosing creative tourism as a way of spending free time (creating stronger bonds with family members or friends, getting to know new cultures, making new friends, etc.).

To question no. 16: *What do you consider to be the impact of creative tourism on the environment, compared to traditional tourism?*, 63% of respondents assessed that the impact is less, 29% considered that the impact could be greater, and 8% said that "no know" (Fig. 6). As a result of the fact that the motivation of this answer was also requested, among the reasons that were the basis of the assessment of the increase in the impact on the environment were: the increase in the number of tourists who do not always behave in a responsible way, the attraction of tourists to areas less circulated from a tourist point of view and less polluted, above the tourist agglomeration, etc.

On the other hand, the respondents who considered that creative tourism has a lower impact on the environment, motivated the choice of this answer by the fact that it does not produce so much waste that pollutes the environment, that people who practice creative tourism have a certain level of education and a more responsible behavior, etc.

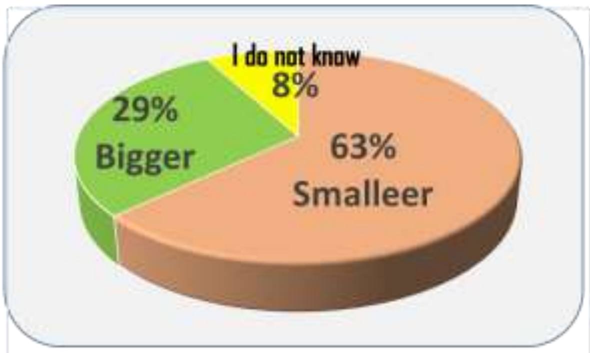

Fig. 6. Impact of creative tourism on the environment
Source: own processing.

Therefore, creative tourism can be considered an innovative model, which, in addition to developing the tourist experience of consumers, can also result in increased sustainability, being a way of

renewal and development of the hospitality industry which can thus combine cultural experiences with learning and entertainment.

CONCLUSIONS

Creative tourism developed as a result of belonging to alternative development models, thus becoming a diversification strategy in a global economy. The desire for uniqueness, to put into practice creative ideas from different fields that can thus participate in the creation of an individualized product, which can refresh classic, conventional tourism, are aspects that have contributed to the development of this form of tourism. In this way, creative tourism is a form of contemporary tourism, which becomes much more adapted to the wishes and expectations of the current generations, it is innovative, it seeks and offers new possibilities for spending free time and it is no longer limited to meeting the needs of rest and relaxation, but to offer more, to offer experiences, to offer memories, connections with the other participants, in a world that suffers from the breaking of social relations and individualism.

Increasing interest in creative tourism was also determined by the effects of the Covid-19 pandemic, when people wanted to practice some forms of tourism that would make them leave the house, but which would keep them in safety, which will allow them social distancing [9]. Later, its attractiveness made creative tourism a way of life, a modern form of tourism with origins in traditions and culture.

The responses collected through the questionnaire and analyzed highlighted the fact that although the concept is quite little known among Romanian tourists, those who took part in such activities are generally young, educated, prefer to travel alone or in groups of friends and choose less crowded or well-known destinations, both in the country and outside the country, where they seek to interact with the local culture. They do not want to be involved in activities that imitate or take over creative ideas, but they want to participate in forms of tourism developed by communities in their own ways and that are adapted to a certain rhythm of life, with which they resonate.

Considering the interest of young people in this form of tourism, this could be a strategic priority for Romania, so that through the strategies it proposes to create innovative models of local tourism, which will contribute to attracting tourists to practice some forms of tourism niche, less polluting, which will contribute to increasing the level of awareness of responsibility towards cultural identity, but also to the environment, which will lead to the decrease of social disparities and the increase of local incomes.

However, we consider that in addition to the promotion activity, the development of tourism in general, and creative tourism in particular, requires the existence of an adequate infrastructure that allows tourists access to these areas.

The present research was carried out only by surveying Romanian tourists. Considering, however, the interest of foreign tourists in the traditions, customs, traditional cuisine of Romania, culture, etc. we will leave room for future research that will also address this aspect.

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CONSUMPTION OF MILK AND DAIRY PRODUCTS IN ROMANIA (2017-2019)

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Abstract

The paper aims to make a comparison between the national situation and the realities related to the consumption of milk and dairy products at global and community level. For this purpose, total consumption and consumption per capita at the general level of the product group, for milk, butter and cream respectively, were used as indicators. At national level, total consumption reached 4,935 thousand t (average of the period 2017-2019), of which milk held 4,905.67 thousand t, butter 23.67 thousand t and cream 5.67 thousand t. Worldwide, Romania accounted for an average of 0.58% of total milk and dairy consumption, 0.59% of milk consumption, 0.21% for butter consumption and 0.16% in case of cream consumption. Related to the Community context, Romania held shares of about 3.30% regarding the total consumption of milk and dairy products, 3.38% for milk consumption, 1.37% for butter consumption and 0.24% for cream. If we refer to the situation of consumption per capita, there are averages of the indicator, as follows: 233.54 kg - total consumption, 232.04 kg - milk consumption, 1.20 kg for butter and 0.30 kg for cream. Reported worldwide, Romania exceeded 3.23 times the total consumption of milk and dairy products and 3.29 times the consumption of milk and in case of butter and cream only 82.19 and 66.67% beside the global level of the indicator were achieved. unlike European Union, Romania exceeded consumption at the general level of the product group and for milk, but for butter and cream the situation was unfavorable (about 1/3 of the Community consumption for butter and only 6.05% for cream).

Key words*: *consumption, milk, inhabitant, cream, butter

INTRODUCTION

The milk sector in Romania has undergone numerous changes since 1990, such as reducing herds but also increasing yields per animal.

We can affirm that milk production is found under the influence of a multitude of factors, among which we can mention environmental factors and especially climatic factors [1].

Obtaining milk in Romania is a traditional occupation, at least starting from the existing natural potential [9].

Cattle, as a species, are the main supplier of milk for consumption worldwide [5]. We are also talking about other species supplying milk, which do not have a very significant share. For example, at European Union level, we are talking about a reduced contribution of sheep and goats to the total milk production [11]. At the same time, we can appreciate that there are premises for improving milk production from sheep and goats, under the conditions of a more efficient exploitation of these species [10].

In the current diet, milk brings an important contribution of protein and calcium [8]. It is also worth noting that milk can also be used for therapeutic purposes, goat's milk can also be used to improve the health of the population, especially for people with digestive tract problems or for people with cow's milk allergy [13].

National situation record a visible progress for the milk and milk products market [3]. With the liberalization of the milk market, producers are facing both challenges and threats that influence their level of efficiency [4]. It can be said that the milk sector is experiencing a certain crisis period in Romania as a result of the decrease in populations, the increase in input prices, problems related to collection, etc. [12].

Thus, the paper makes a comparison between the national context and that related to the consumption of milk and dairy products at global and community level.

MATERIALS AND METHODS

The realization of the work involves the use of two indicators: total consumption (thousand t) and average annual consumption per inhabitant (kg). They represent the total quantity of products available at the level of an area and the quantity of a product or group of agri-food products (primary or processed) consumed by an inhabitant, in the reference period, regardless of the source of supply (wholesale, retail, restaurants, canteens, own production, etc.) and the place where they are consumed (individual households, restaurants, canteens, confectioneries, institutional households, etc.) [6, 7].

For milk and milk products, the level of indicators is presented as follows: total – product group, milk, butter and cream (according to FAO) [2].

For total consumption of dairy products, structural indices for milk, butter and cream were determined.

Highlighting the state of affairs specific to Romania in an international context is highlighted by making comparisons with world and community situations (European Union). Thus, the contributions (in case of total consumption – through structural indices) respectively Romania's positions in terms of consumption per capita are established. The analysis covers the period 2017-2019, for which we also determined the average of the period, thus, the evolution of the indicators being highlighted by dynamics indices reported to the first analyzed base (2017).

RESULTS AND DISCUSSIONS

Table 1 presents data for the total consumption of milk and milk products.

Table 1.Consumption of milk and milk products- structure

No.	Specification	Year						Period average***	
		2017		2018		2019			
		Effective* thousand t	Str. *** -%-	Effective* thousand t	Str. *** -%-	Effective* thousand t	Str. *** -%-	Effective thousand t	Str. -%-
1.	Total**	4,934	100.0	4.976	100.0	4,895	100.0	4,935.00	100.0
2.	Milk	4,905	99.41	4,948	99.43	4,864	99.36	4,905.67	99.40
3.	Butter	23	0.47	23	0.46	25	0.51	23.67	0.48
4.	Cream	6	0.12	5	0.11	6	0.13	5.66	0.12

*Source, FAO, https://www.fao.org/faostat/fr/#data/FBS, Accessed on March 15, 2023.
**total milk but also milk products;
***my calculations.

Taking into account the situation encountered at the national level, total consumption was situated between 4,895 and 4,976 thousand t (in the case of 2019 and 2018, years), and the average of the period reached 4,935 thousand t (Fig. 1).

For milk, there was an average consumption of 4,905.67 thousand t, with sequential levels of 4,864 thousand t in 2019, 4,905 thousand t in 2017 and 4,948 thousand t for 2018 (Fig. 1). For butter, equal consumption levels are observed in 2017 and 2018 (23 thousand t), an average of 23.67 thousand t and 25 thousand t for 2019 (Fig. 1).

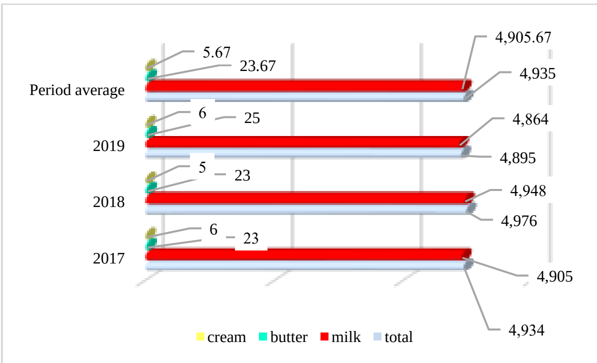

Fig. 1. Consumption of milk and milk products – Romania (thousand t)
Source: Based on FAO Database, https://www.fao.org/faostat/fr/#data/FBS, 15.03.2023.

For cream, the average consumption was 5.67 thousand t, a situation generated by specific consumption levels of 5 thousand t in 2018 and 6 thousand t each for 2017 and 2019 respectively (Fig. 1).
The structure of total milk consumption, for the average of the period, at national level, was as follows: 99.40% drinking milk, 0.48% butter and 0.12% cream.
Table 2 shows the dynamics of total shows the consumption of milk, as well as its derivatives, using dynamics indices and relative units (%).
At national level, there are the following, in terms of total consumption, a number of aspects such as: For the total consumption of milk and milk products, the dynamics of the indicator is uneven, the increases in 2018 (+0.67%) being followed by decreases for 2019 (-0.79 and -1.63%).

Table 2. Total consumption of milk and milk products - dynamics*

No.	Specification	Year						Period average	
		2017		2018		2019			
		Ibf	Ibm	Ibf	Ibm	Ibf	Ibm	Ibf	Ibm
1.	Total	100	100	100.67	100.67	99.21	98.37	100.02	100.82
2.	Milk	100	100	100.88	100.88	99.16	98.30	100.01	100.86
3.	Butter	100	100	100.0	100.0	108.69	108.69	102.91	94.68
4.	Cream	100	100	83.33	83.33	100.0	120.0	94.33	94.33

Source: *own calculations.

The average period exceeded both terms of comparison by 0.02 and 0.82%, respectively; Milk consumption shows a similar trend to that mentioned above. The indices were subunit for 2019 (99.21 and 98.37%), and – otherwise – only supra-unitary values are highlighted: 100.67% for 2018, 100.01 and 100.86% - period average; As regards butter consumption, there is an upward trend– for 2018 the indices were equal, and in case of 2019 there was an advance of the reporting bases by 1.08 times. The average of the period, exceeded the first reporting term by 2.91%, but was inferior compared to the second reference term by 5.32%; If we refer to the specific situation of cream consumption, there is a fluctuating trend of the indicator, the decreases manifested in 2018 (-16.67%), followed by increases in 2019 (+20.0% compared to the previous year). The period average was lower by 5.67% compared to reporting bases.
Table 3 presents Romania's positioning in an international context, in terms of total consumption of milk and dairy products.

Table 3.Consumption of milk and its derivatives– positioning Romania in an international context*

No.	Specification	Year						Period average	
		2017		2018		2019			
		% compared to the global level	% compared to EU level	% compared to the global level	% compared to EU level	% compared to the global level	% compared to EU level	% compared to the global level	% compared to EU level
1	Total	0.59	3.39	0.58	3.31	0.58	3.23	0.58	3.31
2	Milk	0.60	3.46	0.59	3.38	0.57	3.30	0.59	3.38
3	Butter	0.21	1.37	0.20	1.33	0.22	1.39	0.21	1.37
4	Cream	0.17	0.27	0.14	0.21	0.16	0.25	0.16	0.24

Source: *own calculations.

If we refer, strictly, to Romania's positioning in the global and community context, the following findings should be highlighted: worldwide, Romania accounted for an average of 0.58% of total milk and dairy products consumption (extreme values of 0.58 and 0.59%, respectively), 0.59% of milk consumption (variable levels from 0.57% in

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2019 to 0.60% for 2017), 0.21% of butter consumption (very small variations from one year to another: 0.21, 0.20 and 0.22% in the case of 2017, 2018 and 2019 respectively) and 0.16% of cream consumption (sequential contributions of 0.14% for 2018, 0.16% for 2019 and 0.17% for 2017 - Fig. 2); in the Community context, Romania held shares of about 3.30% for the total consumption of milk and its derivatives (3.23% - 2019, 3.31% each for the period average and 2018, 3.39% in 2017). Romania consumed between 3.30 and 3.46% of milk in the European Union (average share of 3.38%). In terms of butter consumption, Romania did not exceed the threshold of 1.40% of the Community total (1.33% in 2018, 1.37% in 2017 and for the average of the period, 1.39% in 2019). The situation being less convenient in terms of cream consumption – had weights as follows: 0.21, 0.24, 0.25 and 0.27% for 2018, period average, 2019 and 2017, respectively (Fig. 2).
Table 4 presents data for the total consumption of milk and milk derivate per capita.
Seen at national level, total consumption was between 229.49 and 237.65 kg (for 2019 and 2018, respectively), in this condition, the average of the period reached 233.54 kg (Fig. 3). For milk, there was an average consumption of 232.04 kg, with sequential levels of 227.88 kg in 2019, 232.01 kg in 2017 and 236.22 kg in 2018 (Fig. 3). For butter, the consumption levels of 1.15 kg are recorded in year 2017, 1.18 kg in 2018, an average of 1.20 kg and 1.28 kg for the year 2019 (Fig. 3).

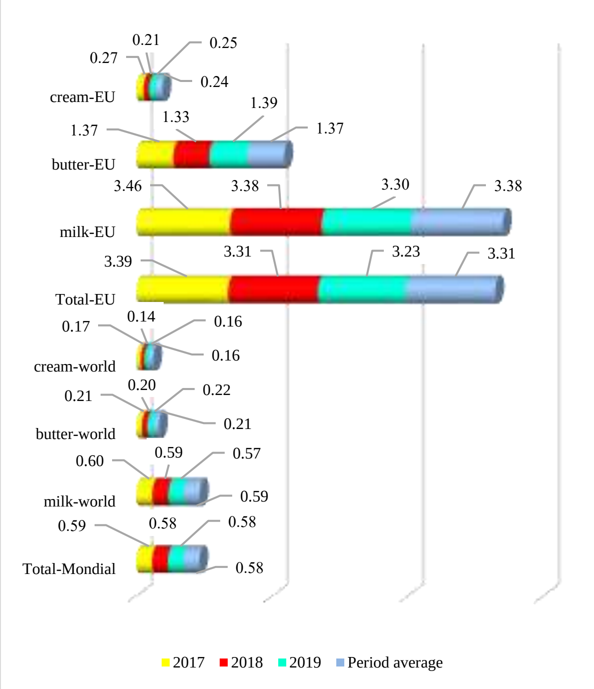

Fig. 2.Consumption of milk and its derivatives– Romania's share within the European Union and worldwide (%)
Source: own calculation.

Table 4. Consumption of milk and milk products per inhabitant - structure

No.	Specification	Year						Period average***	
		2017		2018		2019			
		Eff.* -kg-	Str. *** -%-	Eff.* -kg-	Str. *** -%-	Eff.* -kg-	Str. *** -%-	Eff. -kg-	Str. -%-
1.	Total**	233.47	100.0	237.65	100.0	229.49	100.0	233.54	100.0
2.	Milk	232.01	99.37	236.22	99.40	227.88	99.29	232.04	99.36
3.	Butter	1.15	0.49	1.18	0.49	1.28	0.56	1.20	0.51
4.	Cream	0.31	0.14	0.25	0.11	0.33	0.15	0.30	0.13

Source: *FAO database, https://www.fao.org/faostat/fr/#data/FBS, Accessed on 15.03.2023.
**total milk and milk products;
***own calculations.

For cream, the average consumption was 0.30 kg, situation generated by specific consumption levels of 0.25 kg in 2018, 0.31 kg in 2017 and 0.33 kg for 2019 (Fig. 3). Drinking milk predominates the product group from a structural point of view (shares of over 99%), while butter ranks second (maximum share of 0.56% in 2019) and cream occupies the last place (shares from 0.11 to 0.15% of the total).
The dynamics of consumption per capita is shown in Table 5.
For the total consumption of milk andits derivatives, the dynamics of the indicator is

uneven, with increases in 2018 (+1.79%) followed by decreases for 2019 (-1.71 and -3.43%).

The period average exceeded both terms of comparison by 0.03 and 1.76%, respectively; milk consumption.

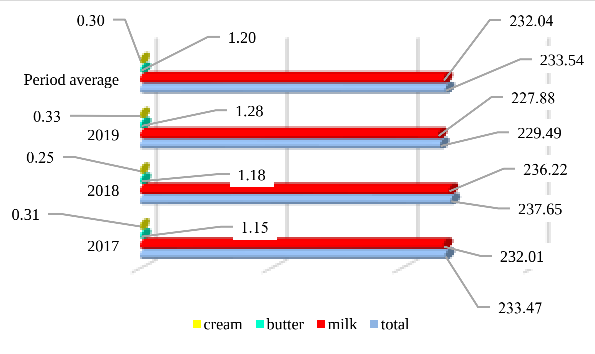

Fig. 3. Consumption of milk and milk products per inhabitant in Romania (kg)
Source: FAO database [2].

The indices were subunit for 2019 (98.22 and 96.47%), and -otherwise- only supra-unitary values are highlighted: 101.81% at the level of 2018, 100.01 and 100.83% for the average of the period; In the case of butter consumption, the evolution is upward – In 2018, the reporting deadline was exceeded 1.02 times, and for 2019 there was an increase above the reporting bases by 1.11 and 1.08 times, respectively.The average of the period, exceeded the first reporting deadline by 4.35%, but was lower compared to the second reference term by 6.25%. If we refer to the specific situation of cream consumption, there is a fluctuating trend of the indicator, the decreases manifested in 2018 (-19.35%), followed by increases in 2019 (+6.45 respectively +32.0% compared to the reference terms). The average period was lower by 3.23 and 9.09% compared to the reporting bases.

Table 5. Consumption of milk and its derivativesper capita - dynamics*

No.	Specification	Year						Period average	
		2017		2018		2019			
		Ibf	Ibm	Ibf	Ibm	Ibf	Ibm	Ibf	Ibm
1.	Total	100	100	101.79	101.79	98.29	96.57	100.03	101.76
2.	Milk	100	100	101.81	101.81	98.22	96.47	100.01	101.83
3.	Butter	100	100	102.61	102.61	111.30	108.47	104.35	93.75
4.	Cream	100	100	80.65	80.65	106.45	132.0	96.77	90.91

Source: *own calculations.

Table 6 shows Romania's positioning, in an international context, in terms of total consumption of milk and dairy products per inhabitant. The situation for European Union, compared with the global one is also presented.

Table 6. The consumption of milk and milk products per inhabitant – Romania's positioning in an international context*

No.	Specification	Year						Period average	
		2017		2018		2019			
		% compared to the global level	% compared to EU level	% compared to the global level	% compared to EU level	% compared to the global level	% compared to EU level	% compared to the global level	% compared to EU level
1.	Romania	327.72	122.91	326.13	121.28	315.67	117.02	323.15	120.38
2.	Milk	334.55	127.94	332.94	126.33	322.05	121.93	329.79	125.38
3.	Butter	79.86	29.87	80.27	29.87	86.49	31.07	82.19	30.23
4.	Cream	68.89	6.50	55.56	4.98	71,74	6.48	66.67	6.05

Source: *own calculations.

By looking to the Romania's positioning in the global and community context, we have to highlight the following: Romania exceeded, 3.23 times, on average, the total consumption of milk and dairy products globally (highest levels of 3.15 and 3.27 times for 2019 and

2017 years), 3.29 times milk consumption (advances from 3.22 times in 2019 year to 3.34 times for the year 2017) (Fig. 4).

If we analyze the consumption of butter, we see that Romania was below the global level, registering quotas of: 79.86% in 2017, 80.27% for 2018, 82.19% for the average and 86.49% in 2019. For cream, it is a national consumption similar to that presented for butter. Romania registered negative differences compared to the world situation as follows: -28.26% in 2018, -31.11% in 2017, -33.33% in the case of the average period, -44.44% for 2018 (Fig. 4).

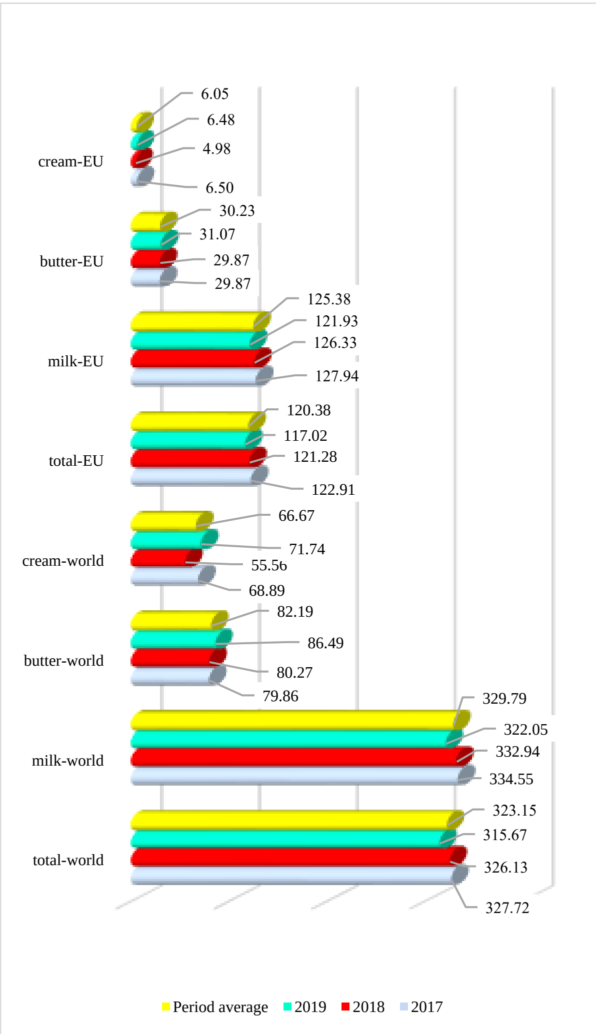

Fig. 4. Consumption of milk and milk derivatives – Romania's positioning beside the world and community levels (%)
Source: own calculation.

In the Community context, Romania achieved an excess consumption at the general level of the product group and for milk (122.91 and 127.94% in 2017, 121.28 and 126.33% in 2018, 117.02 and 121.93% in 2019, 120.38 and 125.38% for the average of the period). Analyzing the consumption of butter per capita, we find that Romania did not exceed the threshold of one third of the community level (31.07% in 2019, 30.23% for the average of the period, 29.87% in 2017 and 2018, respectively). An even less favorable situation is found for cream consumption – weights of 6.50, 6.48, 6.05 and 4.98% for 2017, 2019, period average and 2017, respectively (Fig. 4).

CONCLUSIONS

In terms of total consumption of milk and dairy products, we can observe: the preponderance of drinking milk, in the structure of total consumption (share of over 99%), as well as low shares for butter and cream (0.48% for butter and below 0.12% for cream); Romania must act towards increasing the shares of butter and cream in total consumption, improving the structure of the population's food ration (increasing the share of calories and animal proteins); fluctuating trends appear in the overall product group for milk and cream and a uniformly upward variation in butter; both worldwide and at Community level, Romania is not a decisive factor in boosting consumption (shares below 1% worldwide and below 3.50% at Community level). The situation needs to be improved especially with butter and cream.

If we refer to per capita consumption, the following aspects should be considered: low amplitudes of variation of the indicator (7.16 kg at the general level of the product group; 8.34 kg for milk; 0.13 kg for butter; 0.08 kg for cream); The indicator evolved unevenly, worldwide, in the case of Romania, the total consumption of milk and its derived products and milk consumption evolved unevenly, and the consumption of butter evolved upwards, while for cream the evolution was uneven; Romania is ahead of world and Community levels for the product group as a whole and for milk. For butter and cream, the situation is unfavorable compared to the state of affairs prevailing worldwide and very unfavorable compared to the Community situation.

In the current conditions, Romania needs to consolidate and develop both the primary sector (dairy cow breeders) and the processing sector (processing capacities), as well as to carry out actions to influence consumers to focus on products with a high degree of processing. The prerequisites for these processes must be based on appropriate agricultural and food policy measures carried out at national level.

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THE IMPACT OF CLIMATE CHANGES ON AGRICULTURAL LANDS IN THE SÂNNICOLAU MARE AREA, ROMANIA

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Abstract

This study addresses a very topical issue, climate changes, increasingly present recently, with negative effects on our entire existence, with repercussions on agriculture and the way food is produced in general. In the last decade, climate changes have been increasingly present and adapting to these changes is essential. In this paper, two crops, barley and alfalfa are presented, and how these climate changes produced in the Sânnicolau Mare area during 2020-2022 had negative effects on the soils and, above all, on the production of barley and the number of mows in alfalfa. In the elaboration of the paper, the bibliographic study was combined with a series of laboratory analyses regarding the properties of the two types of soil identified. The idea was developed on the basis that we monitored the annual thermal and pluviometric regimes impact on crops and on soil evolution, through their distribution and through the specific adaptability of the plants to risk conditions in a short period of time. These climatic changes are obvious not only from one year or from one season to another: they appear within the same locality bringing obvious changes in terms of the amount of precipitation in a certain area of that locality.

Key words: *impact, climate change, agricultural land, production, Sânnicolau Mare*

INTRODUCTION

In the opinion of most authors, the alteration crust is a loose deposit – the result of physical-chemical processes that simultaneously affect the upper part of the lithosphere [20, 27, 31, 34].
According to various authors, climate is generally defined as "the multiannual regime or the totality of the successive changes in the weather, of all the atmospheric processes characteristic of a region, as a result of the interaction between climatic factors (radiation balance, influence of physical-geographical conditions and general circulation of the atmosphere), under the increasing influence of human activity, which can be described by means of the data recorded and processed, over a period of several years, within the local or zonal meteorological stations." [2, 4, 11, 13, 15, 25, 26, 32, 33].
Climate influences both directly and indirectly the formation and evolution of soils through a complex of factors: temperature, precipitation, global radiation, cloudiness, relative humidity, evapotranspiration, etc. [10, 11].
The precipitation regime has a much more direct action on the soilification process than the thermal regime. In this sense, the influence of the pluviometric regime on the feldspar content of the sands in the current soils is edifying. The curve built by Grasu et al., 1996 based on Suttner's 1974, cited by Vlad, D., data, shows an inverse exponential correlation between the two elements [1, 3, 18, 28, 35].
The combined action of temperature and precipitation influences the rate of formation of clay minerals in soils, so that, over time, the proportion of resulting clay minerals increases proportionally with humidity and exponentially with temperature [9, 19, 29].
According to Ianoș et. al., 1997, the different ways of combining the two climatic factors – precipitation and temperature – give a certain character to the alteration of primary minerals [6]. In regions with arid climate, alteration has a predominantly physical character, the

product being a detrital material on account of which undeveloped soils appear [11].

Depending on the depth of the pedophreatic level, Ianoş et al., 1992 distinguishes three types of soils (the classification is also mentioned when treating the relief, both factors determining it): automorphic soils – not influenced by the pedophreatic water, with an aquifer level below 5 m; semi-automorphic soils – weakly or moderately influenced by pedophreatic water; the aquifer located at moderate depths (3-5 m), feeds, by capillary ascent, the intermediate horizons of the soil; and hydromorphic soils (gleysoils) or semi hydromorphic soils (meso- and bathy-gleyc varieties), intensely influenced by pedophreatic water, in which the aquifer located at a shallow depth moistens the soil until to the surface, by capillary ascent, at least periodically [6, 7, 8, 23, 32].

In the presence of excess water, soilification acquires certain particularities, as stated by Mihuț et al., 2018: due to poor aeration, reduction processes predominantly take place, forming reduced soluble compounds of iron and manganese, which have specific colours that they also imprint on the soil [12].

In recent times, man has become an active factor in pedogenesis, either directly – through ameliorative works or plant cultivation, or indirectly – through damming, drainage, irrigation, or erosion control works [20, 21, 22, 26, 35].

As a result of anthropogenic interventions, most of the soils have evolved, in the last hundreds of years, in intensively anthropogenically modified conditions [12, 20, 35].

In these cases, the evolution proceeded rapidly, overstepping the stages, without normal interactions between various factors involved in the process – an evolution called meta-soil-genesis [5, 17, 24].

In this context, the paper aimed to assess the impact of climate changes on the soils, barley production and the number of mows in alfalfa in the Sânnicolau Mare area during 2020-2022

MATERIALS AND METHODS

Regarding the studied area

The research was carried out in the town of Sânnicolau Mare, the westernmost city of Romania and of Timiş County, being the third largest city after Timișoara and Lugoj. Sânnnicolau Mare is a border town, 6 km from the border with Hungary, on the unregulated course of the Mureș River [14, 16, 19].

The city is in the low Aranca Plain, on the banks of the Aranca Canal, an old course of the Mureş River (in distant times, it was navigable), which gives it aspects and phenomena like large cities located on rivers and streams, but at a more reduced scale. Its location gives it a rich natural potential, being 5 km from the Mures River flooding meadow, at an altitude of 80-90 m above the Adriatic Sea (Map 1).

Map 1. Map of Romania with the city of Sânnicolau Mare in Timiș County
Source:
https://ro.wikipedia.org/wiki/List%C4%83_de_comune_din_jude%C8%9Bul_Timi%C8%99 [36].

The studied area is under the influence of the Azores pressure centre and under a weak influence of the Siberian maximum barometer centre, being an area with a transitional climate between continental and ocean climate, with an average annual temperature of 10.7^{o}C.

The climate of the area is generally under the combined influence of continental and Mediterranean climates, with more pronounced effects of the Mediterranean type: this phenomenon had, generally, beneficial effects on the development of the plants and of the area [13, 14, 32]. In general, the amount of precipitation in the studied area is sufficient for the development of plants, especially cereals (536.3 mm), but this precipitation is unevenly distributed during the vegetation period. The wind has an average speed of 2.5-3.00 m/sec. Over time, the climatic conditions have favored the development of the locality both from an economic and demographic point of view.

The hydrology of the area is the result of the combined actions of climate, hydrographic, morphological, and geological factors.

Regarding the data obtained

A series of measurements of the physical and chemical properties of the two identified soil types (chernozem and eutricambosoil) were made; research and observations were carried out on an area of 32.00 ha, on two crops – barley, on 25.60 ha, and alfalfa, on 7.40 ha.

The following properties were determined: soil texture, by the Cernikova method; soil density (cm3), with a pycnometer, using distilled water; apparent density of the soil (cm3) in natural settlement, with the help of cylinders; humus content (%), by the Tiurin method; soil reaction, by the potentiometric method, in aqueous extract 1:2.5.

Following the study of the specialized bibliography, the data provided by the Sânnicolau Mare City Hall, O.S.P.A. Timișoara, and the Sânnicolau Mare Meteorological Station and those obtained as a result of our own studies and observations from the field, this paper presents a series of data regarding the total area of the town, data regarding the climate conditions in the analysed period, together with a series of data and information related to the types of soil, the alfalfa crop, the barley crop, the requirements of the two crops in relation to the climate conditions, and the productions obtained in the period 2020-2022 [10, 18].

RESULTS AND DISCUSSIONS

The town of Sânnicolau Mare has an area of about 13,902 ha (respectively 1.55% of the area of Timiș County), of which 78.44% is represented by agricultural/non-agricultural land/other forms – 10,696 ha of agricultural land and 1,186 ha of non-agricultural land.

As for the form of ownership, 97% of the agricultural land is owned by private owners and only 3% by the state (Table 1).

Table 1. Administrative area of the city of Sânnicolau Mare

Ownership	Agricultural lands		Non-agricultura lands		Total
	ha	%	ha	%	ha
ATU public ownership	300	3	100	10	400
ATU private ownership	800	7	1,064	85	1,864
Private ownership	11,588	90	50	5	11,638
Total	**12,688**	**100**	**1,214**	**100**	**13,902**

Source: Town Planning Office, Sânnicolau Mare Town Hall [30].

The entire agricultural area is made up of the following categories of use: arable land, 10,695 ha (84%); pastures and hayfields 1,654 ha (13%); vineyards and orchards, 366 ha (3%).

The forest fund has over 36 ha in use (ranking 8th, with 0.25% of the total administrative area of the city) being represented by forests and other lands occupied by forest vegetation.

From a geomorphological point of view, the territory is part of the large morpho structural unit called the Lower Mureș Depression, an area between the Highiş-Drocea-Zărand Mountains to the north, the Transylvanian Depression to the east, the Poiana Ruscăi Mountains to the south, and the Pannonian Depression to the west. Mureșului Meadow is one of the youngest relief formations located in the northern extremity of the area, showing reduced widths from a few tens to a few hundred meters.

The morphology of the land had an influence on the drainage and depth of the groundwater: the climate and hydrographic factors and the geological factor determined the existence of the water table and the deep aquifer layers, favouring the development of agriculture. Ground water is found at a depth of 4-6 m, which contributed to the cultivation of vegetables.

The influence and action over time of the soil genesis factors (relief, rock, climate, hydrography), as well as human intervention through important hydro-ameliorative works started more than 200 years ago, determined the existence of a highly complex and diverse soil cover. Through the application of a modern land processing technology, in the period 1960-1990, the raw material was provided for the local industry, but also for other areas of the country and even for export

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to the former socialist countries (vegetable cultivation was carried out on an area of over 800 ha).

After a period of stagnation (1990-1997), the land being appropriated, this wealth begins to regain its value through associative forms: the most eloquent example is the appearance of Italian and German investors in agriculture in the area.

Although, over time, the climate conditions have favoured the agriculture of the area, there are periods when temperatures are high in the summer without precipitation and periods when humidity exceeds the normal limits.

The hydrographic network functioned well until 1990, with all the water pumping stations in operation but, after 1990, they stopped working, which determined that the waters in the surface layer reached greater depths, leading to lower agricultural productions. A first signal of resumption of operation is given by the Italian companies that work most of the land in the area and that will put the irrigation system into operation, also helped by the Romanian state. At present, the hydrotechnical system only regulates the waters that come from rains, which have been very few in the last period. The lack of underground drinking water under the hearth of the city meant that, to provide the town with the necessary water, it had to be brought from the town of Sânpetru Mare, from 14 km away, which, however, involved high costs.

Within the city of Sânnicolau Mare, the largest hydrographic network in the country was created so that the entire agricultural area is compartmentalized and surrounded by irrigation and drainage canals with great efficiency in agricultural production.

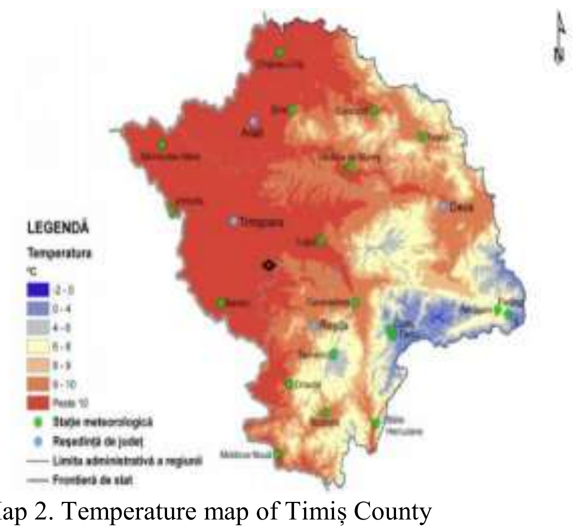
The irrational exploitation of the Mureș Meadow has left deep traces but, in the future, it might be declared a “Nature Reserve.”

The biotic cover of the area, although favourable, made some economic activities difficult because of the rational non-application of environmental protection.

The final clearing of the 316 ha Zăbrani forest in 1911 by the Hungarian government caused the town to lose its most valuable biotic cover, which was thousands of years old.

According to the classification from “Geography of Romania,” volume I (1983), the territory of the unit is in the temperate continental climate zone, in the climate province sector I (with ocean influences), the climate region of the middle mountains, the climate subregion of the Western Carpathians. Against the background of the zonal climate, under the influence of the local relief, characteristic topoclimates are differentiated, both vertically and horizontally, depending on the orientation of the Poiana Ruscăi Mountains and the Lipovei Hills. According to Köppen, the region falls into the boreal climate province, with cold winters, with a layer of stable snow in the winter months, with sufficient precipitation throughout the year, and a relatively moderate thermal regime.

The multiannual average temperature at the Sânnicolau Mare station registers values of 10.7°C, and the multiannual average value of precipitation is 536.3 mm (Map 2).



Map 2. Temperature map of Timiș County
(The legend: temperature; Weather station; The county seat; The administrative boundary of the region; State border)
Source: Meteorological Station in Sânnicolau Mare [10].

According to the data presented in Table 2, the average air temperature, and the amount of precipitation (monthly values) recorded at the meteorological station of Sânnicolau Mare in the interval 01.01.2020-31.12.2022 was different.

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Table 2. Average air temperature (°C)

Year	Month											
	1	2	3	4	5	6	7	8	9	10	11	12
2020	-0.5	5.1	6.9	11.9	15.5	20.7	22.7	23.9	19.5	12.6	5.8	4.8
2021	2.0	4.0	5.1	8.8	15.5	20.9	25.7	22.3	17.6	10.4	6.6	2.3
2022	0.1	4.4	4.9	9.9	18.2	23.8	24.9	24.6	16.3	13.1	7.6	4.2
Mean	1.9	4.5	5.6	10.2	16.4	21.8	24.4	23.6	17.8	12.0	6.7	3.8

Source: Meteorological Station in Sânnicolau Mare [10].

During 2020, the minimum temperature averaged 0.5°C in January, and the maximum temperature was 23.9oC in August. The year 2021 was characterized by a minimum average temperature of 2.0°C in January and a maximum of 25.7°C in July; in 2022, the minimum average temperature was 0.1°C in January and the maximum one was 24.9°C, in July.

Thus, in the three reference years, the lowest average temperature was recorded in January 2020 (0.5°C), and the highest temperature was in July 2021 (24.9°C). Regarding the amount of precipitation (Table 3), it can be observed that the most significant precipitation occurred during June-October 2020, with a maximum of 73.7 l/m^2; in 2021, precipitation was relatively high throughout the year, with a maximum of 57.9 l/m^2 in November, and in 2022, in the first half of the year, precipitation was quantitatively low, with a maximum of 23.8 l/ m^2, in May; and then, starting from the second half of the year, it reached a maximum of 65.6 l/m^2 in August.

Table 3. Amount of precipitations (l/m^2)

Year	Month											
	1	2	3	4	5	6	7	8	9	10	11	12
2020	17.5	32.5	38.4	3.6	24.1	60.5	53.3	46.2	24.5	73.7	5.5	31.0
2021	37.1	32.1	25.7	16.9	29.6	31.4	47.2	36.9	20.3	13.3	57.9	48.2
2022	11.7	10.3	1.1	20.7	23.8	15.2	22.5	65.6	58.4	18.2	28.7	47.2
Mean	22.1	25.0	21.7	13.7	25.8	35.7	41.0	50.0	34.4	35.1	30.7	42.0

Source: Meteorological Station in Sânnicolau Mare [10].

According to the seasons, the precipitation is distributed as follows: spring 134.5 mm, summer 171.2 mm, autumn 132.8 mm, and winter 89.8 mm.

The average annual rainfall was 536.3 mm (526.2 multi-year average over a period of 30 years, 1990-2010). Precipitation recorded a maximum in June-July (135 mm) and two minimums: one, more pronounced in February, and another one, less pronounced, in September.

Periods with precipitation add up to approx. 170 days annually, with the highest frequency in June (15-17 days).

The relative air humidity is around 70% (annual average).

Torrential rains also fall in the area (showers accompanied by electrical discharges), which can have strong negative effects on soils and land.

Snow cover – winter is usually poorer in snow, the ground being covered on average 30 days/year, of which 15 days in January.

The dominant winds are those from the west and north-west, which bring precipitation in the form of showers, and those from the south-east, which are dry. In June, the north-west wind dominates, which shares 25% of the total winds; in September, the south-east winds dominate with a share of 21.5% and the south wind has the lowest frequency and blows especially in the months of April and May.

In the studied area, the average number of days with strong wind (v>11 m/s) is 35, and that of days with storms (v>16 m/s) is 7. The most dangerous months from this point of view are March-May, when the high speed of the winds associated with the high frequency of snowfalls with soft snow favours the occurrence of falls and breaks.

Solar radiation. The duration of insolation is 2,100 h/year. The annual average solar radiation is approximately 118 kcal/cm, of which 100 kcal are recorded in the hot semester and 18 kcal in the cold one.
The duration of sunshine depends on several factors such as cloudiness, latitude, seasons, and altitude.
Being in the western part of the Timiș Plain, the average annual value of the duration of sunshine at this station exceeds 2,200 h. Data analysis highlights a multi-annual average of 2,227.4 h. July has the highest monthly average, 301.8 h, and December the lowest, 61.4 h.
The locality's Meteorological Station operated between 1928-1948, resumed activity in 1953, and continues nowadays.
The studied territory presents a soil cover specific to the eastern part of the Mureș Plain, the main soil types inventoried being the grouping of land units, the meadows belonging to the City of Sânnicolau Mare, Timiș County, in the studied area where the following soil types predominate:
- Chernozems 37%;
- Cambic chernozems (glayed, vermic, salted) 6%;
- Eutricambosoils (mollic, glayed, salted) 16%;
- Gleysols and solonetz 5%;
- Vertosoils (glayed, salted) 8%;
- Alluvial soils (mollic, glayed, salty) 8%;
- Associations of soils (vertisoils, chernozems and solonetz) 20%.
As a result, the overall plant production capacity of grasslands is medium.
Soils are moderately supplied with humus and total nitrogen in the upper horizon, after which it decreases rapidly in depth. The humus reserve is medium (120-180 t/ha), higher in the mollic subtypes and lower in the cambic ones. The C:N ratio is around 15. Cation exchange capacity, degree of base saturation, and reactivity also vary with the nature of the fluvial deposit on which these soils were formed.
According to the 2021 Agricultural Census, the land situation by use category is as shown in Table 4 and Figure 3.

Table 4. Main crops and their cultivated area in Sânnicolau Mare in 2021

Crops	Cultivated area (ha)	Share of arable land (%)
Common wheat and spelt wheat	4,000	37.42
Maize	3,895	36.41
Technical plants	2,000	18.70
Vegetables, melons	100	0.93
Fodder crops	300	2.80
Potato	200	1.87
Other crops	167	1.56
Barley	25.60	0.24
Alfalfa	7.40	0.07
Total arable land	**10,695**	**100**

Source: Own calculation.

According to the data in Table 3, the crops with the highest share are common wheat and spelt wheat, with a share of 37.42% of the total arable land, followed by maize with share of 36.41%. The crops with the lowest shares are vegetables, potato, fodder crops, and other crops.

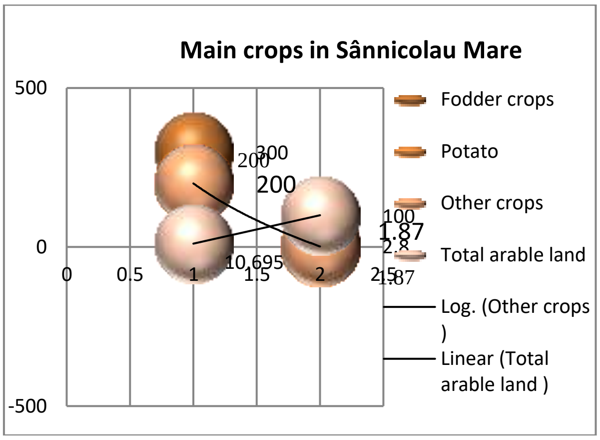

Fig. 3. Main crops in Sânnicolau Mare
Source: Own calculation.

1. Impact of climate changes on alfalfa

Alfalfa is characterized by a superior ability to adapt to different ecological conditions. The highest level of production is recorded in temperate zones, on soils that are well supplied with nutrients.
In areas where precipitation falls below 550 mm, it is recommended that alfalfa to be sown in pure culture, while in areas with precipitation above 550 mm and average annual temperatures below 10.5°C, it can be cultivated in mixture with a grass. The seeds germinate at 1°C, and the maximum temperature is 37°C. If alfalfa was sown in the

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spring, temperatures of -5°C can destroy the young plants. Young plants, however, if covered with snow, can withstand up to -40°C.

For alfalfa, the highest productions are obtained in areas where the average annual rainfall is between 550-600 mm and has a uniform distribution over the entire vegetation period.

As regards the requirements of the culture towards the soil, this culture has very high requirements, in the sense that it can only be cultivated on those soils that have a neutral to weak alkaline reaction (pH has values between 6.2-7.4).

The research was carried out during 2020-2021, on an area of 4.3 ha and the variety studied was Tapio. Table 5 shows both the work done on the alfalfa crop and the entire range of tractors and machines used in the preparation of the crop.

Table 5. Agricultural machines according to the agricultural work performed

Works done:	Tractor	Range of equipment
1. Ploughing after pre-emergent crop	CASE 130 CVX	Maschio Gaspardo Lelio 3+1 L
2. Soil preparation in summer		Souchu Pinet 3,2 m
3. Soil preparation before sowing		Maschio Gaspardo Grator 450 Combinator
4. Application of mineral fertilisers		Sulky DX 20+
5. Sowing		Maschio Gaspardo Nina 400
6. Mowing		Pottinger 160
7. Raking		Claas WS 280 D
8. Baling		Krone KR 125

Source: Own results.

The average air temperature recorded at the Sânnicolau Mare Meteorological Station in August 2020 was 23.9°C, and the amount of precipitation was 46.2 l/m^2, which helped the plant reach a sufficient degree of maturity to withstand low winter temperatures (the average minimum temperature was recorded in January 2021, -2.0°C).

Optimal time of harvesting was established considering the stage of development of the plants. In the present case, the first mowing took place in May 2021, when the average temperature was 29.6°C, the plant reaching the optimal stage of development being also favoured by the high amount of precipitation from the second half of the previous year.

The second mowing was carried out at the beginning of July 2021, when the average temperature was 25.7°C and the precipitation had a value of 47.2 l/m^2. The amount of green mass obtained exceeded the production of the first mowing. The third mowing was carried out at the beginning of September 2021, when the average temperature recorded was 17.6°C, and the average precipitation decreased by half compared to the previous mowing period. This led to a lower quantitative harvest compared to the previous one.

In total, for the alfalfa crop of 2021, 116 hay round big bales were obtained, each weighing about 300 kg. The total harvest was 35 t, with a slight deviation. For baling, the Krone KR 125 round baler was used.

In 2022, because of the very low rainfall in the first half of the year, the alfalfa crop had much lower yields, with the harvest reaching almost half of that of 2021. The first and second mowing yielded 30 round big bales, and the third mowing was quantitatively more productive due to the increase in precipitation in the second half of 2021, reaching 65.6 l/m^2 in August (55 hay bales).

Alfalfa production performance in 2022 compared to the year 2021 is presented in Table 6.

Table 6. Alfalfa hay production in 2022 versus 2021 in number of round big bales and tons

Year	Hay production	
	No. of big round bales	Tons
2021	116	35
2022	85	25.5
2022 - 2021 Abs. differ.	-31	-9.5
2022/2021 %	-26.8	-21.2

Source: Own results.

2. Impact of climate changes on barley

Barley technology is like wheat technology. In Romania, barley is one of the main plants used in crop rotation, being one of the frequently encountered autumn crops when it is particularly important to observe the cultivation technology.

Barley cultivation is aimed at obtaining grains, which find their usefulness in many fields. Barley has various uses, from chives and coffee substitute in human nutrition, to the manufacture of beer, glucose, alcohol, and dextrin. Barley is also one of the most important sources of animal feed, and it can be consumed in the form of grain, green fodder, straw, and hay.

For germination, the seeds need an optimal temperature of 20^{o}C and the existence of an amount of water equivalent to 48% of the grain mass, but germination is also possible at temperatures of 3-4^{o}C and the optimal growth temperatures are 28-30^{o}C.

Compared with other cereals, barley has a much lower power to penetrate the soil, which is why it should not be sown too deeply. If barley is sown at depths of 6-7 cm and not 4-5, as recommended, the crop may have difficulty emerging due to the strong crust that the soil can form.

Barley twinning is more efficient compared to other cereals (wheat, rye), especially if it was sown in autumn, but it differs according to the type of barley, namely it is recommended that twinning in two-row-barley to be weaker so that the uniformity of the plants and that of the grains is not affected, while in barley and spring two-row-barley, the vegetation period is only 90-120 days.

Compared to wheat, barley is more resistant to high temperatures and more demanding on soil conditions, since it has a root stem that has a lower absorption capacity, and the vegetation period is shorter.

Compared to rye and wheat, autumn barley is less resistant to low winter temperatures, the minimum temperature of -15^{o}C does not affect it at the level of the twinning node, only if the plants have not gone through the vernalization process.

Also, the variety has an influence on the optimal plant development environment. Thus, common barley is grown in drier or harsher areas because it has a short vegetation period, while two-row-barley (beer barley) needs a lower amount of protein in the grains, which is why it must be grown in cooler areas, where the level of humidity is high.

The optimal time for sowing is between September 20 and October 5 for winter barley, for the plants to have enough time to take root before winter comes. If barley is sown too early, there is a risk that the plants will develop too much by the time winter arrives, in which case they may be attacked by fusarium, viruses, or powdery mildew. If, however, barley is sown too late, it will have little winter hardiness.

Sowing in spring barley was done as soon as it was possible to enter the field. It has been found that, if this is delayed, there is a considerable decrease in production, the grains are smaller and of poorer quality.

In the reference period, sowing took place in the second half of October, and harvesting took place in June, when the grain reached maturity. However, due to different weather conditions in the period 2020-2022, different productions were obtained.

Due to the high level of precipitation in the first half of 2020, (a maximum recorded in June of 60.5 l/m^2) and due to the high temperatures in the following two weeks (a maximum of average temperatures of 20.7^{o}C), the barley harvest was about 5.5 t/ha.

Compared to 2020, in 2021, the harvest was 6 t/ha. This was due to the higher amount of precipitation in the first half of 2021 (maximum in June of 31.4 l/m^2), being quantitatively higher than those recorded in 2020 when, in April, the amount of precipitation was very low (only 3.6 l/m^2, which caused the stagnation of the plant's development), but also the oppressive temperatures for germination and slow growth of the plant recorded in the second half of 2020.

In 2022, the barley crop had much lower productions than in previous years, only 4 t/ha. This was possible due to the high temperatures and precipitation in the fall of 2021, a fact that determined the early development of the plant until spiking.

Dynamics of barley yield in the period 2020-2022 is shown in Table 7.

Table 7. Evolution of barley yield, 2021-2022

Year	Yield (ton/ha)
2020	5.5
2021	6
2022	4
2021/2020 %	110.9
2022/2020 %	72.7%
2022/2021%	66.6 %

Source: Own results.

The data from Table 7 reflects that the best year for barley was 2021, when the yield was by 10.8% higher than in 2020.

The worst year was 2022 when the yield was by 35.4% lower than in 2021 and by 21.3% smaller than in 2020.

CONCLUSIONS

Sânnicolau Mare has an area of 13,902 ha (1.55% of the area of Timiș County), of which 78.44% is agricultural/non-agricultural/other forms, respectively 10,696 ha agricultural land and 1,186 ha non-agricultural land.

By categories of use, the lands are classified as follows:

- Arable land: 10,695 ha;
- Family gardens: 300 ha;
- Pastures and hayfields: 1,036.02 ha;
- Used agricultural area: 12,013 ha;
- Unused agricultural area: 48 ha.

Being located in the western part of the Timiș Plain, the average annual value of the duration of sunshine at this station exceeds 2,200 h.

Data analysis highlights a multi-annual average of 2,227.4 h. In July, the highest monthly average was found, 301.8 h, and in December, the lowest one, 61.4 h.

According to the data provided by the Sânnicolau Mare Meteorological Station, for the year 2020, the minimum temperature was in January, with an average of 0.5°C and a maximum in August, of 23.9°C. The year 2021 recorded minimum average values in January (of 2.0°C) and maximum average values in July (of 25.7°C).

The year 2022 was a warmer year, the minimum average values were positive in January (0.1°C), and the maximum values were 24.9°C, in July.

During the three reference years, January 2020 recorded a minimum value of -0.5°C, and July 2021, the highest average value of 24.9°C.

In conclusion, several requirements favouring alfalfa production can be identified, among which the following are more important:

- Temperature should be 10°C for a uniform and fast germination and the minimum of -37°C;
- If there is a layer of snow, the plants can withstand temperatures of -40°C;
- Average annual precipitation should be between 550-600 mm in order to obtain a significant production;
- Alfalfa is very picky about the soil, therefore its cultivation must be done only on soils that have a neutral or weak alkaline reaction (chernozems, preluvosoils, alluviosoils, etc.).

It is also important that the crop preceding alfalfa be the one that clears the land early, that is why wheat, barley and early potatoes are especially indicated, and in the case of alfalfa sown in the spring, sunflower or corn crops are indicated.

An alfalfa culture can be economically used for 4 years.

The highest productions are obtained in the 2nd and 3rd years.

On mows, the highest production is obtained in the first one, the others representing 50-70% of the production of the first mow (more in irrigation conditions, less in drought conditions). In general, 40-60 t g.m./ha are obtained in alfalfa and under irrigation conditions 80-100 t g.m./ha.

As for barley, sowing was done at mid-October, and harvesting in June.

In 2020, barley production was 5.5 t/ha. Compared to 2020, in 2021, production was 6 t/ha and, in 2022, production was 4 t/ha.

Thus, the highest barley production was obtained in 2021 and the lowest, in 2022.

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ASSESSMENT OF THE PRODUCTIVE CAPACITY OF AGRICULTURAL LANDS FOR THEIR SUSTAINABLE USE

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Abstract

The purpose of the paper was to assess the production capacity of the lands in Periam, Timiș County, in wheat, barley, corn, and sunflower. We chose 17 more important and better determining indicators and, based on them, we established, for each crop, the credit ratings, after which we classified the soils in the studied area into fertility classes. In accordance with the methodology for developing pedological studies, the degree of suitability was determined for each of the four crops: 91.73% of the area of this locality is represented by agricultural land, of which arable land represents 79.22%. and 0.41% is forested land. Following the evaluation of arable land (4,663 ha), it was found that 45.38% fall into the first class, 33.63% in Class II, 20.10% in Class III, and 0.89% in Class IV, with an average grade of 75. This makes these lands highly productive. As a general conclusion, each farmer should periodically evaluate the fertility of the farm soils, make a balance of the nutrient requirements for each crop by considering the plants' requirements according to the vegetation phase, the technology applied, the local soil land climate conditions based on realistic forecasts. In this way, a series of costs with fertilizers and soil work are reduced, the excess is eliminated, and the deficiency of nutrients is corrected, the recommended doses are fractionated and applied differently depending on the needs of the plant, the humidity, the reaction and the texture of the soil. Following the results obtained, it appears that these lands have a high production capacity.

Key words: *assessment of agricultural land, sustainable use, soil, Periam*

INTRODUCTION

The assessment of agricultural land is one of the most important activities, participating in increasing production and planning a sustainable agricultural system, able to adapt to all pedological and climatic conditions in the area, considering the continuous increase in population and the continuous need for food. The four crops chosen are essential and represent a basic food source for humans and animals [3, 4, 5, 15]. The production of these staple crops influences local and national food security [16].

After Țărău et al. (2002), the evaluation of agricultural land is an essential activity centred on land management, being one of the areas of major importance, increasingly appreciated in the recent period both nationally and globally, in the conditions of the transition to a functional market economy [2, 7, 9,].

Thus, the scope of this field is considerably widened, social-economic fields of sustainability also being considered [1, 8, 17], along with two new categories represented by technological aspects (FAO, 1970) and by aspects related to the conservation of resources land and environment (FAO, 1993).

In the field of land evaluation, remarkable research was carried out in our country by great Romanian soil science specialists [6, 7, 11, 12].

Adequate land evaluation is a method that identifies the factors that limit the cultivation of certain plants in a certain area or on certain types of soil [1, 2, 14]. This type of land evaluation includes a qualitative and a quantitative evaluation [16, 17]. Following the qualitative assessment, a series of information related to climate, hydrology, geology, vegetation, and soil properties are considered [13, 18]; in the quantitative assessment, the results obtained are much more detailed and they generally refer to the estimated yield [10, 9]. The FAO land assessment framework [7, 8] and physical land assessment methods [13] have been widely used for assessing land suitability.

In this context, the goal of this research is to assess the productive capacity of the lands in Periam, Timiş County, Romania, for wheat, barley, maize, and sunflower crops, to establish credit ratings and to classify them into fertility classes for each type of soil from the seven types identified.

MATERIALS AND METHODS

Site description

The studied area is in the western part of Romania, in Timiş County (Map 1).

From a geographical point of view, the research territory is part of the Torontal Plain, a component of the Western Plain. Among the main processes encountered there are meanders and floods with alluvium and drifts because of the reduced slope and subsistence process. The plain of the locality is crossed by the Aranca and Galaţca rivers, which are old courses of the Mureş River [3].

Due to its geographical loation, the climate of Periam commune belongs to the moderate continental type with ocean and Mediterranean influences, the Sânnicolau-Mare topoclimate characterized by a steppe climate. From an agricultural point of view, this climate is favourable for plants that need higher temperatures; the number of days corresponding to the vegetation period (temperatures above 5ºC) is 180-200 days. The average amount of precipitation is 550 mm annually, and the number of rainy days is less than 110 days/year. Also, the amount of precipitation during the summer is 27%, and dry periods are more frequent than in the rest of the plain. [1, 15, 19]. The number of days with snow cover is below 30.

From a hydrographic point of view, the Aranca and Galaţca rivers are used as irrigation canals. Analysing the situation from a geological point of view, there are permeable formations that can contain aquifer layers [9, 18]. Following the studies carried out, two types of aquifer horizons were highlighted: a phreatic aquifer layer and an aquifer layer under pressure. Between these layers, thick impermeable formations (clays and marls of various types) are interspersed. Groundwater is found at different depths [11, 19].

Map 1. Map of Romania, Timiş county AND Timiş rivers
Source:
https://ro.wikipedia.org/wiki/Comuna_Periam,_Timi%C8%99 [20].

The research was carried out in the outskirts of Periam, where 35 soil profiles were excavated.

To reach the proposed objectives, soil analyses were carried out, and the following physical and chemical properties were determined:

- Soil texture, by the Cernikova method (the principle underlying this pipetting method is the sedimentation of the particles in a liquid at different speeds depending on the diameter according to Stokes' law);
- Soil density (cm^3) was measured in the laboratory (using a pycnometer and distilled water);
- Soil apparent density (cm^3) was measured on the ground (in natural settlement), using cylinders;
- Total porosity (%), by calculus;
- Aeration porosity (%), by calculus using the values of some hydro physical and physical indices;
- Determining the humus content of the soil (%) by titrimetric methods, respectively the Tiurin method. The principle of this method consists in the oxidation of C in the humus, using a solution of chromic anhydride (or

potassium bichromate) in the presence of sulfuric acid;

- The reaction of the soil was determined potentiometrically (with the help of an electrode that was inserted into a solution with a ratio of 1:2.5);
- Total nitrogen was determined by the Kjeldhal method;
- Mobile phosphorus was determined by the Egner-Rhiem-Domingo method (using a UV-VIS spectrophotometer);
- Assailable potassium was determined using an atomic absorption spectrophotometer;
- Total cationic exchange capacity, by the Bower method;
- Degree of saturation in bases (V%), by calculus.

Calculus of credit scores

To assess the agricultural land in Periam, from the totality of the environmental conditions, 17 more important and better-established indicators were chosen. [10, 11].

Based on them and on the value scales, rating coefficients were extracted from the tables, annexes 3-1 to 3-18 (according to the methodology for the development of soil studies, part II), which express the degree of suitability of an indicator for the four crops and for the category of agricultural use.

The results obtained depending on the type of soil and on the crop (wheat, barley, corn, sunflower) are extensively presented, both in tabular and graphical form, considering the physical and chemical soil properties, climatic conditions, groundwater, or other factors that limit their fertility. For each indicator, depending on its scale of use or crop, tables were compiled with the values of the respective coefficients.

Classification of agricultural land into quality classes

Currently in Romania, the assessment of the quality of agricultural land is done according to Law no. 16/1994, which considers the existing credit rating works in the I.C.P.A. or O.J.S.P.A. archives. According to this methodology, the production potential of the land is classified – depending on the soil, relief, climate, groundwater, natural rating for arable land – into 5 quality classes.

The methodology for assigning agricultural land to the quality class is unique, and the competent bodies are the Research Institute for Soil Science and Agrochemistry and the County Offices for Soil Science and Agrochemical Studies. According to the credit rating methodology existing in our country, the most productive land can reach a maximum of 100 ratings in Romania's natural conditions, except for irrigated land in the warm areas of the country, which can accumulate up to 150-160 credit ratings (after potentiation for irrigation).

RESULTS AND DISCUSSIONS

The new context caused by both the war in Ukraine and the economic situation in our country, needs considering a periodic inventory of agricultural land, taking measures leading to higher yields, cultivating varieties and hybrids to adapt as best as possible to the pedoclimatic conditions in this area, reducing the expenses necessary for the establishment and maintenance of crops through the identification and real evaluation of each type of soil based physico-chemical analyses. All this will help us make the best choice regarding the assortment of crops, cultivated areas, and rotation and fertilization plans according to the estimation of the level of the planned harvests.

The first preliminary studies carried out in this area by a part of the team took place in 2018, and the data presented in this paper will be supplemented in terms of the evaluation of agricultural land for the arable category, considering the soil and climate conditions from 2020-2022, of the calculus of credit ratings, and of the classification into quality classes for the four basic crops (wheat, barley, maize, and sunflower) [19].

The evaluation of agricultural lands is a complex operation that is carried out periodically (once every 4-5 years) involving the establishment and characterization of the natural conditions, of the technologies used for each crop according to the suitability of the soils for certain crops and ways of use.

From a geomorphological point of view, the studied area is part of the plain area whose altitude is 90 m and which is formed on parental materials represented mostly by loess and clays, which, depending on the height, includes two steps: one formed from higher lands, and a lower one, permanently subjected to flooding, which led to the formation of different soils (Table 1).

Table 1. Soil types and areas covered (ha and %)

Soil type	Area	
	ha	%
Psamosoil	47	0.80
Alluviosoil	265	4.50
Chernozem	3,905	66.34
Eutricambosoil	805	13.67
Vertosoil	12	0.20
Gleysoil	132	2.24
Stagnosoil	39	0.65
Soil associations	681	11.60
TOTAL	5,886	100

Source: Own calculation.

The largest areas are occupied by chernozems, with 3,905 ha, respectively over 66%, followed by eutricambosoils with 13.67%. In the higher areas, eutricambosoils and vertosoils appear, and in the lower areas, alluviosoils, gleysoils and stagnosoils, along with soil associations, including solonetz.

Chernozem. It is the most important soil, both by the large areas it occupies within the studied territory, and by its fertility. Physical and chemical properties are favourable for the cultivation of all four crops: wheat, barley, maize, and sunflower.

The texture of the chernozem is loamy-sandy throughout the profile.

Soil reaction (pH) is weakly alkaline with values in the Am horizon of 7.34, in the A/C horizon the value increases to 7.65, and at the basis of the profile, the pH is 8.04.

Calcium carbonate ($CaCO3$) is extremely small, with values in the Am horizon of 0.56, in the A/C horizon with values of 2.43, and in the Cca horizon with values of 4.66%.

Humus content is medium with values between 2.07 and 1.02%.

Humus reserve has the value of 318.19 t/ha.

The content of phosphorus is low, in the Am horizon the value of 15.6 decreasing towards the A/C horizon to 13.2, and in the Cca horizon to the value of 12.4 ppm.

Potassium content is medium to low, with the following values: in the Am horizon 122, in the A/C horizon 74, and in the Cca horizon, 56 ppm.

The degree of saturation in bases (V%) has the value of 100 over the entire profile, making it a eubasic soil.

For each indicator, depending on its scale of use or culture, tables were compiled with the values of the respective coefficients (Tables 2 and 3).

Table 2. Suitability of soils for wheat and barley

Soil type	Wheat		Barley	
	Credit rating	Fertility class	Credit rating	Fertility class
Psamosoil	54	III	50	III
Alluviosoil	84	I	82	I
Chernozem	96	I	94	I
Eutricambosoil	56	III	48	III
Vertosoil	42	III	46	III
Gleysoil	38	IV	40	IV
Stagnosoil	24	IV	28	IV

Source: Own calculation.

From the analysis of credit ratings for the crops of grassy cereals (winter wheat and winter barley), a sharp differentiation of the soil units can be observed from the point of view of the conditions that create them for the crop plants. The highest scores are obtained by chernozem, with 96 ratings for the wheat crop and 94 ratings for the barley crop, followed by alluviosoil, with 84 ratings for wheat and 82 ratings for barley respectively, which places them in the best class (fertility class I).

Table 3. Suitability of soils for maize and sunflower

Soil type	Maize		Sunflower	
	Credit rating	Fertility class	Credit rating	Fertility class
Psamosoil	52	III	62	II
Alluviosoil	86	I	90	I
Chernozem	90	I	90	I
Eutricambosoil	56	III	52	III
Vertosoil	38	IV	36	IV
Gleysoil	52	III	48	III
Stagnosoil	28	IV	24	IV

Source: Own calculation.

At the opposite pole, with only 24, respectively 28 ratings, was the stagnosol,

which fell into the IV fertility class, next to the gleysoil in terms of the two crops.
As for maize, the highest credit ratings (90) are obtained by chernozem, followed by alluviosoil, the two types of soil being included in the 1st fertility class, while vertosoil and stagnosoil were included in the 4th fertility class with only 38 and 28, respectively, ratings for maize.
The sunflower crop, scored close to or even higher than maize, adapts better to soils that benefit from a lot of heat and that are well-structured and aerated soils. The highest score of 90 ratings was obtained by alluviosoil and chernozem, which ranks them 1st in terms of suitability for sunflower, followed by psamosoil with 62 ratings, class II, respectively, while vertosoil and stagnosoil obtained the lowest score, of 36 and 24 ratings, the two types of soil being, thus, classified in the IVth fertility class for both sunflower and maize.
The fertility level of the soils in the town of Periam and their classification into quality classes was also highlighted by the average yields obtained for the four crops (wheat, barley, corn and sunflower) (Table 4 and Fig. 1).

Table 4. Average yields (in kg/ha) of the main crops in Periam commune, depending on soil type

Soil type	Fertility class	Average productions (kg/ha)			
		Wheat	Barley	Maize	Sunflower
Chernozem	I	7,500	8,200	8,000	2,505
Alluviosoil	I	7,300	7,900	7,800	2,360
Psamosoil	III	6,550	6,640	5,950	2,150
Eutricambosoil	III	6,600	6,480	6,550	2,100

Source: Own calculation.

The soil types included in fertility class I were the chernozoms and alluviosols, which obtained the following credit ratings (N.B.): The chernozom, between 86 points for corn and 96 points for wheat and the Alluviosol, between 82 points for barley and 90 points for sunflowers. On these soils, the productions obtained (Table 4) show that chernozem is the most fertile soil in the studied area, a fact reflected by the average productions obtained during the studied period (2020-2022) and which fell between: 7,500 kg/ha in wheat, 8,200 kg/ha in barley, 8,000 kg/ha in maize and 2,505 kg/ha in sunflower, closely followed by Aluviosol with 7,300 kg/ha in wheat, 7,900 kg/ha in barley, 7,800 kg/ha in maize and 2,360 kg/ha in sunflower.

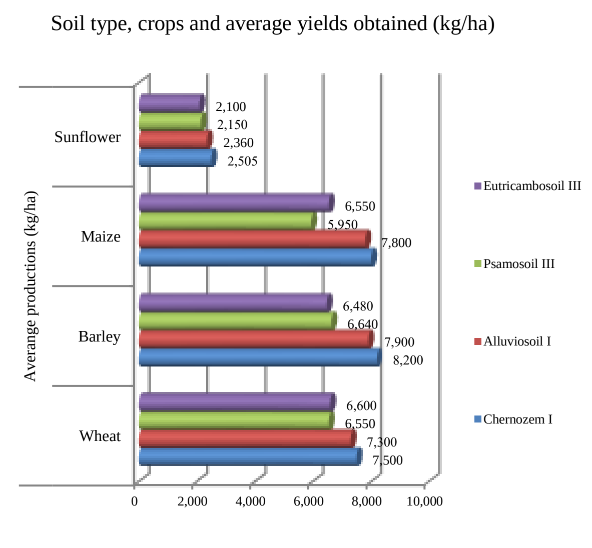

Fig. 1. Soil type, crops and average yields obtained (kg/ha) in Periam
Source: Own calculation.

Psamosols and Eutricambosols were the soils that obtained between 48 and 56 points, being classified in the III-a quality class and whose productions were between 6,550-6,600 kg/ha for wheat, 6,480-6,640 kg/ha in barley, 5,950-6,550 kg/ha in corn and respectively 2,100-2,150 kg/ha la floarea soarelui.

CONCLUSIONS

Within the studied territory, the four crops have the largest share, the cultivated areas being significant, which makes their expansion also take place on soils that have lower fertility and which, by applying soil improving measures, can give yields higher in terms of their production and quality.
From a geomorphological point of view, the studied territory has the form of a loess plain, with slightly irregular shapes, with wide flat horizons, which, due to subsidence, have taken the form of isolated and very shallow depressions.

Geographically, the low plain of Torontal is part of the group of divagation or subsistence plains.

Among the forms and processes often encountered there are strong meanders, floods with alluvium, and ramifications. All this comes from the slope, which is very low, and from the subsistence process. The plain of the locality is crossed by Aranca and Galaţca, which are old courses of the Mureş River.

The idea of fertility normally implies the best biological, physical and chemical properties of the soil, the abundance or existence in high amounts of all the nutrients necessary for plants, together with enough water.

The soils encountered within the studied territory are of the chernozem, psamosol and alluviosol types, i.e., soils with good drainage. Considering all their favourable physical, chemical, and biological properties, these soils have a high natural fertility, which makes them suitable for the four studied crops (wheat, barley, corn, and sunflower). Among them, the largest area (3,905 ha) is covered by chernozems, followed by alluvia on 265 ha. These soil types fall into the 1st fertility class for the four crops.

Gleysoils and stagnosoils appear in depressed areas due to the high level of phreatic waters rich in potassium, or due to the flat relief which, during rainy periods, leads to water stagnation in the first part of the soil profile, which places them in the 3rd class of fertility for wheat and barley and in the 4th fertility class for maize and sunflower, respectively. Gleysols occupy an area of 132 ha and stagnosoils, 39 ha.

Eutricambosoil and vertosoil are 3rd class fertility soils for all four crops studied. The area occupied by vertosoils is very small, 12 ha, while eutricambosoils occupy 805 ha.

Considering the area occupied by these soils, their physical, chemical, and biological properties, as well as their suitability for the four studied crops, the conclusion is that the research territory falls into the category of fertile areas in the western part of Romania and in Timiș County. However, there are some limitations regarding summer temperatures and the lack or uneven distribution of precipitation during the growing season, which limits their fertility and productive potential in certain periods or to certain crops.

To increase the natural fertility of these soils, it is recommended to take the following measures:

- Organic and mineral fertilization, especially on planosol, vertosoils and eutricambosoils;
- Application of lime amendments on vertosoils, gleysoils, and stagnosoils;
- Irrigation during dry periods, especially on chernozems, vertosoils, and planosol;
- Removal of excess moisture (phreatic and stagnant) in the case of gleysoils and stagnosoils;
- Reduction of the degree of subsidence in vertosoils and chernozems, and salinity.

As a general conclusion, each farmer should periodically evaluate the fertility of the farm soils, make a balance of the nutrient requirements for each crop by considering the plants' requirements according to the vegetation phase, the technology applied, the local soi land climate conditions based on realistic forecasts. In this way, a series of costs with fertilizers and soil work are reduced, the excess is eliminated, and the deficiency of nutrients is corrected, the recommended doses are fractionated and applied differently depending on the needs of the plant, on soil texture, reaction, and humidity.

For economic reasons, a correct management of fertilizer application is required. Special attention should be paid to nitrogen-based fertilization, because this element can be lost in the form of nitrates with the water from precipitation or, if applied in large doses, will cause soil acidification.

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THE ROLE OF THE IMPLEMENTATION OF DIGITAL TECHNOLOGIES IN THE DEVELOPMENT OF THE AGRICULTURAL SECTOR IN THE REPUBLIC OF MOLDOVA

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Abstract

Digital technologies represent a new direction increasing the efficiency of the agro-industrial sector and the sustainable development of agriculture. At the current stage, we can note the role of the transmissibility of new technologies and innovations in the agri-food complex, vis-a-vis regional improvement and development, the need for economic-financial and human sources for the implementation of innovations, as well as the efficiency of their implementation in practice. Management efficiency is treated through the complex and synergistic approach of economic, financial and ecological efficiency of enterprises. The purpose of the present article is to propose the digital assurance chain and to analyze the importance of current digital services in the development of intelligent management in agriculture. In the process of developing the objectives proposed in this article, the authors used the following methods, such as: analysis and synthesis, the statistical and mathematical method, the comparative method, the survey, the interview that would ensure the development of the entire economy by ensuring the sustainability of the agri-food sector. The proposed proposals will be used by agricultural entrepreneurs, not taking into account specialization and fields of activity, as well as by certain state institutions in the Republic of Moldova.

Key words: *agri-food sector, development, Industry 4.0, farmers-innovators, digitization.*

INTRODUCTION

One of the impediments to new digital technologies and innovations is the inefficiency of management at the level of the region and of economic agents in the agri-food sector. The innovative agricultural sector is connected to the leading field of environmental verification in close connection with production standards. In our view, improving management through the use of new digital technologies is the future of agriculture, and attempts to ignore them lead to the stagnation of the development of this sector [1].

We state this hypothesis because there are already international studies that prove itthe fact that the Internet of Things, robotics, artificial intelligence and big data are already thereapplied by agricultural entrepreneurs and these modern tools are essential contributors tostreamlining the management of production processes in this sector and contributing to ensuring a sustainable development of the economy [5]. In the foreground, in this context, the problem of making the management of the sector more efficient appears agricultural, because according to international estimates, the world population will reach the figure of 9.2billions until 2050, and to satisfy the population's demand for agricultural products, farmers must produce 70% more (FAO) [10].

At the same time, the progress achieved at the global level hascaused the pollution of the environment and the depletion of natural resources, and the continuity of mankind could be undermined by poor management of land and water resources, as well as pollution the environment. The current conditions of activity, the global economic and health crises imposeproducers to implement new models of agricultural business management instead of those traditional, to preserve sustainability in agriculture. Globalization, which affects the agricultural sector, imposes a new strategic vision regarding the digitization of agriculture.

Literature review

Romanian, Russian and native scientists and researchers: Amarfii [1, 2], Parmacli D., [11], Bajura T, Stratan A. [4], Todorova and Zaharco [15] and others, present several approaches to the problems related to the implementation of digital technologies in the economy, agriculture, service sphere. Todorova and Zaharco [15], Boincean [7], examine the development of the agricultural sector through the application of ecological technologies, the creation of processing enterprises on principles of "green economy". The complex approach to economic, financial and ecological efficiency is supported by researchers Perciun and Amarfii [13], Studies by researchers Beluhova-Uzunova and Dunchev [6], examined the implementation of innovations and digital technologies of regions and industry entities. The application of digitalization-based mathematical models for estimating business efficiency, including in the agricultural sector, was mainly examined by Russian researchers: Hedley [8], Hirsch-Kreinsen [9], Angelova and Stoyancheva [3].

In this context, the aim of the paper is to propose the digital supply chain and evaluate the role of modern digital products in increasing management efficiency in the agricultural sector.

MATERIALS AND METHODS

In order to achieve the objectives proposed in the research, the general scientific methods were applied: analysis, synthesis, history and logic, critical analysis of materials, clustering, but also methods of analysis and economic-financial diagnosis, survey, statistical processing of empirical data and official data , the method of graphs, indicators and indexes, comparison, grouping, etc.

The studies that have been carried out denote the theoretical and conceptual part of the effectiveness of management in the agricultural field under the conditions of the use of ICT, as well as the theory of improvement-economic development strategy Industry 4.0 in the digital age. The refinement of the theoretical term of industrial ecosystems in the agri-food field can serve as an example for the efficient management of the given field, financial flows, relations with customers and company personnel [12]. The innovation brought by Industry 4.0 consists in the fact that the product until the finishing process ofproduction can interact with the production machinery so as to transmit the information forthe following stages of the processing process. This communication between the product and the factors of production achieves the connectivity between the elements of the production process as a whole, giving birth to an intelligent production system, capable of making decisions and communicating autonomously [1].

RESULTS AND DISCUSSIONS

As seen in thestreamlining of production and service management, Industry 4.0 focuses on creating intelligent and communicative systems, including machine-to-machine communication and human-machine interactions. Now and in the future, enterprises must deal with establishing effective data flow management that is based on the acquisition and evaluation of data extracted from the interaction of intelligent and distributed systems. The main idea of data acquisition and processing is the installation of self-monitoring systems that allow taking precautions before operating the system. Thus, companies sought the right adaptation of Industry 4.0 [3]. The development of digital agriculture could catalyze a radical transformation of all industries, because digital agriculture will not only change the way farmers work, but will fundamentally transform every link of the value chain in the economy. Digital agriculture will affect farmers' behavior and will also affect suppliers, processing, distribution and retailing of agricultural products to consumers. Digital technologies can be applied at all levels and sectors of activity and reflect a radical change in resource management towards optimized quality, individualized, intelligent and anticipatory, real-time, hyper-connected and data-driven management [1].

Another international practice in the field of Agriculture 4.0 is the virtualization of agri-food supply chains (Fig. 1).

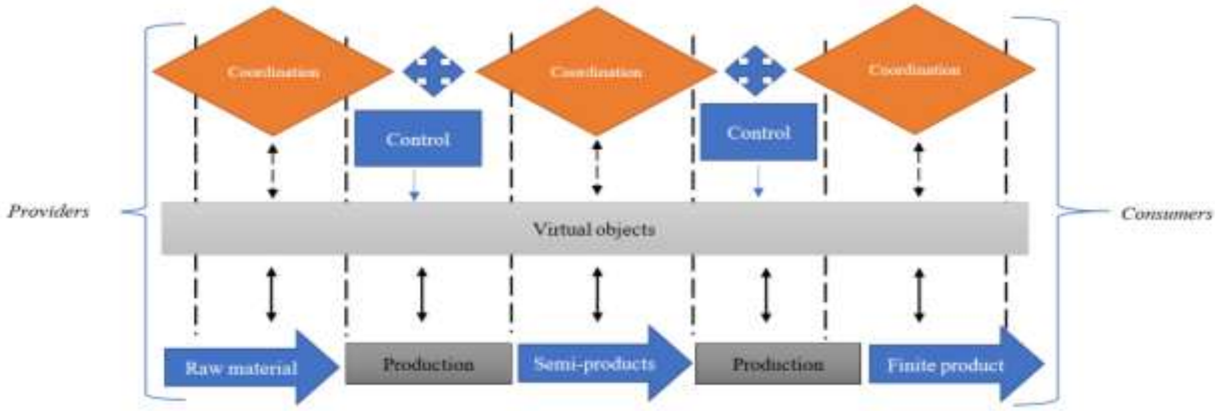

Fig. 1. Virtualization of supply chain management through the Internet of Things
Source: Elaborated by the authors.

The components of the supply chain are inputs (pesticides, fertilizers, mature agricultural products, crops, shipments and orders, packaging, etc.) that undergo transformation processes through agricultural producers, product processors, traders. The fourth industrial revolution allows enterprises to efficiently combine production capacities and speed of meeting consumer demands, based on a more productive and competitive management system. In the framework of digital agriculture, existing technologies enable the realization of smart farms. However, the acceptance of technologies by individual farmers depends on several factors, primarily financial capabilities, but also the ability to use and identify best practices in the given field. The importance of a change in farmers' mentality is crucial to enable an efficient and sustainable production system. Although considerable research efforts have been devoted to the development of intelligent models in the agricultural sector, their application to individual farms is limited, despite the many advantages that intelligent agriculture can bring; how these might be achieved in the dimensions of productivity, compatibility and sustainability remain unclear [4]. A structural approach, legislation appropriate to the technological environment, improvement techniques and new qualifications are decisive for agriculture 4.0. Industry 4.0 in agriculture represents a new stage of development of this sector. Information products and technologies allow not only the creation and maintenance of databases, but also provide high speed of adaptation to changes, building algorithms that can automate decision-making processes [1]. The premises of the digitization of domestic agricultural enterprises and the implementation of Agriculture 4.0 are determined by international and European trends in the field of business digitization, the potential for digitization of the national economy and the agricultural sector, but also the way entrepreneurs and managers in this sector perceive the need for digitization.Industry 4.0 is a political, economic and social challenge for the whole world, the aim of which is to absorb digital innovations in products, processes and business models. Many developed countries in Europe, America and Asia have included the concept of Industry 4.0 in their long-term development plans. In Europe, more than 1,300 billion euros will be financed over 15 years in the improvement of digital technologies. Many enterprises from Europe, the USA and Asia have been accepted into the team for the use and promotion of Industry 4.0 components in their work.The digital systems currently owned by international companies are evolving rapidly, and information is being stored in the cloud to increase availability and accuracy [12, 11, 9].

All this allows greater flexibility to changes (both anticipated and unexpected) in the production process. Strengthening cooperation between machines and people will enable manufacturers to improve product quality by reducing manual work and increasing the use of real-time data to detect errors. Automation also increases the efficiency of logistics in the enterprise. Production processes will become more flexible. Robots, smart machines and smart products that communicate with each other and make certain autonomous decisions provide this flexibility. Digital agriculture is the most effective and necessary approach to achieve all these transformations by using computing and communication technologies to increase profitability and sustainability in agriculture. Therefore, technological innovation in the field is considered a solution for agro-industrial countries. Agricultural technologies, based on IT products, automation and robotization, used on a large scale will catalyze the increase in productivity and profitability of agricultural activities. The digitization of agriculture improves working conditions for farmers, reduces the negative impact of agriculture on the environment, but also ensures a much higher profitability of agricultural enterprises [4, 7].

In a short time, digital agriculture will take the place of the traditional one, the producers, understanding that by investing in technology, they can achieve effective results, such as the economy of raw materials and other resources either material or financial.

Results of the survey with entrepreneurs and managers in the agricultural sector

One of the basic stages of recognition of economic agents in agriculture is the need to digitize agricultural businesses, the priorities of making financial investments for the modernization of the given sector. Calculation of the degree of perception of economic agents in agriculture, of the need to modernize the agricultural business, an empirical study was conducted on the degree of digitalization of agricultural enterprises with the help of digital survey tools.The electronic survey was applied to a representative sample of 200 entrepreneurs and managers active in the field of plant breeding, animal breeding and the provision of services in agriculture.

The Survio digital platform was used to conduct the electronic survey, 2022 [14].

The study carried out, applying the clustering tool, allowed us to group entrepreneurs and managers in the agricultural sector, according to the degree of perception of the need to implement IT in their activity into four basic types of farmers:

a. *farmers-innovators*, who develop new innovative products to make the production process more efficient in agriculture, represent 7% of those interviewed;

b. *advanced farmers in the use of IT* products, those who use modern sensors, satellite images and other products to increase agricultural performance, represent 12% of the total;

c. *farmers who are interested in the implementation of IT* in agriculture and are experimenting with some products (trying to apply some IT products because they understood their usefulness) - 33%;

d. *conservative farmers*, who give up the use of new technologies in agriculture (they consider the technologies to be expensive and ineffective) - their share is 48% (Fig. 2).

The existing gap between the 4 categories of farmers and the large share of conservative farmers (48%) has a negative impact and stagnates the implementation of information technologies in agriculture.

Among the interviewed farmers, 63% mentioned the lack of financial assistance and government subsidies for the implementation of ICT in agriculture, as well as the lack of fiscal incentives for agricultural enterprises that make investments and apply digital technologies in their activity.

In the empirical study, the tendency of farmers for the widespread use of sensors, drones and high-performance monitoring systems, which require access to the Internet, was found.

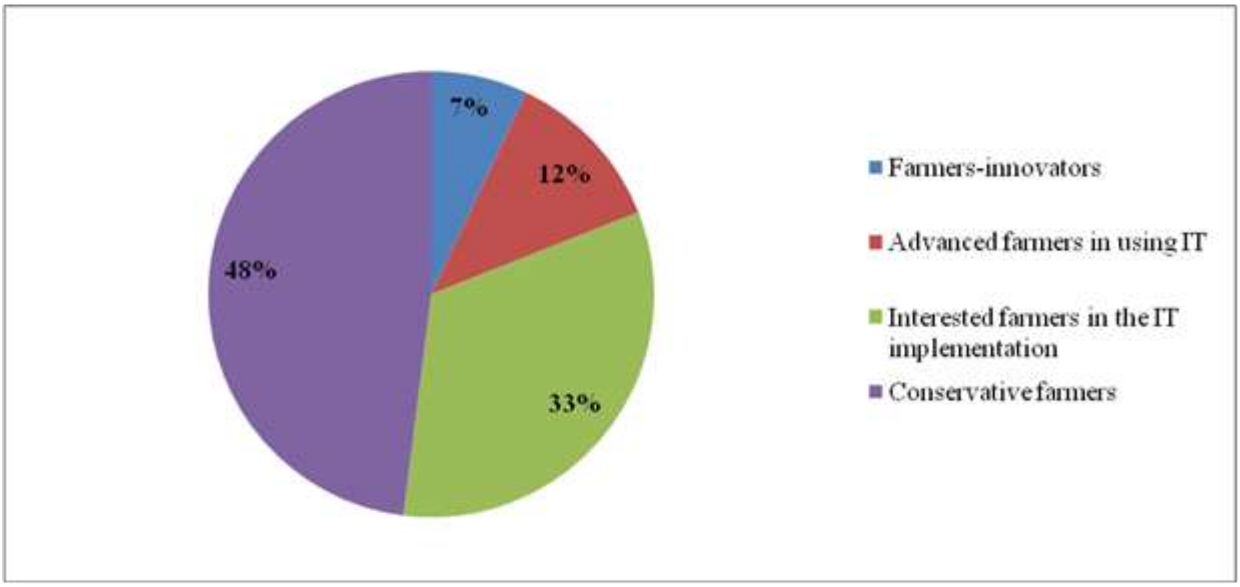

Fig. 2. Classification of the entrepreneurs and managers dealing with agribusiness, according to the degree of perception of the need to implement IT in their activity
Source: Own results.

According to the survey, 18% of the interviewed farmers rated the WI-FI network as "good quality", 23% called the access to the wireless network "problematic", and for 9% of the farmers the Internet is of "bad quality". The other respondents rated the quality and speed of the Internet as "satisfactory" (Fig. 3).

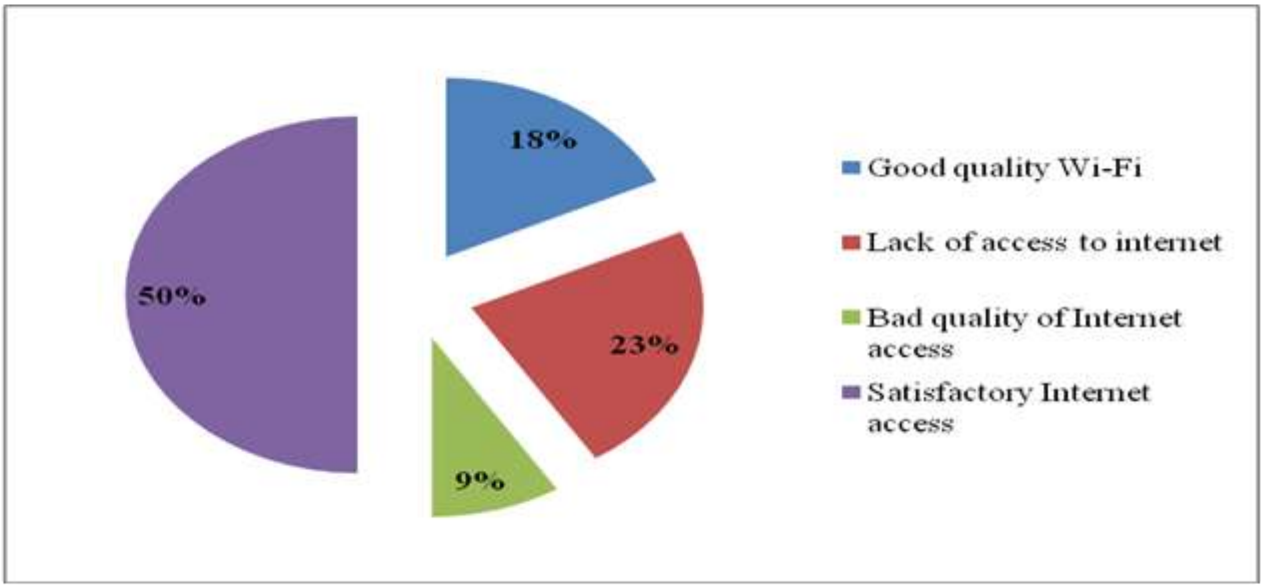

Fig. 3. The respondents' answers regarding the Internet and Wi-Fi access
Source: Own results.

If certain information is not received in time and there are connection problems, the value of precision agriculture is reduced.
The survey in question had Moldovan farmers who are active users of the 4G network as respondents.
The farmers interviewed also referred to the diversification of remote management capabilities of agricultural processes in the research.
In our view, this is an important step in the development of digital agriculture.

Table 1. Perception of the need for digitization of agricultural businesses

Answer options	Answers	%
Very necessary	103	51.5
Necessary	65	32,5
A medium need	23	11,5
It is not necessary	6	3
I do not know	3	1.5
Total	200	100

Source: Own calculation.

As a result of the assessment of the degree of perception of the need for business digitization by entrepreneurs and managers in the agricultural sector, 51.5% of respondents mentioned the implementation of information technologies in the business they manage as "very necessary" and 32.5% as "necessary ", 11.5% consider the digitization of business "an average necessity", and 3.0% consider that agricultural businesses should not be digitized

Mobile applications have capabilities for setting and changing technology parameters. For example, the app can change settings on an unmanned tractor or a garden robot without interrupting the work process.

Mobile applications for parallel guidance and fertilizer and soil moisture monitoring systems are popular among ICT-advanced farmers.

Therefore, there is a tendency among farmers to intensively use ICT products, creating favorable conditions for the development of digital agriculture.

So, the involvement of digital technologies in the field of agriculture of the Republic of Moldova will increase the growth of economic and financial indicators by reducing and optimizing the costs of human factors and the optimal distribution of means and successes achieved will reflect on sustainable development, the development and rational use of natural resources.

CONCLUSIONS

In the opinion of the authors, for the development of the potential of digitization in the field of agriculture in the country, the need for marketing services to promote digitization ideas in rural localities, i.e. agricultural entrepreneurs, the improvement of digital knowledge for the development and use of digital technologies in the field of agriculture and the formation of a sufficient innovation environment is opportune. to attract investment and external funding for the development of digital services in agricultural businesses**.** Digital technologies in agriculture must be applied based on the strategic approach of the state, the systematic development of innovative programs aimed at the branch of plant and animal breeding in the regions of the country.

The empirical study carried out allowed us to validate the hypothesis regarding the need for digitalization of agricultural businesses in order to make management more efficient, perceived by trainers and managers in this sector of activity. For the practical use of Industry 4.0 innovations in agriculture, it is necessary to meet the economic, technical, environmental and personnel criteria. The efficiency of information technologies in agriculture is proven economically in international practice, regarding the Republic of Moldova, the authors analyzed the agricultural sector and determined the connection between the use of ICT tools and the efficiency of the management of economic agents in agriculture.

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THE INFLUENCE OF THE VENTILATION SYSTEM IN THE ROOM FOR REARING PIGS AND THE TYPE OF FEEDING ON THE INDICATORS OF MICROCLIMATE AND PRODUCTIVITY OF PIGS

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Abstract

The article investigated the influence of systems for creating a microclimate with uniform pressure and geothermal negative pressure in combination with liquid and dry feeding systems on the parameters of the microclimatic environment in the piglet rearing room and the intensity of their growth. For this purpose, four groups of 150 pigs each were formed, two of which were kept with a uniform pressure ventilation system and two with negative pressure geothermal ventilation. For each ventilation system, one group was fed dry granulated compound feed, and two groups were fed liquid mixtures based on the same compound feed with an addition of 2.7 liters of water per kilogram of feed. The pigs were kept under the same conditions and were fed a diet that was equivalent in composition and nutritional value. Group I included piglets that received dry feed and were raised in a room with uniform pressure ventilation. The animals in the group II were kept in the same room, but consumed liquid feeds. Pigs in the III and IV groups were kept in rooms with geothermal ventilation. Piglets in the III group were fed dry feed, while piglets in the IV group were fed liquid feed. The results of the study showed that the ventilation system has an influence of 76.48% on relative humidity, 76.96% on ammonia content, 65.77% on carbon dioxide content and 65.07% on hydrogen sulfide content. The feeding system only affects the hydrogen sulfide content with a strength of 5.79%. Better microclimate parameters were provided by uniform pressure ventilation. Higher average daily gains, higher feed consumption, better feed conversion and lower cost per 1 kg gain were found in groups of pigs fed liquid feed and kept with geothermal ventilation.

Key words: *pig rearing, feed conversion, microclimate, method of feeding, cost*

INTRODUCTION

The influence of microclimate on animals consists of a complex of factors of external environment: temperature, humidity, speed of air movement, chemical composition, microbial colonisation and dust load of air, lighting [11, 19].

The most important parameter of microclimate is the temperature of indoor air [1]. It has the greatest influence on the health status and productivity of animals [38]. The hygienic value of temperature is that it makes an impact on the thermoregulation of the body [39]. At the same time, temperature directly affects the relative humidity in the pig house [7]. The effects of relative humidity on animal health and productivity should be considered in close relation to temperature. An increase in the level of relative air humidity in the room leads to a slowing down of the evaporation of moisture droplets through the respiratory organs of animals, as the decrease in the partial pressure of water vapor balances with the value of the elasticity of water vapor on the surface of the mucous membranes of the nasopharynx and respiratory tract [9, 30]. In addition, humidity saturating indoor air alters its heat capacity and thermal conductivity, leading to the deposition of condensate and the development of pathogenic microflora [21]. High relative humidity (85% and higher) negatively affects and reduces heat transfer and thus feed consumption at both high and low ambient temperatures [32].

The hygienic value of humidity is that it affects the body of the animals both directly and indirectly [10]. Cold, moist air, which retains and conducts more heat, increases heat loss from the body (Renaudeau), lowers body temperature, forces excessive food intake and causes colds [41]. Humid air at high temperatures inhibits heat transfer due to reduced evaporation of sweat from the body surface, resulting in overheating of the body, deterioration of appetite [20] and reduced productivity [26]. The indirect effect of humidity on animal organisms is determined by an increase in the accumulation of harmful gases [35], microorganisms in the air [4, 37], a decrease in the heat-shielding properties of the external enclosures of the room [6], corrosion of metal equipment [16], deterioration of feed preservation, quality products [40].

A change in relative humidity from 70 to 95% leads to an increase in mortality in pigs from 0.05 to 17.5%. High indoor relative humidity reduces the digestibility of nutrients. The average daily gain of rearing pigs is 653 g at 85% relative humidity and at 91.8% – only 553 g [14]. The unsatisfactory condition of the microclimate of livestock premises leads to a decrease in productivity by up to 15% with a simultaneous increase in feed costs by 10–15% [7]. Excessive feed expenditures to support heat exchange processes at low temperatures and high humidity lead to a decline in pig farming efficiency, especially on farms with small herds. And the survival rate of suckling piglets increases by 10.6% when normal humidity is maintained [27]. In contrast, however, other authors report no effect of relative humidity on average daily gains or feed intake of pigs [22].

Here, the humidity depends not only on the indoor and outdoor temperature, the external relative humidity of the environment [28], but also on the available sources of moisture in the centre of the room for keeping pigs. An additional increase in humidity occurs from the pigs' respiration and evaporation from their bodies [8], as well as evaporation from the surface of the manure in the pits [25], from the transport systems, feed distribution and watering [34]. Relative humidity, the type of feeding and the composition of the ration also affect the gas composition of the internal environment, which is related to the functioning of the pigs' organisms and the release of gases [3, 13, 42].

Both dry and liquid feeding of pigs are widely used in industrial pig farms. Each feeding method has its advantages and disadvantages that can increase or decrease the overall productivity of pigs [23]. Liquid feeding usually uses the same feedstuffs as dry feeding, but with additional hydration or fermentation of the ration ingredients [29]. Liquid feed can be easier to digest and provide a wide range of nutrients. As a result, pigs fed liquid feed mixtures may have a higher growth rate in both the growing and fattening phases [24]. Liquid feeds tend to be more palatable, resulting in higher consumption compared to dry feeds. Pigs generally absorb feeds with a liquid preparation method better, resulting in higher consumption compared to dry feeding methods [18]. However, feeding with liquid feed increases the humidity in the room. Liquid feed mixtures are a source of additional humidity, either directly through the evaporation of water from feeders and feed pipes [17] or indirectly - through the evaporation of moisture from the slurry pits and the floor [25], as the use of liquid feed often leads to a more liquid slurry content in pigs [12]. Liquid power systems of older designs, equipped with pumps with low efficiency and have a large number of bends in transport pipelines require excessive hydration in water-to-feed ratios to reduce the viscosity of mixtures. This results in reduced pig growth and poor feed conversion due to reduced feed intake, which is limited by the pig's intake capacity, and the energy expended to release excess water [36]. In addition, the use of a liquid feeding system leads to increased manure production and therefore higher costs for fumigation and transport and storage of slurry due to the diluted nutrient content [2, 33].

The use of liquid feeding, which is becoming more widespread among pig producers, may therefore have certain advantages for increasing the efficiency of pig farming, but also for meeting hygienic requirements in terms of microclimate indicators, especially the level of relative humidity in the room. Therefore, the study of the interrelation between the relative humidity in the room for keeping pigs and the type of feeding is important.

The aim of our work was to investigate how liquid and dry feeding of pigs affects the level of relative humidity in the housing space and to investigate the dependence of indicators of pig productivity on the feeding method and indicators of microclimate in the pig complex.

MATERIALS AND METHODS

Piglets from half-breed sows of the landrace and the large white English breed as well as from boars of the synthetic terminal line PIC 337 were used for the study.

The aim of the study was to investigate the productive characteristics and efficiency of piglet rearing under the conditions of different systems for creating a microclimate and different systems for preparation, transportation, distribution and supply of feed. For this purpose, four piglet groups of 1,200 animals each were formed in the commercial breeder of LLC "NVP "Globinsky Pig Complex" in Kremenchutsk district of Poltava region. After the suckling period, the piglets were weaned from the sows, weighed and sent for rearing. During rearing, four groups of pigs were formed according to the scheme of the experiment (Table 1).

Two control pens were set up in each individual group to weigh the animals. Individual weighing of the animals was carried out in these pens on the day of their entry into the experiment and at the changeover to a new feed ration on the 41st day of life and after completion of rearing on the 70th day of life.

The piglets of all experimental groups were kept under identical conditions, each group being housed in a pen with an area of 51 m^2, with 0.33 m^2 per piglet, while each animal had a warm floor of 0.1 m^2 at its disposal. The excrements were cleaned using a vacuum-gravity system, with faeces removed from the underground troughs twice during the growing period. To ensure free access to water, height-adjustable nipple pumps and cup pumps were used, which were located at a height of 20 cm above the slatted floor.

Table 1. Scheme of research

Indicator	Uniform pressure ventilation		Geothermal ventilation of negative pressure	
Feeding system	Spotmix II	Spotmix II	Tube-O-Mat	HydroMix
Method of feeding piglets	Dry	Liquid	Dry	Liquid
Number of piglets per pen, head	150	150	150	150
The average age of piglets at the time of placement for rearing, days	21	21	21	21
Average age of piglets when transferred to fattening, days	70	70	70	70

Source: own calculations.

The animals were fed a complete ration of granulated feed. From the day of weaning and until the piglets reached an average weight of 9 kg, they were given pre-starter pelleted feed, which was also used during the weaning phase. They were then switched to the cheaper pre-starter feed, which was used until the piglets reached a weight of 12 kg. After that, they were transferred to feed with starter feed produced at the Globino feed plant until the end of rearing on day 70 (Table 2).

Table 2. Nutrient content in the diet of growing pigs

Indicator	Units of measurement	Prestarter up to 9 kg	Prestarter 9-12 kg	Starter up to 70 kg
Exchange Energy	mJ	13.89	13.58	13.25
Raw protein	%	20.5	18.99	18.32
Crude fiber	%	2.6	3.2	4.4
Raw Fat	%	1.8	3.36	3.4
Lactose	%	8.405	–	–
Lysine	%	1.6	1.15	1.03
Methionine	%	0.45	0.36	0.32
Methionine cyst.	%	0.8	0.68	0.64
Threonine	%	1.1	0.776	0.69
Calcium	%	0.65	0.82	0.84
Phosphorus	%	0.5	0.53	0.47
Sodium Na	%	0.15	0.24	0.24
Chlorine Cl	%	0.3	0.39	0,39
Magnesium	%	0.16	0.18	0.20
Potassium	%	0.95	0.86	0.80
Vitamin A	M.O.	17,452.94	12,975.35	12,935.32
Vitamin D	M.O.	3,452.92	2,331.28	2,328.73
Vitamin E	mg/kg	51.58	41.73	42.4
Vitamin B_1	mg/kg	7.64	5.46	5.39
Vitamin B_2	mg/kg	14.98	8.32	8.32
Vitamin B_6	mg/kg	10.97	9.73	10.19
Vitamin B_{12}	µg/kg	57.18	34.98	34.93
Vitamin K	mg/kg	1.73	1.17	1.16
Iron	mg/kg	182	180	180
Manganese	mg/kg	89	86	86
Zinc	mg/kg	126	115	115
Copper	mg/kg	24	24	24
Iodine	mg/kg	0.38	0.38	0.38
Cobalt	µg/kg	870	350	350
Selenium	mg/kg	0.55	0.50	0.50

Source: own calculations.

It is important to note that the difference between the control and experimental groups was the use of different systems for creating a microclimate and methods for preparing, feeding and distributing feed to the piglets. Feed accounting was done using the portion feeding control processor and duplicated in the primary documentation. In addition, leftover feed was checked daily, and if present, it was weighed and subtracted from the total amount of feed eaten.

The pigs of the 1st and 2nd groups were kept in the rearing room of the rearing farm No. 3, which was equipped with a system for generating uniform pressure ventilation from the Big Dutchman company (Demydivka village, Kremenchuk district, Poltava region). Within the framework of this microclimate support system, the intake of outdoor air was carried out through intake shafts D 630 (Photo 1, Fig. 1, pos. 1), located in the central part of the gable roof of the building, and the discharge through exhaust shafts D 630 (cross-sectional area S=0.30 m^2, Ukraine) (Photo 1, Fig. 1, item 3) in the number of 22 shafts, located in the ridge part of the roof and equipped with three-phase exhaust fans Ø 63 cm Deltafan Lat (Poland).

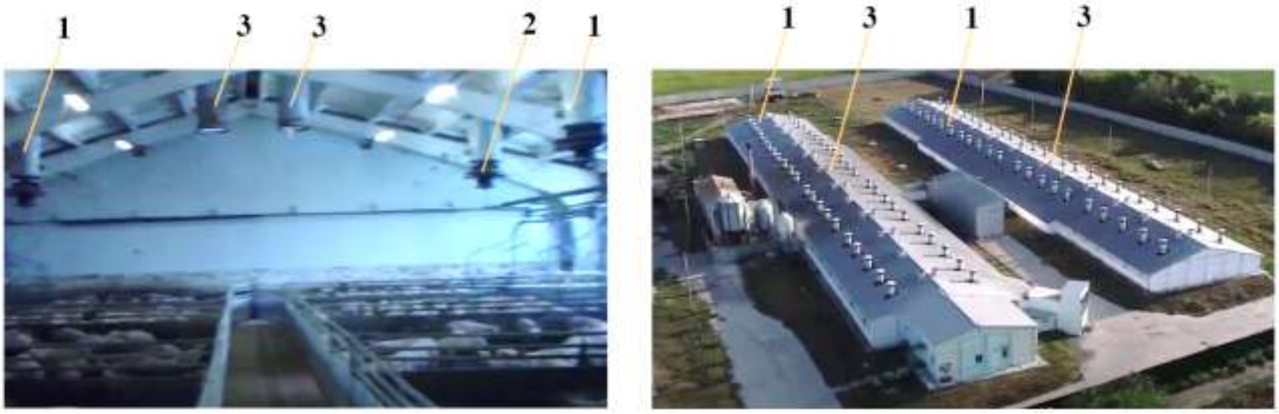

Photo 1. General view of the farm for raising pigs using the uniform pressure microclimate system of pig complex No. 3 (Demydivka village)
Note: 1 – tidal shaft; 2 – humidification and air system; 3 – exhaust shaft.
Source: processed photo of LLC "Globinsky Pig Complex"

The premises were heated with water-heated floors in the cold season. Additional cooling of the interior of the pig complex was provided by forced humidification of the air (Photo 1, Fig. 1, item 2).

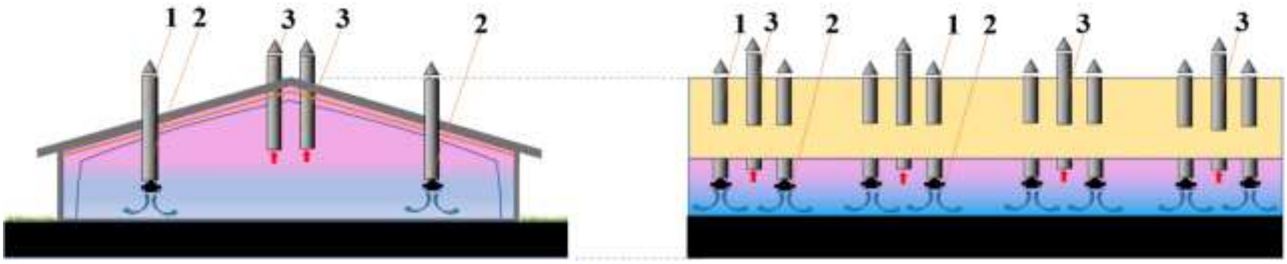

Fig. 1. Scheme of air movement of the system for creating a microclimate of uniform pressure in pig complex No. 3 (Demydivka village)
Note: 1 – tidal shaft; 2 – humidification and air system; 3 – exhaust shaft.
Source: Own determination.

Pigs of the first control group were fed using the Spotmix II system of the Austrian company Schauer (Photo 2). This system made it possible to feed animals with dry fodder. Transportation of feed mixtures to the feeders was carried out through the pipeline with the help of compressed air and a system of revolving connections in dry form.

Photo 2. Spotmix II feeding system (Schauer) for the preparation of dry fodder for pig complex No. 3 (Demydivka village)
Source: processed photo of LLC "Globinsky Pig Complex".

Piglets in the II group were fed the same Spotmix II feeding system from the Austrian company Schauer (Photo 3), which was configured to prepare liquid feed. Dry feed was also added to the feeder in this group, where it was moistened with water via high-pressure nozzles. A portion of dry feed with a moisture content of 14% contained 2.7 liters of water.

The feeding front of piglets in these groups was 15 cm per head. The feed was distributed 12 times a day. If there was uneaten feed in the feeders, the feeder filling sensor was activated and the system skipped the next feed distribution to these feeders.

Photo 3. Spotmix II feeding system (Schauer) for the preparation of liquid feed for pig complex No. 3 (Demydivka village)
Source: processed photo of LLC "Globinsky Pig Complex".

Pigs of experimental groups III and IV were kept during rearing in pig farms No. 2 (Babichivka village, Kremenchug district, Poltava region) and No. 4 (Obiznivka village, Kremenchug district, Poltava region), which had buildings typical for all rearing farms and were equipped with the same negative pressure type geothermal ventilation systems of the negative pressure type. Outside air entered the premises for keeping animals through an intake shaft (Photo 4, Fig. 2, pos. 1, 3) placed outside on the ground surface near the supporting wall of the building. Through the air duct buried in the ground (Fig. 6, pos. 5), the air entered the underfloor ducts (Fig. 2, pos. 4) located in the piglets' living area, where it spread through the perforated floor (Fig. 2, pos. 2) into the interior of the pigsty. Exhaust air was discharged by means of under-ceiling exhaust air shafts D910 (cross-sectional area S=0.66 m^2, Ukraine) (Photo 4, item 1 and Fig. 2, item 3) in the number of 16 shafts per room, equipped with Deltafan three-phase fans Ø 91 cm (Poland). Thanks to the movement of underground ducts and subfloor buried channels, the outside air was cooled in the summer and additionally heated in the winter.

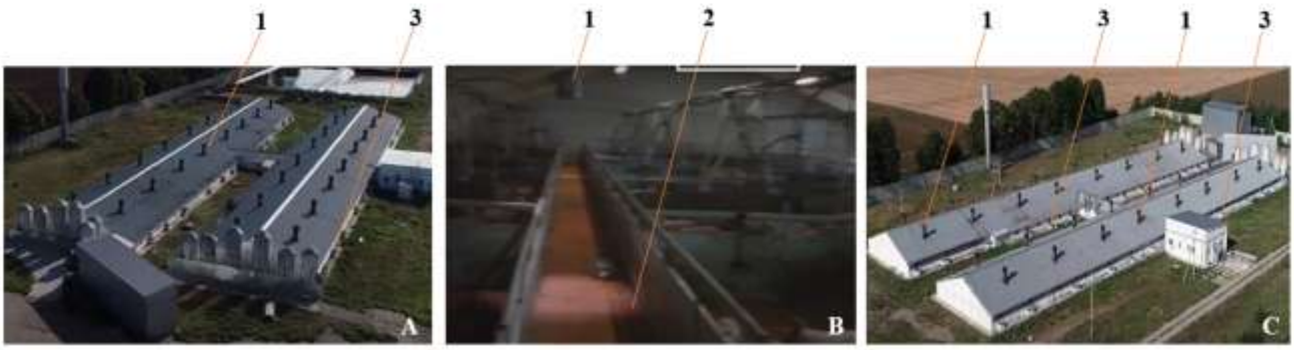

Photo 4. General view of farms for raising pigs using the microclimate system of geothermal type pig complex No. 4 (Obiznivka village) and pig complex No. 2 (Babichivka village)
Note: 1 – exhaust shaft; 2 – perforated floor; 3 – tidal mine, A – pig complex No. 4 (Obiznivka village), B – general view of the room for rearing, C – pig complex No. 2 (Babichivka village)
Source: processed photo of LLC "Globinsky Pig Complex"

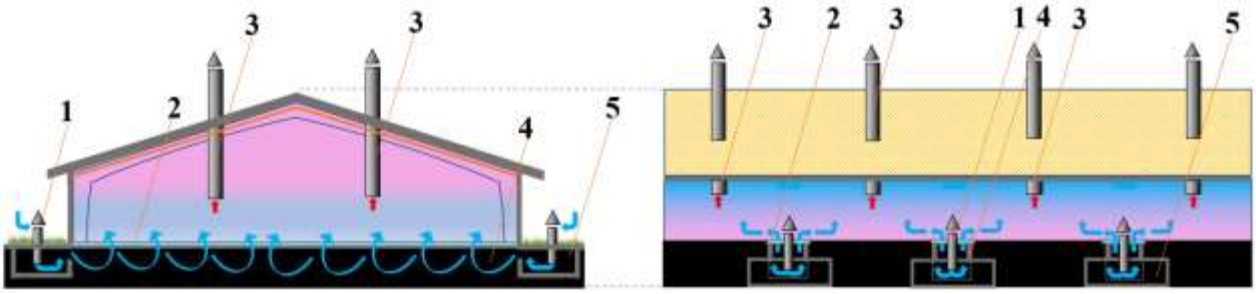

Fig. 2. Scheme of air movement of the geothermal system for creating a microclimate of pig complex No. 4 (Obiznivka village) and pig complex No. 2 (Babichivka village)
1 – tidal shaft; 2 – perforated floor; 3 – exhaust shaft; 4 – underfloor channel; 5 – underground duct
Source: Own determination.

Piglets of the group III were fed in pig farm No. 2 (Babichivka village, Kremenchug district, Poltava region) with Tube-O-Mat automatic feeders of the Danish manufacturer Master Trading (Photo 5). The feeding front was 2.5 cm per animal. Each feeder was equipped with two feed spreaders, with the help of which the piglets moistened the dry feed in the troughs of the feeders to the desired moisture level. During the first week after being housed in the rearing group, the piglets were fed from a floor mat in the pen. The feed was accounted for automatically using sensors on the torsion scales of the storage hoppers. Stainless steel nipple drinkers are located on the sides of the feeder. There are wells for water in the drinker. Water is supplied from the central water supply to the automatic feeder via hoses.

Photo 5. Tube-O-Mat feeding system (Master Trading) for the preparation of dry fodder for pig complex No. 2 (Babichivka village)
Source: processed photo of LLC “Globinsky Pig Complex”.

For feeding the pigs of the research group IV of the pig complex No. 4 (Obiznivka village, Kremenchuk district, Poltava region), the HydroMix feeding system of the Big Dutchman company with residue-free feed distribution and pipe flushing was used (Photo 6). In this system, two small tanks serve simultaneously as mixing and dispensing tanks. For this purpose, the total required feed quantity is divided into several small portions. While the feed is mixed in one container, the contents of the second container are dispensed simultaneously. At the beginning of feed distribution, the computer sets the required amount of the main mixture for each valve for further distribution to each individual pen with piglets. Cup and teat valves with a teething ball were used for piglet feeding to reduce water loss.

The measurement of microclimatic parameters included the determination of the internal temperature in the living area of the piglets, relative humidity, ammonia, hydrogen sulfide and carbon dioxide content.

The determination of microclimatic indicators was performed twice a week (every Tuesday and every Friday) during the experiment for each group.

Photo 6. HydroMix (Big Dutchman) feeding system for the preparation of liquid fodder for pig complex No. 4 (Obiznivka village)
Source: processed photo of LLC "Globinsky Pig Complex".

The soil temperature in each of the pen was determined at seven points using a Testo 805 pyrometer (measuring range: -25...+250 °C, accuracy: ±1 °C (-2...+40 °C), Germany). The velocity of air movement and its temperature were measured with a Testo 425 m thermal anemometer (measuring range: 0...30 m/s, accuracy: ±0.03 m/s (0...20 m/s), Germany). The content of ammonia (NH_3), hydrogen sulfide (H_2S) and carbon dioxide (CO_2) in the air was determined using the DOZOR-CM4 gas analyzer (Ukraine). The measurement ranges and measurement errors of the "DOZOR-CM4" were as follows: for carbon dioxide measurement range: 0–10,000 ppm, accuracy: ±2.500 ppm; for ammonia measurement range: 0–28.18 ppm, accuracy: ±7.05 ppm; for hydrogen sulfide measurement range: 0–21.12 ppm, accuracy: ±3.52 ppm). The value of relative humidity was determined using a Testo 605 thermohygrometer (measuring range: 5–95% RH, accuracy: ±3.0% RH, Germany).

Both ventilation systems were controlled by the same microclimate control modules 307PRO L15CE6 (Denmark).

Information about changes in microclimate parameters in the room was received by the control module from the connected temperature sensors DOL 12 (measuring range –10…+40 ° C, accuracy: ±0.5 °C, Denmark), relative humidity sensor DOL 114 (measuring range 17–100% RH, accuracy: ±3% RH (10–95%), Ukraine), vacuum sensor DOL 18 (measuring range 6.89–68.9 KPA, accuracy: 0.5" (100 Pa), Denmark), CO_2 sensor DOL 19 (measuring range 0–10,000 ppm, output signal 0–10V/4–20mA, Denmark), NH_3 sensor DOL 53 (measuring range 0–100 ppm, output signal 0–10V, Ukraine). The information on the parameters of external climatic conditions comes from meteorological stations located on the territory of the pig complex.

The volume velocity of air movement through an exhaust shaft was measured using the following formula:

$$Q = V*S \text{…………………}(1)$$

where:
Q is the volume flow rate in m^3/s;
V is the flow velocity in the cross-section in m/s (measured with a Testo 425 m thermal anemometer);
S is the cross-sectional area of the exhaust shaft, m^2.

The cross-sectional area of the exhaust shaft is determined by the following formula:

$$S = \pi r^2 \text{……………………..}(2)$$

where:
$\pi = 3.14;$
r is the radius of the circle, where:

$$r=D/2 \text{…………………….....}(3)$$

where:
D is the cross-sectional diameter of the exhaust shaft.

The volume velocity of air movement for the entire space was determined by multiplying the volume velocity of air movement for one exhaust shaft by the number of exhaust shafts.

Statistical processing of the experimental data was performed using biometric methods in the Microsoft Excel environment. The difference between the mean values of the measured and calculated values was considered statistically significant at the first threshold of $p<0.05$, at the second threshold of $p<0.01$, and at the third threshold of $p<0.001$ using Student's t-test. The applied method of two-factor analysis of variance was also calculated using Microsoft Excel. The rules for the treatment of animals in our experiments corresponded to the current legislation on the protection of animals from suffering and pain, namely the EU Directive "On the protection of farm animals" of the Council of the EU Directive 2010/63/EU [5]. The Commission for Bioethics and Treatment of Animals in Scientific Experiments of the Sumy National Agrarian University granted ethical permission (No. BT-23-02/02-01).

RESULTS AND DISCUSSIONS

The study of the difference of microclimate indicators in a room for pig farming with uniform pressure ventilation allowed to detect a higher internal temperature when dry compound feed was used in comparison with rooms where a liquid type of feeding was used, by 1.0 ^{o}C or 4.8% ($p<0.05$). At the same time, the internal temperature in a room with geothermal ventilation was 1.5 ^{o}C or 7.6% higher than in the experimental room when dry feed was used ($p<0.05$).

The comparison of indoor temperature in dry feeding between two types of microclimate systems showed that their values were 0.8 ^{o}C or 3.9% higher in rooms with uniform pressure ventilation than in rooms with geothermal ventilation ($p<0.05$). In the case of liquid feeding, the study of the values of indoor temperature showed that their values in the rooms with geothermal ventilation were higher than in the rooms with uniform pressure ventilation, by 1.7 ^{o}C or 8%. With the liquid method of feeding, the study of the values of the internal temperature showed that its values were higher in the room with the geothermal type of ventilation than in the room with the uniform pressure type of ventilation by 1.7 ^{o}C or 8.0% ($p<0.05$).

Table 3. Indicators of the microclimate in the room for keeping pigs depending on the method of their feeding, n = 14

Indicator	Uniform pressure ventilation		Geothermal ventilation of negative pressure	
	Dry feeding method	**Liquid feeding method**	**Dry feeding method**	**Liquid feeding method**
Internal temperature ^{o}C	$20.5±0.18^{bA}$	$19.5±0.44^{aA}$	$21.2±0.50^{bB}$	$19.7±0.28^{aA}$
Relative humidity % vol	$69.8±1.59^{aA}$	$74.1±1.23^{bA}$	$71.3±1.91^{aB}$	$74.3±0.99^{aA}$
Air velocity m/s	$0.13±0.020^{aA}$	$0.14±0.021^{aA}$	$0.07±0.019^{aB}$	$0.08±0.017^{aB}$
Volumetric velocity of air movement for one shaft m^3/s	$0.039±0.0291^{aA}$	$0.042±0.0325^{aA}$	$0.046±0.0294^{aA}$	$0.052±0.0441^{aA}$
Volumetric velocity of air movement for the entire room m^3/s speed	$0.858±0.0541^{aA}$	$0.924±0.0622^{aA}$	$0.736±0.0436^{aA}$	$0.832±0.0511^{aA}$
Ammonia (NH_3) content, mg/m^3	$13.5±1.20^{aA}$	$12.9±1.01^{aA}$	$13.0±1.43^{aA}$	$12.4±0.97^{aA}$
Carbon dioxide (CO_2) content, % vol	$0.3±0.02^{bB}$	$0.2±0.02^{aA}$	$0.2±0.01^{aA}$	$0.3±0.02^{bB}$
Hydrogen sulfide (H_2S) content, mg/m^3	$3.1±0.27^{bB}$	$2.1±0.14^{aA}$	$2.2±0.14^{aA}$	$2.3±0.16^{aA}$

aa – there is no significant difference between indicators for different feeding systems and the same ventilation system ($p>0.05$); ab – there is a significant difference between indicators for different feeding systems and the same ventilation system ($p<0.05$); AA – there is no significant difference between indicators for the same feeding systems and different ventilation systems ($p>0.05$); AA – there is a significant difference between the indicators for the same feeding systems and different ventilation systems ($p<0.05$).
Source: own calculations.

The value of relative humidity in the room with the type of ventilation of equal pressure when using the liquid feeding method was 8.3% vol and 12.6% higher, respectively, compared to the group in which dry feed mixtures were used ($p<0.001$). At the same time, no difference in relative humidity was observed in a room equipped with a geothermal system to support the microclimate.

Relative humidity during dry feeding was not the same in the rooms with both types of ventilation. In particular, in the groups where liquid pig feeding was used, the relative humidity in the room with the geothermal pressure microclimate system was 5.5% vol or 8.3% ($p<0.05$) higher than in the room with uniform pressure ventilation. At the same time, the relative humidity indicator for a liquid feeding system was the same among the different systems for creating a microclimate.

Air movement velocity was 0.06 m/s or 46.1% higher in the room with uniform pressure ventilation and dry feeding than in the room with geothermal ventilation and dry feeding ($p<0.05$). Similarly, the air movement velocity in the room with uniform pressure ventilation and liquid feeding was 0.06 m/s or 42.8% higher than the air velocity in buildings where negative pressure ventilation with underground outdoor air supply and liquid feeding of breeding pigs was used ($p<0.05$).

The gas composition assessment showed that the ammonia content was the same for both the uniform pressurised ventilation system and the geothermal system when dry and liquid feeding methods were used.

The higher content of carbon dioxide by 0.1% vol or 33.3% ($p<0.01$) was for the dry method of feeding in the room with classical ventilation and for the liquid method of feeding in the room with the liquid method of feeding by 0.1% vol or 50.0% ($p<0.001$). With dry feeding, the CO_2 content was higher in the room with uniform pressure ventilation by 0.1% vol or 33.3% ($p<0.001$). In the liquid feeding system, the carbon dioxide content was higher than in the geothermal microclimate creation system by 0.1% vol or 33.3% ($p<0.01$).

The higher content of hydrogen sulfide was found in the room with uniform pressure ventilation when using dry fodder by 1.0 mg/m^3 or 32.2% ($p<0.01$). Whereas in rooms with a geothermal ventilation system, the H_2S content did not differ. The content of hydrogen sulfide when using dry fodder mixtures was higher in the room with a system for creating a microclimate of uniform pressure by 0.9 mg/m^3 or 29.0% ($p<0.01$).

Two-factor variance analysis of the data made it possible to state that both the method of feeding and the type of ventilation had an effect on the indicators of the microclimate, except for the temperature in the room (Fig. 9, Table 4).

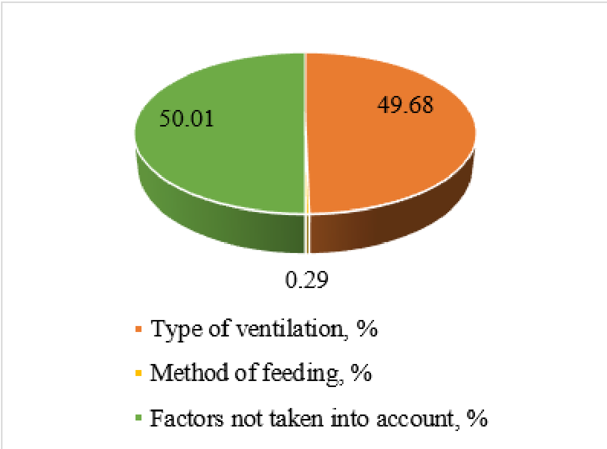

Fig. 9. Two-factor variance analysis of the influence of the method of feeding and the ventilation system on the temperature in the room, %
Source: own calculations.

Table 4. The influence of the method of feeding and the ventilation system on the temperature in the room, %

Source of Variation	SS	df	MS	F	P-value	F crit
Ventilation system	80.24	28	2.86	0.99	0.50	1.88
Method of feeding	0.47	1	0.47	0.16	0.68	4.19
Error	80.78	28	2.88			
Total	161.5	57				

Source: own calculations.

In contrast to the factor of the method of feeding pigs, the type of ventilation system influenced the indicator of relative humidity with a strength of 76.4% ($p<0.001$) (Fig. 10, Table 5).

Ammonia content had no significant dependence on the feeding method, however, the type of ventilation influenced its content in the air of the pig house with a strength of 76.9% ($p<0.001$) (Fig. 11, Table 6).

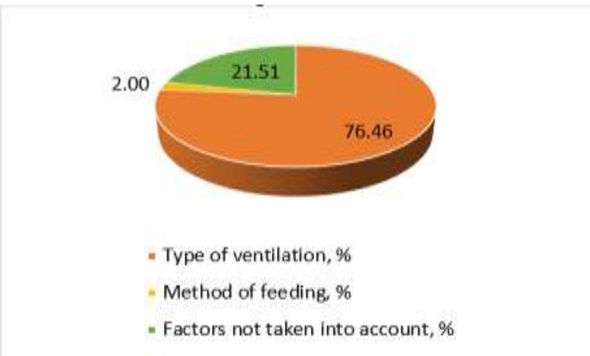

Fig. 10. Two-factor variance analysis of the effect of feeding method and ventilation system on relative humidity, kg
Source: own calculations.

Table 5. Influence of feeding method and ventilation system on relative humidity, kg

Source of Variation	SS	df	MS	F	P-value	F crit
Ventilation system	2,701.25	29	93.14	3.55	0.0005	1.86
Method of feeding	70.88	1	70.88	2.70	0.11	4.18
Error	759.81	29	26.20			
Total	3,531.95	59				

Source: own calculations.

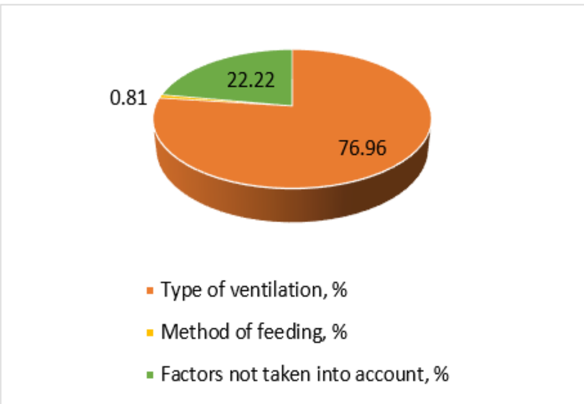

Fig. 11. Two-factor variance analysis of the influence of the feeding method and the ventilation system on the ammonia content, %
Source: own calculations.

Also, the type of ventilation had an effect on the content of carbon dioxide with a strength of 65.7% ($p<0.05$) (Fig. 12, Table 7). The level of carbon dioxide did not depend on the method of feeding.

Table 6. Influence of feeding method and ventilation system on ammonia content, %

Source of Variation	SS	df	MS	F	P-value	F crit
Ventilation system	1,318.65	29	45.47	3.46	0.0006	1.86
Method of feeding	13.88	1	13.88	1.05	0.31	4.18
Error	380.71	29	13.12			
Total	1,713.25	59				

Source: own calculations.

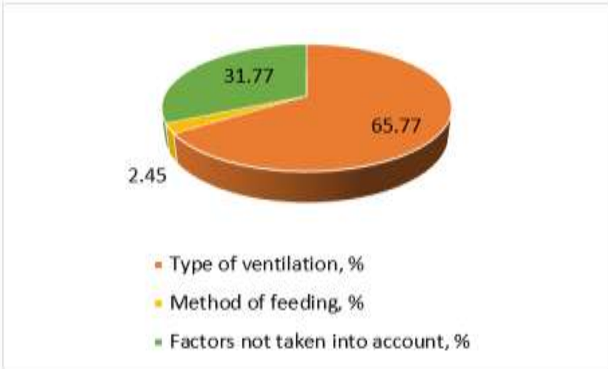

Fig. 12. Two-factor variance analysis of the influence of the method of feeding and the ventilation system on the content of carbon monoxide, %

Table 7. Influence of feeding method and ventilation system on ammonia content, %

Source of Variation	SS	df	MS	F	P-value	F crit
Ventilation system	0.24	29	0.008	2.07	0.02	1.86
Method of feeding	0.009	1	0.009	2.24	0.14	4.18
Error	0.11	29	0.004			
Total	0.37	59				

Source: own calculations.

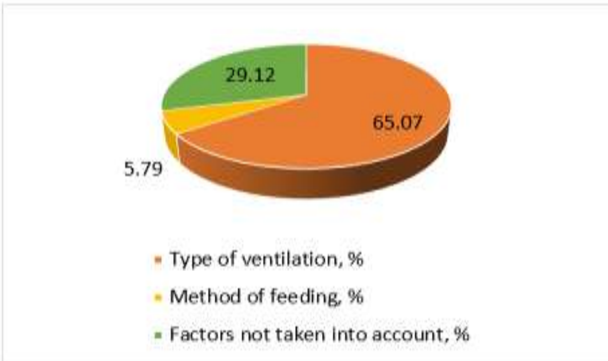

Fig. 13. Two-factor variance analysis of the influence of the feeding method and the ventilation system on the content of hydrogen sulfide, %
Source: own calculations.

The level of hydrogen sulphide probably depended on both the type of microclimate system by 65.0% ($p<0.05$) and the feeding method by 5.7% ($p<0.05$) (Fig. 13, Table 8).

Table 8. Influence of feeding method and ventilation system on hydrogen sulfide content, %

Source of Variation	SS	df	MS	F	P-value	F crit
Ventilation system	33.77	29	1.16	2.23	0.01	1.86
Method of feeding	3.00	1	3.00	5.76	0.02	4.18
Error	15.11	29	0.52			
Total	51.89	59				

Source: own calculations.

The study of piglet performance indicators showed that piglets had a higher weight at the end of their rearing with both types of ventilation when a liquid feeding method was used. Indeed, the higher weight of piglets at transfer to fattening in rooms with uniform pressure ventilation was 1.8 kg or 7.3% higher for piglets eating liquid feed compared to those eating dry feed mixtures by 1.8 kg or 7.3% ($p<0.001$). There was a similar advantage of 0.9 kg or 3.3% ($p<0.05$) for animals eating liquid feed compared to peers eating dry feed when geothermal ventilation of the room was used (Table 9).

At the same time, a comparison of the weight of piglets at the transition to fattening in animals fed dry feed but kept under different systems for creating a microclimate showed that their value was 2.8 kg or 11.4% higher when geothermal ventilation was used ($p<0.001$). Piglets that consumed liquid feed and were kept in rooms with different microclimates had a weight 1.9 kg or 7.2% higher at the end of rearing than piglets kept in a room with underground preparation and air supply to their habitat ($p<0.001$).

In a room with uniform pressure ventilation, the absolute growth rate of piglets raised on a liquid feeding system was 1.8 kg or 9.7% higher than piglets fed dry feed ($p<0.001$). At the same time, in the pig house where the geothermal ventilation system was in operation, absolute gains were observed to be 0.9 kg or 4.2% higher in piglets fed liquid feed ($p<0.05$). Raising pigs with dry feeding in a room with uniform pressure ventilation resulted in a lower indicator of piglet weight at the transition to fattening compared to the values in the housing with geothermal ventilation by 2.9 kg and 15.7%, respectively ($p<0.001$).

Absolute growth of liquid-fed pigs proved to be 2.0 kg or 9.9% better under geothermal ventilation than peers whose growth occurred under uniform pressure ventilation ($p<0.001$).

Based on the evaluation of average daily gains, it was found that pigs fed liquid feed grew 36.7 g or 9.7% better than those fed dry feed under uniform pressure ventilation ($p<0.001$). Examination of the effect of type of ventilation on piglet growth intensity revealed that animals fed dry feed in a pig house with geothermal ventilation gained 59.1 g or 15.7% more compared to their peers with uniform pressure ventilation ($p<0.01$). Pigs on liquid feed had higher average daily gains when housed under geothermal ventilation, by 40.8 g or 9.9% ($p<0.05$). The evaluation of feed consumption showed higher feed consumption when pigs were fed liquid in both a room with uniform pressurised ventilation and with geothermal ventilation.

Specifically, in rooms with ventilation of uniform pressure, liquid feeding consumed 2.7 kg more feed per piglet during the rearing period than dry feeding. In the groups where geothermal ventilation was installed, feed consumption per piglet was also 0.8 kg higher with liquid feeding than in the groups receiving dry feed mixes (Table 10).

When comparing feed consumption per piglet in dry feeding but different microclimate systems, 3.7 kg higher values for this indicator were found in animals kept in a room with a geothermal ventilation system. Liquid feeding pigs also showed 1.8 kg higher values of the indicator of feed consumption per piglet during the period in pigs raised in systems creating a geothermal-type microclimate.

It should be noted that the average daily feed intake also increased when liquid feed was used in microclimate systems of both types. In rooms with uniform pressure ventilation, piglets fed liquid feed consumed 0.05 kg more feed than their counterparts fed dry feed. The average daily feed consumption was also higher for piglets fed liquid feed than for piglets fed dry feed mixes in a room with geothermal ventilation. With geothermal ventilation, the average daily feed consumption was 0.07 kg higher for both dry feed and liquid feed. It was found that feed conversion was 0.04 kg worse when pigs were fed dry feed compared to feeding liquid feed under uniform pressure ventilation and 0.03 kg worse under geothermal ventilation. In dry feeding, feed conversion was 0.08 kg higher in animals using a uniform pressure ventilation system. Similarly, feed conversion was higher in the group using liquid feeding, where it was higher in the room with uniform pressure ventilation.

Table 9. Performance indicators of pigs in rearing with dry and liquid methods of feeding and different systems of room ventilation

Indicator	Uniform pressure ventilation		Geothermal ventilation of negative pressure	
	Liquid feeding method	**Dry feeding method**	**Liquid feeding method**	**Dry feeding method**
The weight of the piglets when they are placed for rearing, kg	6.1 ± 0.08^{aA}	6.1 ± 0.12^{aA}	6.0 ± 0.11^{aA}	6.0 ± 0.09^{aA}
Age of piglets when placed for rearing, days	20.7	20.7	20.5	20.7
Weight of piglets when transferred to fattening, kg	24.5 ± 0.29^{aA}	26.3 ± 0.32^{bA}	27.3 ± 0.28^{aB}	28.2 ± 0.31^{bB}
Age of piglets when transferred to fattening, days	70.4	70.4	70.2	70.2
Absolute growth, kg	18.4 ± 0.26^{aA}	20.2 ± 0.24^{bB}	21.3 ± 0.30^{aA}	22.2 ± 0.28^{bB}
Average daily increments, g	375.5 ± 10.2^{aA}	412.2 ± 13.5^{bA}	434.6 ± 12.2^{B}	453.0 ± 12.9^{B}
Preservation of piglets, %	98.3	97.8	97.5	97.7

aa – there is no significant difference between indicators for different feeding systems and the same ventilation system ($p>0.05$); ab – there is a significant difference between indicators for different feeding systems and the same ventilation system ($p<0.05$); AA – there is no significant difference between indicators for the same feeding systems and different ventilation systems ($p>0.05$); AA – there is a significant difference between the indicators for the same feeding systems and different ventilation systems ($p<0.05$).
Source: own calculations.

The feed cost for raising one animal was 1.24 EUR higher for liquid feeding than for uniform pressure ventilation and 0.36 EUR higher for negative pressure ventilation with underground supply of outside air. In rooms with a geothermal microclimate, the feed costs for rearing a piglet were 1.68 EUR and 0.18 EUR higher for both dry feeding and liquid feeding.

However, the feed cost per 1 kg of growth was higher by 0.017 EUR in piglets fed dry feed in the group where uniform pressure ventilation was functioning and by 0.012 EUR in the group where geothermal ventilation was installed, compared to peers fed liquid feed in both microclimate systems.

When geothermal ventilation was used in the premises, the feed cost for 1 kg of growth was lower than for both feeding systems, by 0.035 EUR – when dry feed was used and by 0.030 EUR – when liquid feed was used.

We can state that our conclusions regarding the increase in the preservation of piglets when the humidity in the room is reduced are in agreement with the reports of other authors [27], but only for the pig complex where the system was used to create a microclimate with uniform pressure.

However, it should be noted that our results agree with the reports [3, 13, 17, 31, 34, 42] on the influence of the feeding method on the humidity index in the room for rearing pigs. In our experiment, this indicator changed with a dry feeding method, when we compared rooms with different ventilation and using a system for creating a microclimate with uniform pressure, the influence of the feeding method on this indicator was found. However, when using a geothermal ventilation system, the relative humidity did not depend on the feeding method.

Table 10. Average daily consumption and consumption of feed for different feeding systems of piglets

Indicator	Uniform pressure ventilation		Geothermal ventilation of negative pressure	
	Dry feeding method	Liquid feeding method	Dry feeding method	Liquid feeding method
Absolute growth, kg	18.14	20.20	21.3	22.2
Spent fodder per head, kg	31.20	33.94	34.93	35.74
Average daily feed consumption, kg	0.63	0.68	0.70	0.72
Feed conversion, kg	1.72	1.68	1.64	1.61
The average price of 1 kg of compound feed, EUR	0.45	0.45	0.45	0.45
Fodder cost of growing 1 head, EUR	14.12	15.35	15.81	16.17
Feed cost of 1 kg of gain, EUR	0.77	0.76	0.74	0.72

Source: own calculations.

As in previous publications, we demonstrated in this experiment that the type of feeding affects the intensity of growth of piglets. In particular, contrary to the conclusions of [36], we found that when piglets were fed liquid, their average daily growth rate increased, which is consistent with the data obtained previously [29].

Similar to the results of [36], we also did not observe any deterioration in feed conversion when piglets consumed liquid feed, but on the contrary observed an improvement, which may be caused by better nutrient uptake when using a liquid feeding system and is in agreement with reports [24].

We could observe a higher feed intake when using liquid feeding, similar to the data of other researchers [18] who reported a positive effect of liquid feeding on this indicator.

We could only partially confirm the reports [2, 34] on the influence of the liquid feeding system on the increase of gas formation in the room. In particular, the ammonia content did not depend on the type of feeding, the amount of feed eaten, or the system used to create a microclimate, which is not consistent with the data of other authors [15] who observed the relationship between the release of this gas and the amount of feed consumed by the pigs. At the same time, carbon dioxide content and hydrogen sulphide content increased equally in dry feeding compared to liquid feeding of pigs in rooms with equal pressure ventilation and decreased equally in rooms with geothermal ventilation when pigs were fed dry feed mixtures.

CONCLUSIONS

The ventilation system probably has a strong influence on relative humidity and carbonation, while the feeding system probably only influences hydrogen sulphide.

The use of a geothermal ventilation system in combination with both feeding methods resulted in a higher velocity of air movement in the living area of piglets and its volumetric velocity, which led to a higher average daily feed consumption of the piglets, a higher intensity of their growth, a greater mass at transfer to fattening and a better feed conversion, which contributed to the reduction of the cost of 1 kg growth. At the same time, the carbon dioxide content, the hydrogen sulphide content, the temperature of the room air and its relative humidity were higher only in dry feeding, which contributed to better preservation of the piglets. The carbon dioxide content and the hydrogen sulphide content in the air, on the other hand, were higher with liquid feeding.

Uniform pressure ventilation resulted in lower absolute and average daily gains, average daily feed intake and poorer feed conversion in both liquid and dry feeding compared to the geothermal ventilation system, with a higher feed cost per 1 kg gain.

The combination of a geothermal system to create a microclimate with liquid feeding of piglets in rearing makes more economic sense and ensures an increase in the growth intensity of the animals and a reduction in rearing costs compared to combinations of this ventilation system with dry feeding of pigs and with combinations of a ventilation system with uniform pressure for both feeding types.

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IMPACT OF BT. COTTON PRODUCTIVITY ON FARMERS' INCOME IN SOUTHERN PUNJAB, PAKISTAN

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Abstract

The increasing adoption of Bt cotton, known for its high productivity and resistance to pests, has prompted this investigation into its impact on farmers' earnings. This study aims to explore how the productivity of Bt cotton affects farmers' income in the Khanewal and Multan districts of Southern Punjab. To gather data, we employed a stratified random sampling method, targeting small, medium, and large-scale farmers in both districts. Using regression analysis, we assessed the influence of Bt cotton productivity, along with other relevant factors, on the annual gross income of these farmers. Results revealed that per acre revenue from Bt cotton, education of farmers, livestock ownership, tractor ownership and distance from the market have significant impacts on the annual gross income of the farmers.

Key words*: *Bt Cotton, Farmer Income, Productivity, Punjab

INTRODUCTION

Cotton occupies about 2.5 percent of the world arable land area and is cultivated in around 80 countries in the world [34]. The role of agriculture biotechnology has been acknowledged in the reduction of hunger by increasing crop yield and higher income for farmers, especially in developing countries [3, 25]. As indicated by [4], the only substantial way that biotechnology has contributed to the well-being of the poor is through higher income from the production of genetically modified cotton because the crop has been recognized as the largest consumer of pesticides due to the wider attack of different insects. The agriculture sector is the third largest sector of Pakistan, contributing 22.7 percent share of the gross domestic product (GDP), which absorbs 37.4 percent of the total labour force [10]. The sector has observed 4.40 percent growth rate in 2021-22 against 3.48 percent in 2020-21 [10]. Cotton is an important kharif crop which is one of the main sources of raw materials for the textile industry in Pakistan. Cotton is among the major crops of Pakistan having a share of 3.1% in agriculture value addition, (5% 5 years before) and contributing 0.6% of GDP which was 1% about five years ago [10], Cotton plays a central role in rural economic development in poverty-stricken areas of the cotton belt. In Pakistan, cotton is mainly cultivated in two provinces. Punjab, being the most conducive for cotton cultivation, produces es 66% of the country's cotton followed by Sindh which contributes 33% of production [32]. Around 90% of farmers in Punjab and 82% in Sindh involved in cotton production own less than 5 hectares of the land thus has severe effects on the livelihood of this major chunk of the population [18].

Since the early 1990s cotton production in Pakistan, has been facing the challenge of large-scale pest infestation contributing to unexpected fluctuations in cotton yield and significant economic losses. A wide range of pesticides has been introduced to control various cotton pests during the last 15 years, which has notably increased the cost of cotton production. Moreover, as the pests developed resistance to these chemicals, their effectiveness declined over time [11]. Therefore, there was a need to reduce this increasing cost of production especially under the scenario of globalization. With the introduction of Bt cotton in Pakistan, its use increased continuously. By 2007, nearly 60 percent of the cotton area was under BT varieties in Pakistan [20, 21]. Currently, numerous developed and developing countries worldwide cultivate Bt cotton across 7.2 million hectares. These countries have reported significant outcomes, including reduced pesticide and fertilizer usage, as well as decreased instances of insects and bollworms. Moreover, there has been an increase in per-acre yield [5,14].

Several empirical studies such as [5, 7, 1, 35, 20, 21, 6, 31, 8] have revealed that the adoption of Bt cotton has reduced not only pest attacks but also increased yields and profits to the farmers. In addition to these empirical studies such as [2, 5, 12, 30, 33, 20, 23, 24, 15, 28, 29] have also concluded the significant impact of Bt crop cultivation on income/poverty of rural households. BT cotton is a genetically modified strain of cotton, and it comprises a gene taken from the bacterium Bacillus thuringiensis. The gene causes the plant to produce an insecticidal protein that kills certain cotton pests [9, 1, 35]. Moreover, [21] has concluded that Bt varieties have higher gross margins than non-bt varieties, but she did not include the implicit cost while calculating gross margin. In this study we have also aimed to calculate the benefit-cost ratio while including implicit cost. In this way, we shall be able to access the true benefits to the farmers they obtain from Bt cotton cultivation.

This study aims to investigate the influence of BT cotton cultivation on farmers' income within the study area. Additionally, it seeks to assess and compare the benefit-cost ratio among Bt growers in both District Multan and District Khanewal.

MATERIALS AND METHODS

The study was conducted during 2016-17. Data were collected from 158 small-scale farmers (who have land less than 12 acres), medium-scale farmers (who have more than 12 and less than 25 acres), and large-scale farmers (who have land more than 25 acres) using a stratified random sampling method.

Multan and Khanewal districts of Punjab province were selected for study purposes. The main reason for the selection of the districts was to save the expenses for data collection as these districts were approachable on a daily basis for data collection even though the districts are equally famous for Bt cotton sowing.

From each district two tehsils were selected randomly and from each tehsil 5 villages were randomly selected for data collection. Data were collected through a well-structured questionnaire.

Regression analysis was utilized to assess the influence of Bt cotton cultivation on the overall income of sampled farmers. Data analysis was conducted using Stata 11 software. In this study, the Log-log multiple regression model was employed to estimate the impact of Bt cotton sowing on farmers' income in the study area.

The log-log model that was employed in this study has the equation shown below.

$$Ltinc = \beta_0 + \beta_1 Lnr\_bt + \beta_2 Ledu + \beta_3 Lexpe + \beta_4 Lls + \beta_5 Ldfm + \beta_6 Lage + \beta_7 dtrac + \beta_8 dsoi + \beta_9 dext + \beta_{10} dtb + \beta_{11} dloan + \mu_i \quad \text{.......(1)}$$

The description of the variables is given below in Table 1. In above the log-log model β_1 , β_2 , β_3 ,…… β_{11} are the coefficients of independent variables and β_0 is the slope parameter, whereas μ_i represents the error term.

To estimate the benefit-cost ratio, we used the given below formulae in our study.

With Imputed Cost:

Benefit cost ratio (BCR) = Economic profit/TC

Without Imputed Cost

Benefit cost ratio (BCR) = Business profit/TVC

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Table 1. The description of the variables

Variables	Variable Type	Measuring Units
Ltinc	Dependent	Natural log of total annual income from all sources in thousand rupees.
Lnrbt	Independent	Natural log of net revenue per acre (in thousand rupees) only from sale of Bt crop.
Ledu	Independent	Natural log of education. It is measured as number of schooling years.
Lexpe	Independent	Natural log of work experience. It is measured as number of years of farming.
Lls	Independent	Natural log of livestock holding. It is measured as a number of cows and buffalo farmers have.
Ldfm	Independent	Natural log of distance from the market. It is measured as KM.
Lage	Independent	Natural log of age in years.
dtrac	Independent	Dummy variable for tractor (farmers have tractor = 1, otherwise = 0)
dsoi	Independent	Dummy variable for the source of income (If source of income only form agriculture = 0, If farmers have multiple sources = 1).
dext	Independent	Dummy variable for agriculture extension services availability (1 if service available, 0 otherwise).
dtb	Independent	Dummy variable for tubewell ownership (1 if own tubewell, 0 otherwise).
dloan	Independent	Dummy variable for agriculture loan (1 if loan taken, 0 otherwise).

Source: Own Calculation.

RESULTS AND DISCUSSIONS

The results of the log-log multiple regression model are presented in Table 2. Results show that variable net revenue from the sale of Bt cotton has a positive and significant impact on the total income of farmers. The coefficient of the variables is estimated as 0.459 and it is highly significant. The result can be elaborated that a 1 percent increase in net revenue per acre from Bt crop will increase the total annual income of farmers by almost 0.459 percent. The results are in correspondence of the findings of [20, 21, 31, 8].

Education plays an important role in enhancing the productivity of human resources. The estimated coefficient of the education variable is 0.266 which is significant at a 2 percent level of significance. It means that by increasing one percent increases in education, total income can be increased by 0.266 percent. [19, 26, 27] stated that education with experience can further increase the productivity level of human resources. In this study, the sign of variable experience is as per expectations, but coefficients were found non-significant. This may be owing to the small sample size. Livestock holding is found non-significant. However, it is significant at an 11 percent level of significance.

Existing markets and their distance from production areas play a vital role in enhancing the economic activities in adjacent areas. In our study, the variable distance from the market is found significant with a negative sign as per expectations.

Table 2. Results of the estimated model

dependent variable= Ltinc	Coefficient values	Std. Error	t-value	P-value
Const.	4.113	1.162	3.54	0.001
Lnrbt	0.459	0.208	2.21	0.028
Ledu	0.266	0.114	2.33	0.021
Lexpe	0.117	0.163	0.72	0.474
Lls	0.114	0.072	1.59	0.113
Ldfm	-0.309	0.105	-2.96	0.004
Lage	0.124	0.260	0.48	0.639
dtrac	0.927	0.158	5.88	0.000
dsoi	0.089	0.147	0.61	0.545
dext	0.048	0.135	0.35	0.724
dtb	0.140	0.155	0.90	0.370
dloan	0.008	0.144	0.06	0.953
R^2	**0.44**			
F (11, 146)	**11.38**			
Prob>F	**0.000**			
Jarque-Bera Normality Test	0.3363	**Chi^2**	0.8452	

Source: Own Calculation.

A one percent decrease in distance from the market will cause to increase in the total annual income of farmers by 0.309 percent. A similar impact has been observed by [16].

Dummy variables are incorporated into the model when quantitative information is lacking, yet their inclusion is deemed crucial for comprehensive model representation. In this study, we included dummy variables for tractor ownership, sources of income, availability of government extension services, ownership of tubewell, and agricultural loans. The dummy variable used for the tractor is found statistically significant. It illustrates that farmers who have tractors earn more income as compared to those who have no tractors if all other factors are kept constant. This result also conforms to the result of [17]. All other dummy variables are found non-significant. It means that these variables do not create a difference between have and have not. Most of the farmers have responded that they have a single source of their income. Similarly, most small and medium farmers have reported that they do not have their tubewells. Extension services are very poor all over Pakistan. The employees of the extension department do not pay regular visits to farmers especially those who reside away from the main road.

Different diagnostic tests were employed to check the normality of error terms, model specification, and heteroscedasticity. The Jarque-Bera (JB) test was employed to assess the normality of the data distribution. Since the calculated chi-square value was found to be less than the tabulated value, we refrained from rejecting the null hypothesis (H_0: distribution of residual term is normal). To test whether the model is correctly specified (H_0: there is no specification error) the link test has been used. The results in Table 3 show that the model was correctly specified. Because the coefficient of the hat was near 1 and the t-statistics of the hat square were insignificant which indicates that the Model is correctly specified, therefore, the null hypothesis was not rejected.

The result of the white test is presented in Table 4 and the calculated value of chi-square for heteroscedasticity is estimated as 80.98. While it's tabulated value at 1 percent level of significance is 100.45. Since calculated value is smaller than tabulated value hence H_0 is not rejected. i.e., variance of error term remains the same throughout the normal distribution.

Table 3. Results of linktest for functional form

Itinc	Coefficient	Std. Error	T-value	P-value
Hat	1.52	1.54	0.99	0.323
Hatsq	-0.36	0.11	-0.34	0.733
Constant	-1.89	5.58	-0.34	0.735

Source: Own Calculation.

Table 4. Results of White test for heteroscedasticity

H_0	**Homoscedasticity**		
H_1	Heteroscedasticity		
chi^2(72)	80.98	**Prob > chi^2**	0.2195

Source: Authors' Calculation.

The benefit-cost ratio (BCR) is one of the measures to assess the profitability of any economic activity. Bt cotton technology has been adopted by the farmers due to its profitability.

The results in Table 5 reveal that BCR is highest in the case of small farmers followed by large farmers in both districts. This study negates the viewpoint of [13] who reported that this technology is more suitable for large farmers.

Nevertheless, it is crucial to highlight that the BCR surpasses one only when the imputed cost is not taken into consideration. When factoring in the imputed cost, the BCR is less than one across all categories of farmers in both districts. This observation suggests that factors are exerting a negative impact on the profitability of Bt cotton growers.

These findings stand in contrast to those reported by [22], who asserted that the BCR remains above one even when imputed costs are incorporated. Discrepancies in the results could potentially stem from variations in the province, costs of other inputs, and provincial policies.

These factors may be the low price of output, higher prices of inputs, and inadequate field management practices. The comparative analysis between districts reveals that the BCR without imputed costs is higher for small and large farmers in the Multan district, whereas for medium farmers, it is greater in the Khanewal district. The primary contributing factors to the higher BCR in the Multan district are the lower land rent and increased yield.

Table 5. Per Acre Benefit Cost Ratio (BCR) of Bt Cotton Growers in District Multan and Khanewal.

Category of Farmers	Multan District		Khanewal District	
	BCR with imputed cost	BCR without imputed cost	BCR with imputed cost	BCR without imputed cost
Small	0.66	1.79	0.54	1.50
Medium	0.43	1.27	0.53	1.34
Large	0.89	1.69	0.52	1.38

Source: Own Calculation.

This study examines the impact of Bt cotton cultivation and other allied factors on the total income of the farmers. The explanatory variables such as net revenue per acre from Bt income, education, distance from market, and tractor ownership are found to have positive and significant impacts on the total income of the farmers. Furthermore, the estimation of the BCR demonstrates that it exceeds one when the imputed cost is excluded from the estimation process.

However, the inclusion of imputed cost in the BCR calculation results in a value less than one. This pattern holds true across all categories of farmers. When making an inter-district comparison, it is observed that the BCR without imputed cost is higher for small and large farmers in Multan district, whereas for medium farmers, it is greater in Khanewal district.

CONCLUSIONS

The proximity of farmers to the market is a pivotal factor, influencing transportation costs and facilitating easy access for selling produce at more favourable prices. The study reveals that the cultivation of Bt cotton is driven by its resistance against bollworm and pest infestation, resulting in reduced pesticide costs.

Considering these findings, several recommendations are proposed. Firstly, despite the positive impact of Bt cotton productivity on farmers' total income, the unreliability of seed quality from various suppliers poses a risk. It is recommended to ensure the provision of high-quality seeds to protect farmers from potential exploitation by seed supplying agencies. Secondly, the establishment of seed testing labs in each district can verify the quality and authenticity of Bt seeds. Thirdly, recognizing the significance of mechanization in timely field operations and increased productivity, the study underscores the positive impact of tractor ownership on total income. Therefore, it is suggested that tractors be made available to farmers at subsidized rates or through interest-free instalment plans, especially for small and medium-sized farmers.

Moreover, the study emphasizes the crucial role of education in human resource development. Education programs, such as farmer's field training, are proposed to impart effective management skills and enhance productivity. Additionally, the establishment of markets at the union council level is recommended, considering that closer proximity to markets positively correlates with higher total income for farmers. This initiative aims to facilitate year-round transactions for the purchase and sale of various agricultural products, reducing transportation costs associated with large distances from markets.

Furthermore, the analysis of the benefit-cost ratio indicates that it is less than one when imputed costs are factored in. This implies that farmers may not be in a profitable position when considering imputed costs due to high inputs and low output prices. Policies aimed at reducing input prices are strongly advocated to uplift the socio-economic conditions of farmers.

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THE CONSUMERS' ACCEPTANCE OF PURPLE-FLESHED POTATO ON THE MARKET IN ROMANIA

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Abstract

Potato has been consumed for more than four centuries in Europe, and during the last century, it was also the subject of modern biotechnology breeding to obtain different varieties with specific uses. Therefore, new potato varieties have been constantly introduced into the marketplace. Up to the beginning of this century, purple-fleshed potatoes (PFPs) were not very common in Europe, nor in Romania. But, due to their significant nutritional importance, an increase in these varieties' acceptance on the marketplace was observed. While the purple-fleshed potato may offer unique nutritional advantages, challenges may arise in terms of consumer education and acceptance. The scope of this article was to apply a scientific-based questionnaire and to be disseminated with the support of students among the consumers in Sibiu County. A total of 278 answers have been received. Based on the analysis of this survey, it can be concluded that generally, the public is open to accepting different types of potato varieties. However, the need for scientific explanations was considered essential to getting informed answers from all respondents. The most interested in the PFPs seems to be the young generation, most originating from urban or rural areas. Thus, PFPs may have the chance to enter the marketplace in Romania quickly.

Key words: *novel food, population acceptance and consumption, purple-fleshed potatoes (PFPs)*

INTRODUCTION

Currently, due to its increased adaptability to different pedoclimatic conditions, *Solanum tuberosum* L. is cultivated in more than 120 countries around the world, with potatoes being consumed daily by more than a billion people [9]. Moreover, this species is listed as the fourth most cultivated crop plant in the world [5], after maize (*Zea mays* L.), rice (*Oryza sativa* L.), and wheat (*Triticum aestivum* L.). As it is long-established, potato is a species originating in the highlands of the Equatorial Andes in South America, respectively, in Peru, where two distinct centers of origin have been identified in the regions of Huancayo and Cuzco [4]. Once the idea of the center of origin of culture species proposed in 1917 by Vavilov was accepted, after 1920 a series of scientific expeditions to South America began, which ended with an impressive collection of germplasm comprising at least 200 species of wild and eight cultivated tuber-producing species belonging to the genus *Solanum*. During this period, potatoes became the subject of scientific research at high standards around the world, especially due to their nutritional potential, as the potato crop became one of the seven pillar crops in the world [2, 24]. Potatoes with purple or red flesh have high concentrations of anthocyanins, but also an antioxidant action four or five times higher compared to potato tubers with yellow or white flesh [11]. Among the most important benefits can be listed: protection of the immune system due to the increased intake of antioxidants present on the flesh tubers; helping to regulate blood sugar; lowering blood pressure; helping to lose weight due to the low intake of fats; and most importantly, they prevent the appearance of tumors or cancer due to the large amount of antioxidants that the purple-fleshed potato (PFP) tubers have [6, 7, 3]. In terms of nutritional composition, the equivalent of 100 g of raw potato tuber consists of 77.46 g of water, 17.47 g of carbohydrates (mainly starch), 2.20 g of fiber, 2.02 g of protein, and only 0.09 g of fat, all of which add up to 77 kcal [16].

Promoting new potato varieties on the market is crucial for biotech companies to attract the attention of farmers, producers, and consumers. Promoting these varieties at agricultural events provides a direct way to interact with farmers, explaining their advantages and benefits [13]. The acceptance on the market of new potato varieties became a relevant subject for their future trade. The use of both online and offline promotion channels increases awareness and information related to new varieties and their positive influence on new potential consumers [12]. Field trials and practical demonstrations are essential, allowing farmers to witness the performance of new varieties under real growing conditions [1]. This creates confidence and encourages farmers to continue growing new varieties and placing them on the market [25]. By combining these communication strategies starting with 1955, the impact of promotion is maximized, facilitating the successful entry of new potato varieties into the market, followed by consumer acceptance and consumption, and the functioning of the potato market at a new level [19]. To ensure food and nutritional security and, at the same time, to rationally exploit agricultural land, farmers have begun to introduce and cultivate different plant species from exotic areas that can adapt to new climatic conditions [20]. For example, in the last decade, the cultivation of PFP has been adopted by some Romanian farmers. PFPs are not sufficiently known by European consumers, even if they are varieties already adapted to cultivation. For this reason, in Romania, it is very important to promote the market entry of PFP varieties.

The main purpose of this study is to identify the degree of acceptance of PFP among Romanian consumers. The secondary aim of this study is to make potato consumers aware of PFPs marketing, their nutritional and food value, and the potential for inclusion in the menu by adding this information to a questionnaire with extensive scientific explications.

MATERIALS AND METHODS

A. Applied questionnaire for PFP knowledge and consumption. A Google Form was developed comprising sets of questions related to PFPs knowledge and consumption. These questions were structured in two parts. The first part of the questionnaire had a total of 20 questions, using both closed-ended and open-ended 5-point Likert scale questions. This part aimed to obtain information on the frequency with which the respondents consume potatoes and how they consume them, followed by checking their knowledge of the purple potato and the respondents' openness to consumption.

The second part of the questionnaire consisted of five questions that describe the respondent's typology, such as age, gender, place of origin, last completed studies, and profession. The estimated time for completing the questionnaire was 4-5 min. It was completed online during the year 2020. Each question was accompanied by scientific information related to PFPs and the questioned subject.

B. Target group. The questionnaire was released with the support of students of the Faculty of Agricultural Science, Food Industry, and Environmental Protection, Lucian Blaga University of Sibiu. Thus, the primary target group is students studying subjects related to agriculture. The second target group was chosen randomly, regardless of social class, education level, age, or gender. The application of the questionnaire was carried out through media coverage on social networks (a Facebook group specifically in the field of agriculture in Sibiu County), but also through its distribution by students in agri-food local markets from Sibiu and Mediaș city as well as in the rural area of Sibiu County. Upon accessing the link, survey participants were informed of its purpose.

C. Data analysis and interpretation. The obtained data were cumulatively interpreted with the help of graphs processed in the Excel

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program, a component of Microsoft Office. The proposed sample consisted of 250 respondents. All the answers obtained after submitting the questionnaire were confidential and anonymous, later being interpreted with the statistical program SPSS, version 13.

The Chi-Square test was used for the comparative analysis [18] of the questionnaire items according to the age groups and the urban or rural origin. Only answers that reached the level of statistical significance of p=0.05 were taken into consideration [22].

RESULTS AND DISCUSSIONS

For more than five centuries, potato cultivation started slowly and continued in a faster way, becoming widespread worldwide due to its adaptability to different climate zones and soil types, but it is noted that it is mainly cultivated in Europe. By analysing the FAOSTAT 2021 database, in 2021 in Europe, Ukraine had an area cultivated of 1,283,200 ha, followed by Russia with 1,142,111 ha and Germany with 258,300 ha. The area cultivated with potatoes in Romania in 2021 was 84,530 ha; our country ranks the 10th in Europe.

Potato cultivation at the level of the European Union brought great value to the agricultural sector, so that in 2019, it produced 56.62 million tons of potatoes, worth over 13 billion euros.

However, no data is available about the cultivation or consumption of PFPs. Most popular potato varieties are white-fleshed, but recently PFPs have entered the marketplace. These potato varieties slowly became more and more popular and were cultivated in many countries, including Romania. For this reason, we conducted a survey and applied a questionnaire among some respondents from Sibiu County to understand the level of knowledge and acceptance related to PFPs consumption. Before resorting to designing the questionnaire, a bibliographic search was made in the Web of Science Core Collection database (WOS) [26] using the keywords `*potato acceptance marketing*`. This scientific research was made to identify the degree of knowledge of PFPs among the population. In this way, 62 scientific papers related to the searched keywords were identified. All scientific papers, consisting of articles, reviews, or short communications collected from electronic libraries, were published in the last 30 years. Thus, 8 were published between 1993 and 2002, 13 between 2003 and 2012, and 42 between 2013 and 2023. The number of publications is constantly increasing, which means that this topic is relevant for researchers. In the second stage, all articles were analyzed based on their keywords, and the most used keyword was `acceptance` (Fig. 1). However, of the total number of identified papers, only one addresses PFPs. We mention that there are also relevant scientific publications not included as they were not introduced into the WOS database, such as that of 1955 [19].

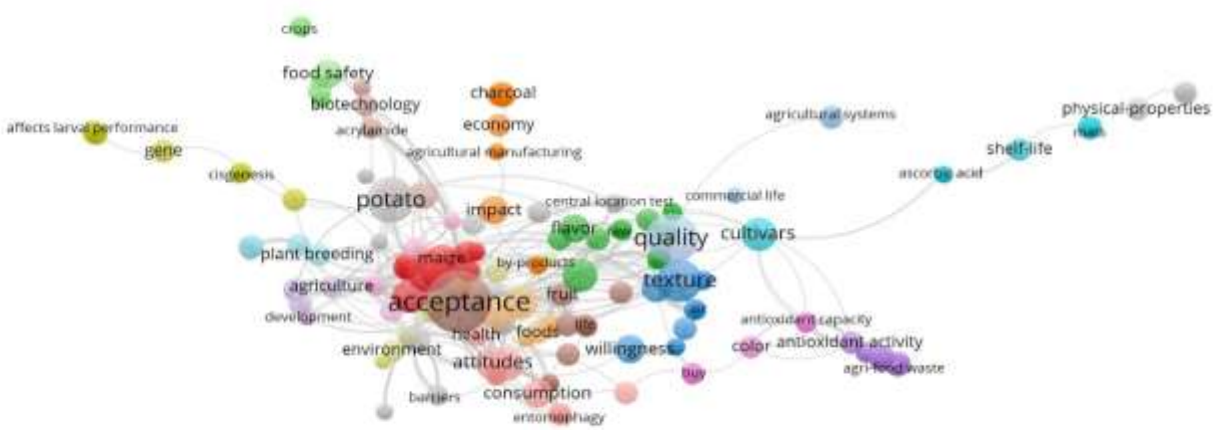

Fig. 1. Graphic representation of cooccurrence of all keywords collected from 62 scientific papers with potato acceptance marketing as a general subject of study.
Source: processed data on VOS-viewer, version 1.6.15 [14].

A set of 20 questions were electronically disseminated as a Google Forms questionnaire. Following the dissemination of the questionnaire, 279 responses were collected. The data obtained were presented in the form of frequencies and percentages by applying the Chi-Square test. Related to *potato consumption*, the results are presented in Fig. 2. It can be considered that the younger respondent group (i.e., the 20–25 age group of consumers) is consuming potatoes much more often compared to the elder group (61.63%), compared with (p = 0.000) the other groups of age who answered that they would often consume this food (43.75–52.94%).

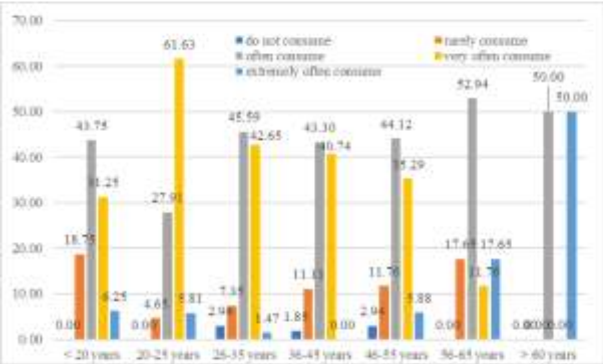

Fig. 2. Frequency of potato consumption by age groups in Sibiu County, Romania (p=0.000)
Source: original by processing obtained data.

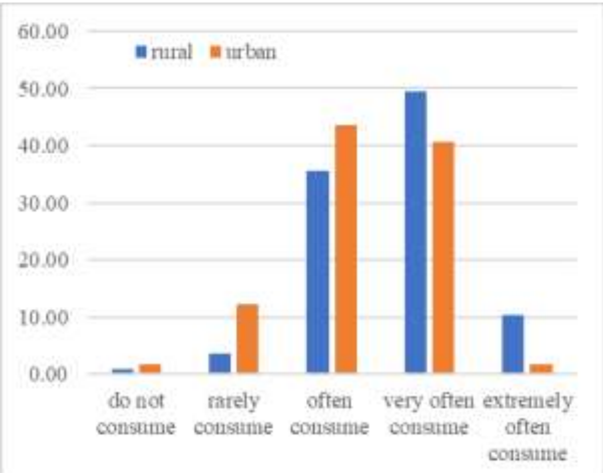

Fig. 3. The frequency of potato consumption according to the rural and urban areas of origin in Sibiu County Romania (p=0.002)
Source: original by processing obtained data.

Depending on the *respondent's origin* (i.e., rural and urban areas) in Fig. 3, the rural respondents (i.e., 49.53%) consume potatoes much more often compared to those from urban areas (i.e., 43.60%). However, the difference between these two groups is not too high. Considering the *type of potato cooking*, respondents aged up to 35 years preferred fried potatoes (41.18–51.16%), compared to the group over 45 years, who frequently consume mashed potatoes (38.24–41.18%). In this case, no statistical differences were observed for rural and urban area origin groups (i.e., 38.71%).

The respondents' responses to questions regarding *their knowledge about the existence of PFPs* are presented in Fig. 4.

It is observed that the groups of respondents aged between 36 - 45 years, 46 - 55 years, respectively, 56 - 65 years, answered that they are familiar with these varieties (72.22–88.24%), compared to (p=0.058) the elder age groups (50.00–68.75%).

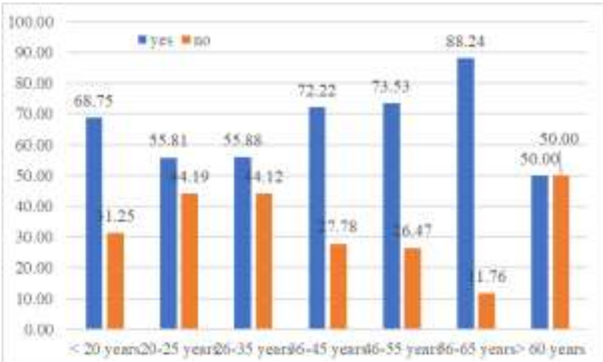

Fig. 4. Knowledge regarding the existence of PFP according to age in Sibiu County, Romania (p=0.058)
Source: original by processing obtained data.

As in the previous case, from Fig. 5, it appears that the same age groups stated that they have seen potato varieties that have purple flesh in stores (44.44–76.47%), compared to (p=0.003) the remaining age groups (25.00–50, 00%).

It seems that of the people surveyed under the age of 20, only a percentage, 25.00%, had the opportunity to identify such varieties on supermarket shelves or in the market (Fig. 6). Based on these data it can be considered that the high difference between the people knowing about PFP and its marketing might be due to the misunderstanding of the first question and confusing PFP with red skin potatoes.

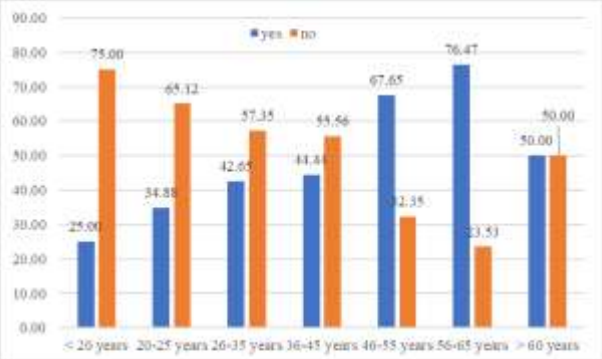

Fig. 5. Knowledge of PFP marketing according to age in Sibiu County, Romania (p=0.003)
Source: original by processing obtained data.

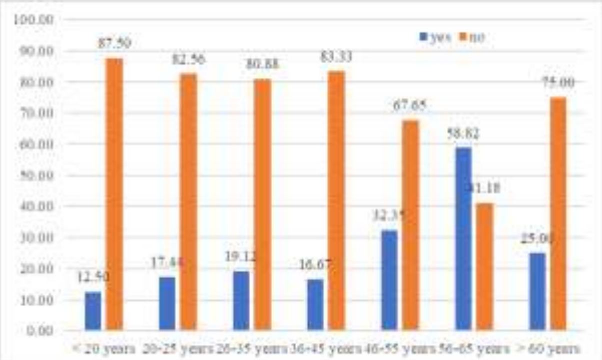

Fig. 6. The purchase of PFP from stores according to age in Sibiu County, Romania (p=0.005)
Source: original by processing obtained data.

In this regard, in vernacular Romanian terms red potatoes are referring to red skin potatoes and not to flesh potatoes.

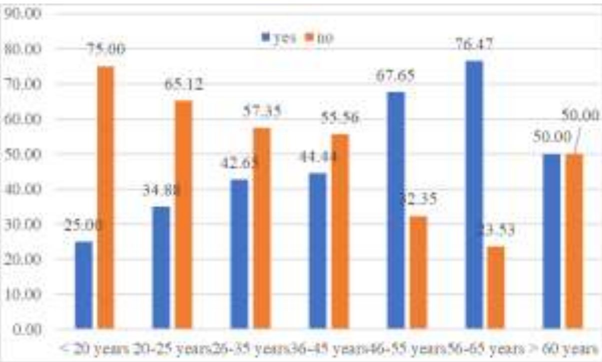

Fig. 7. Sales perception of PFP in Romania according to age in Sibiu County, Romania (p=0.003)
Source: original by processing obtained data.

By analyzing the data presented in Fig. 7, it can be seen that 58.82% of respondents in the 56-65 age group have also bought such potatoes, compared to (p=0.005) the other age groups (12.50–32.50%). And those from the age groups 46-55 years (50.00%), respectively 56-65 years (47.06%) knew that in Romania PFP are cultivated and marketed by small farmers, compared to (p=0.003) the other age groups (17.44%–25.00%).

Considering the origin of respondents, no statistically significant differences were observed in the existence, trade, and consumption of PFPs.

Another subject was the *knowledge related to anthocyanin richness of PFPs*. Thus, according to the data presented in Fig. 8, many respondents, both rural (40.19%), and urban (53.49%), are supporting the idea that it might be important for PFPs varieties to be cultivated on a larger scale in our country (p=0.022). According to the distribution of respondents by age, no statistically significant differences were obtained.

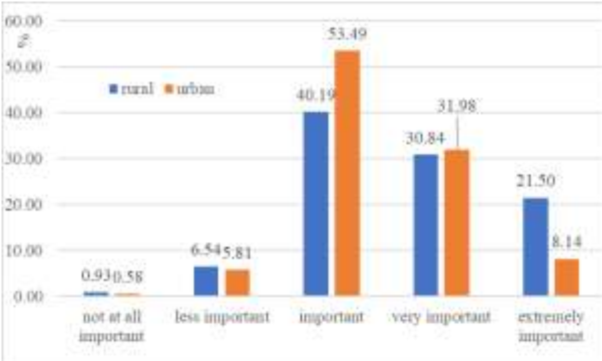

Fig. 8. The importance of PFP cultivation depending on the respondent's origin in Sibiu County, Romania (p=0.022)
Source: original by processing obtained data.

Regarding the *use of antioxidant substances* (e.g., anthocyanins) extracted from PFP (Figs. 9 and 10), respondents under 20 years old (43.75%) and those aged between 20-25 years (36.05%) showed themselves to be very interested, followed by the age groups 26-35 years (61.76%), respectively, 36-45 years (64.81%) who declared themselves interested in this subject, compared to (p=0.012) the other age groups. Regarding the area of origin 41.12% of the respondents who come from the rural area consider themselves interested, and 24.30% extremely interested, compared to (p=0.011) those who come from the urban area, where 52.33% are interested and only 9.30% extremely interested in this topic. It is relevant to mention that scientific data have been provided to all respondents inside the questionnaire during the survey.

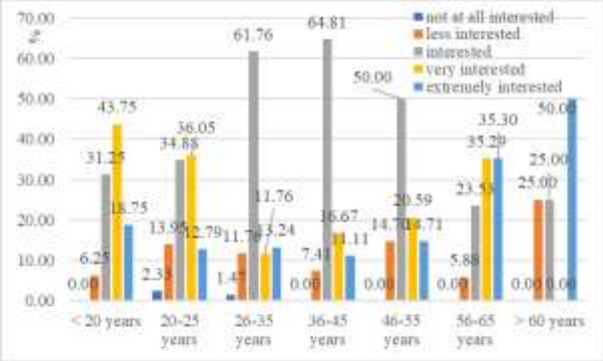

Fig. 9. Interest in anthocyanins extracted from PFP according to age of respondents from Sibiu County, Romania (p=0.012)
Source: original by processing obtained data.

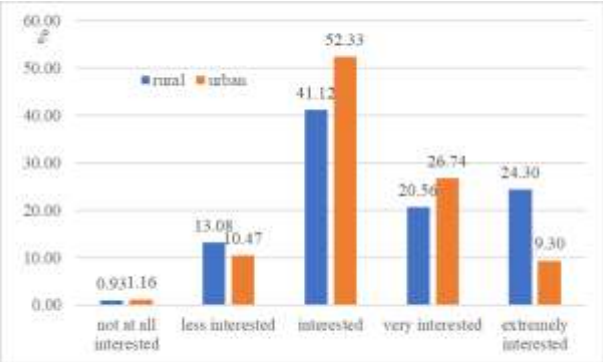

Fig. 10. Interest in anthocyanins extracted from PFP according to origin of respondents in Sibiu County, Romania (p=0.011)
Source: original by processing obtained data.

Another question was related to *the potential consumption status of PFPs fresh and cooked*. Thus, the data analysis revealed that the respondents are open about the consumption of plants or tubers in a fresh state, obtained *in vitro* (Fig. 11 and Fig. 12), so that from the age category under 20 years (50.00%) they declare very willing to try, followed by the age groups 20-25 years, 26-35 years, respectively 36-45 years (41.86%–55.56%). They stated that they are willing to consume, in this form, potato varieties rich in antioxidant compounds, compared to (p=0.002) the other age classes.

If we look at the area of origin of the people surveyed, 47.66% respondents who come from rural areas declare themselves willing to consume seedlings and/or microtubers, followed by 19.63% who are very willing and extremely willing, compared to 7.56% urban respondents (p=0.015) who are extremely open to eating such foods. The elder group seems not to be so interested due to their difficulty understanding how to apply cruse potatoes in cooking recipes (Fig. 12).

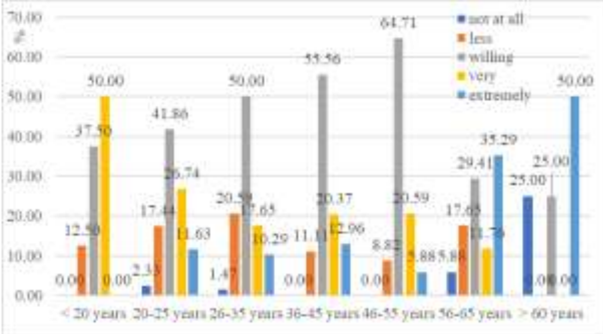

Fig. 11. Openness to the consumption of plantlets and microtubers according to age from Sibiu County, Romania (p=0.015)
Source: original by processing obtained data.

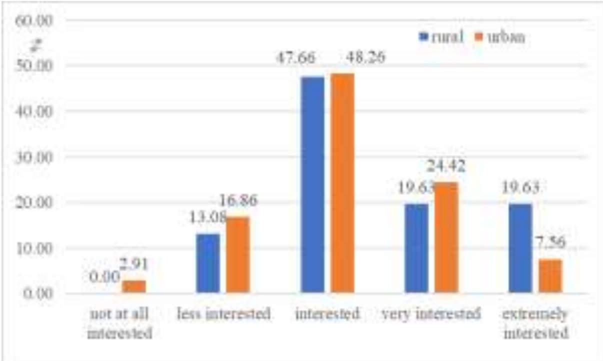

Fig. 12. Openness to the consumption of plantlets and microtubers according to the origin of respondents (p=0.015)
Source: original by processing obtained data.

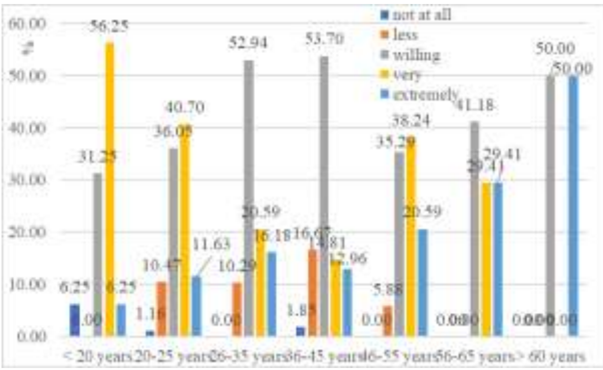

Fig. 13. Considering PFP a `novel food` according to age of respondents from Sibiu County, Romania (p=0.020)
Source: original by processing obtained data.

Taking into account the *market price of PFP varieties and the potential labeling as novel food* (approximately 3-4 times higher than white-fleshed varieties) and also the fact that a limited number of the population knows these varieties, respondents under 20 years of age and those aged between 20-25 years (40.70–56.25%) consider it very important that this food is considered `novel food` on the territory of our country, while the categories aged between 26 and 65 years, with the exception of respondents aged between 46-55 (36.05%–53.70%) were of the opinion that it is important for the food to be classified as `novel food`, compared to (p=0.020) the other age groups (Fig. 13.).

In rural areas, 32.71% of respondents believe that it is very important that these potato varieties are considered `novel food` and 22.43% answered that it is extremely important, compared to (p=0.006) 51.74 % urban respondents who think this label is important for purple-fleshed potato (Fig. 14).

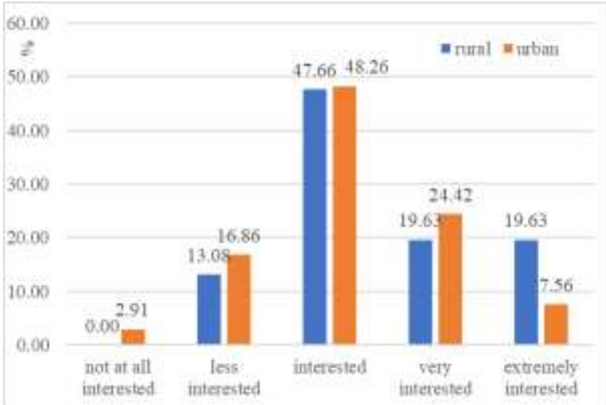

Fig. 14. Considering PFP a `novel food` according to origin of respondents in Sibiu County, Romania (0.006)
Source: original by processing obtained data.

From the total number of respondents (278), most declare that they graduated from a bachelor's degree program (37.30%), followed by high school graduates (29.70%), master's degree (25.10%), secondary high school (4.70%) and in the end, PhD study (3.20%). From there, we can see that the level of education of respondents can influence their understanding of the term `novel food`. People with a higher level of education and life experience may have a better grasp of concepts related to food, enabling them to comprehend the complexities of novel foods and their implications. In this way, education and experience can play a crucial role in shaping a person`s ability to comprehend and critically evaluate information about innovative or unfamiliar food products.

A whole series of studies from abroad revealed the need to evaluate consumer preferences for certain characteristics of potatoes as food [15]. The main objective of these studies was to generally support a certain policy in the market regarding the increase or decrease of the proportion of some varieties of potato compared to others. Such studies have been carried out in America, Europe, Africa, and Asia [1, 8, 23, 10, 21]. In addition to the promotion of certain varieties, there are other studies that aim to follow the effect of purple potato consumption in Japan [17]. The first associations of the potato with the term `novel food` were made in 1993, for genetically modified potatoes when researchers studied consumers' perception of the degree to which `novel food` foods are dangerous and, at the same time, their openness to their consumption [23].

CONCLUSIONS

Regarding the degree of knowledge of *Solanum tuberosum* L., PFP varieties, among the Sibiu County population, a percentage of 36.20% of all the surveyed respondents stated that they did not know that there are potato varieties that have the whole pulp of the tuber completely colored in purple, and 69.90% of all respondents have never consumed such potato varieties. Also, when the benefits of consuming these varieties were listed, only 1.80% of respondents stated that they were not willing to try consuming, purple-fleshed potato varieties in any form. Old age generation is more resistant to include fresh potatoes in their diet also due to medical conditions. A higher level of education generally correlates with a better understanding of all newly introduced terms. These results highlight the respondents' openness to accepting new varieties of potato in their diet.

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CHALLENGES IN IMPLEMENTING CIRCULAR ECONOMY STRATEGIES IN ROMANIA

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Abstract

One of the great challenges of humanity today is to manage the consumption of resources and increase their recycling. Current overconsumption constantly aggravates resource insufficiency, by producing an aggressive impact on the environment. The circular economy model is the way to provide the necessary resources and from politicians to companies and consumers the transition to this modern economic system requires responsibility. Worldwide there are concerns in this direction, looking for new ways of financing such sustainable models, both in production and consumption. The functioning of the circular economy model is not easy, it involves transition funds and consistent investments This study aims to analyse the degree to which specific circular economy strategies are known, understood and implemented in Romania. Also, the quantitative research undertaken on the Romanian market analyses the connection between various factors, such as the structure of the social capital, the field of activity, the number of employees, the investments in research-development-innovation, the organizational culture and the stage of the transition to the circular economy in which those companies are.

Key words**:** *circular economy, sustainability, strategy implementation, strategic management, organisational culture; research-development investments*

INTRODUCTION

As the literature reveals, the concept of circular economy is not a new one. Concerns regarding the transition to renewable energy and the fundamental change of the economic system began to appear as early as the 1970's when the idea of a model based on the transformation of waste resulting from all activities from production to consumption (and even after this point) into inputs, began to take shape. This system, unlike the linear economy concept, involves the development and implementation of actions and activities that target the problems caused by climate change, pollution and waste generation.

The linear economy, as it is perceived, is based on the production model "use of resources - use of products – waste generation" (Fig. 1).

According to this model, raw materials are used to produce goods that move along the producer's and consumer's consumption chain and finally to landfills. In contrast, a circular economy emphasizes the use of inputs while ensuring that inputs for the production process can be recycled and reused, ensuring that their economic value increases [2].

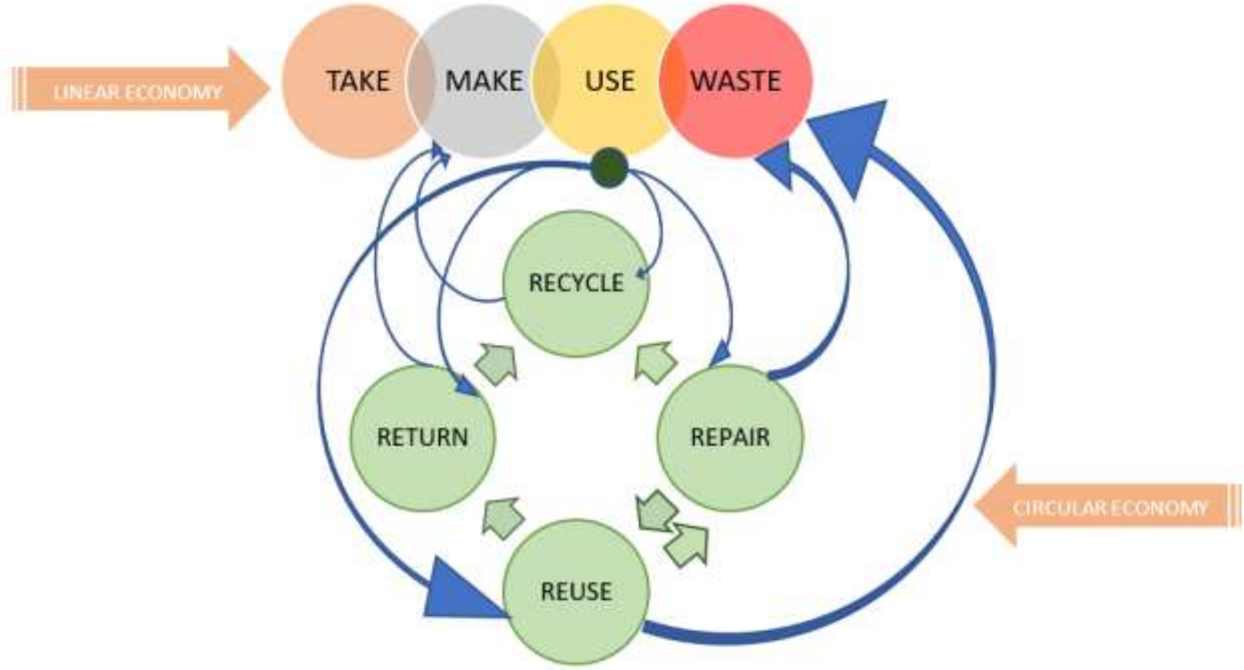

Fig. 1. The linear economy model vs. the circular economy model
Source: Adaptation after [48]

Literature review

Most specialists relate, from the perspective of defining the circular economy term, to the definition developed by the Ellen MacArthur Foundation: a circular economy decouples economic activity from the consumption of finite resources. The circular economy is seen as a framework for solutions that address global challenges such as climate change, biodiversity loss, waste and pollution [12]. In the vision of other authors, circular economy is restorative being destined to maintain the quality, utility and value of products, components and materials [32]. The circular economy can also be seen as a regenerative system where resource input and waste, emissions and energy leakage are minimized by slowing down, closing and narrowing material and energy loops. Through a long-term design, maintenance, repair, reuse, remanufacturing, reconditioning and recycling, this goal could be carried out [24].

The concept of circular economy has intensified its concerns since the 1980s mainly regarding its definition, principles and [35]. Because the resources are limited, amny experts sustained that the transition to circukar economy is compulsory, introducing the concept of sustainable development [41] as a necessity for society.

[47] offered a comprehensive guide on the concept of circular economy for businesses environment and supply chains. She referred to the design for circularity, product life cycle, remanufacturing, and closed-loop supply chains, giving case studies and examples in various economic industrial sectors.

[14] emphasized the potential thresholds and challenges of the concept, because the circular economy is not a panacea for sustainability and needs a profound change in the economic system and the adoption of new business models and technologies.

The effective implementation of environmental policies began to take shape from the 2000s, when in China more emphasis began to be placed on resources and how they are used, on products and on extending their life cycle, and on reducing the resulting waste. Efforts in the same direction are also noticeable within the European Union, whose vision on this aspect is summarized in the plans launched since 2014 [15] and 2015 [16].

According to those plans, the economy of the European Union was (and still is) highly dependent on resources (specific feature of the linear economy) and new ways were sought to revitalize competition and integrate new technologies into the market. The transition to the system based on the circular economy represents an advantage not only for the market, by stimulating competitiveness and innovation, but also for the environment, by reducing waste and resource dependence [11]. The benefits are undeniable, and such innovative models lead to the reduction of dependence on raw materials by strengthening the relationship between the company and its customers, offering products with a high degree of customization, the emergence of a participatory economy based on digital technologies (IoT, blockchain or artificial intelligence) [17].

In 2021, the EU adopted the New Circular Economy Action Plan which points out the need to implement the circular economy [19]:

- sustainable business practices and European companies and economies will be the ones to implement and at the same time enjoy several benefits in the global race towards circularity.

-circular economy principles should be at the heart of any European and national industrial policy and Member States' national recovery and resilience plans under the Recovery and Resilience Mechanism, keeping in mind the three basic pillars [13]: waste disposal and pollution; the circulation of goods and materials; the regeneration of the natural environment.

At the end of 2022, according to the continuous efforts registered at the level of the European Union regarding the creation of the legislative framework specific to the circular economy and its implementation, the European Commission published the Circular Economy Package II, which sets as major objectives the provision, for European consumers, of compliant packaging options with the new orientation and the abandonment, where feasible, of additional packaging. Concepts such as biobased, compostable and biodegradable plastics are clarified for both the consumers and industry and suggestions are offered for the design, use, disposal and recycling of some materials so that they should be truly environmentally beneficial [18].

In this context, the purpose of this study was to analyse the degree to which specific circular economy strategies are known, understood and implemented in Romania.

MATERIALS AND METHODS

The study is based on various information sources useful for describing different aspects related to the circular economy as presented below.

Circular economy versus sustainability

Some experts wondered if the circular economy is nothing more than another name for sustainability, because sustainability so described in various ways, some of the most relevant being:

-carrying out all activities in such a way that ecosystem functions are conserved [28];

-changing the approaches to economic activity and beyond, so that everyone's lifestyles support security, well-being and health, especially by maintaining the supply of non-substitutable goods and services [36];

-an indefinite perpetuation of all forms of life [10].

-development of society that involves meeting the needs of the present without compromising the ability of future generations to meet their own needs [5].

The study undertaken by Geissdoerfer and his team [24] on the common points and differences between the two concepts, led to a definition of sustainability more adapted to our reality, thus: sustainability is seen as a balanced and systemic integration of economic, social and intra and intergenerational environment. There are obviously common points between sustainability and the circular economy, but also several differences. Although, at the level of specialized literature, this cannot be highlighted very clearly, the common points refer to their global nature, to the characteristics of production and consumption on an industrial scale, and to the impact that the specific actions of each have on future generations. At the same time, one cannot fail to notice that the purpose, in each individual case, can be quite different, being determined by the context. It can be said, although the discussion is still open, that there is clearly a close connection between the two concepts, the existence of the circular economy being an essential condition for sustainability on a global scale.

In other words, the transition from the linear economy model to that of the circular economy is based on the involvement of the whole society and emphasizes its ability to develop sustainable resource management models by changing societal behaviour and old business models accordingly [25]. The adoption of closed-loop production models and the circular economy have the purpose to grow the efficiency of resource use, mainly regarding urban and industrial waste for assuring a better balance between the economy, environment and society.

The change of the linear economy into a circular one requires a reorganization of the main services at the society level, especially concerning energy, transport, production and food repartition. Also, these transformations must be doubled by changes at the level of institutions, changes that should be reflected in the updating of regulations, customs, standards and production practices. At the same time, all this must also be supported at the consumer level, by encouraging him to change his behaviour to align with the principles of sustainability [43].

A number of defining characteristics of a sustainable economic system have been proposed by Tim Jackson in his work, and they refer to the fact that the system is a closed-loop one, which stimulates the reduction of consumption, contributes to social and environmental improvements, tends to zero waste, focuses on the transmission of process and experience, harnesses talents and relies on cooperation [31]. Also, in one of the studies of the European Commission, published in 2020, the idea is emphasized that such a sustainable system is vital, and social improvements also refer to the provision of high-quality, functional and safe, efficient and affordable products, with a longer lifespan, which are designed to be reused, repaired and recycled at a high-quality level. New business models such as product-as-service and digital solutions will have a considerable weight in improving the quality of life, creating innovative jobs and updating knowledge and skills [17].

A study published in 2019 raises the alarm that, worldwide, we could talk about a percentage of the circular economy of only 9% [6], which means a global economy that runs under the rules of the linear economy and this despite all the efforts to educate and raise awareness about the situation of natural resources, about global warming or about waste and pollution. According to the most current report from the same agency, from 2023 [7], the percentage of circularity has decreased down to 7.2%, as a result of the increase in the overall rate of extraction of raw materials and the fact that more and more materials enter stocks, such as roads, houses and goods durable, thus leaving less material to return to the economy.

The measures proposed to increase this percentage are within everyone's reach, but the effort must be a collective one, not one coming only from the companies. The goal should be directly related to the rehabilitation of natural resources, and for this we need targeted policies and practices that fundamentally redefine the relations between the dominant economic environment and other spheres of society and nature.

Strategic management of the circular economy

Before introducing the strategic process for obtaining a Sustained Competitive Advantage (SCA), it is important to understand that, in general, what determines the success or failure of a company that approaches the principles of circularity is the organizational culture. Indeed, strategic decisions are naturally affected by the type of culture developed within an organization, as this causes certain strategic issues to receive the most attention while others are overlooked.

Despite being a difficult and time-consuming task, changing organizational culture is often considered a key aspect to ensure that strategic change occurs successfully and effectively. Therefore, strategists must ask themselves whether the strategic change they have envisioned can take place within the existing cultural framework of the firm, or whether this must also change. Because culture is a source of stability for a company's employees and customers, it should generally be avoided to implement change too quickly or in response to negative events (e.g., an environmental disaster caused by the company's operations); fostering a cultural change implemented in small steps and described as something positive and beneficial for all. If the positive aspect can always be sustained when circular solutions are proposed, the pace of change is not always guaranteed.

There are four types of strategic changes (Fig. 2) that can occur based on differences in speed and scale of implementation [3]:

Adaptation**:** changes at low scale and speed. This move does not require a change in strategy, nor does it have a major impact on the company's structure. Today, in the face of tightening environmental legislation, increasing consumer awareness of the environment and price fluctuations, many companies have partially switched from using harmful production inputs such as chemicals and plastics to materials bio more circular. For example, Dutch multinational AkzoNobel has joined forces with clean technology leader Photanol to naturally produce bio-chemicals for the company's products instead of typical fossil fuel raw materials [1].

Rebuild: small-scope, high-velocity changes. Often, rebuilding can be accommodated within the current culture, even if the organization is heavily impacted by the change. Rebuilding the circular economy can happen, for example, when a company succeeds in moving to closed-loop operations with the support of key suppliers and environmentally friendly suppliers. Carlsberg, for example, is investing heavily in circular packaging solutions and has selected a group of 'green' suppliers to work with [39]. Such a transformation can take place without major changes in the company's core business, particularly because the remanufacturing or recycling activities take place externally.

Evolution: large-scale and high-speed changes Such changes involve extensive and multi-stage processes that may take a long time to complete. For example, automakers such as Nissan and BMW are slowly transitioning to electric motor technology in an effort to anticipate future industry trends. Although most cars are still fuel-powered, the BMW I3 and Nissan LEAF are clear evidence that these companies have plans to step up their efforts towards zero-emission cars [21].

Revolution: *changes with transformation-like scale and high speed*. The Italian energy and resources group ERG, for example, underwent a radical and rapid transformation of its business by selling all its oil and gas activities and reinvesting in wind power plants.

Extent of change

		Realigment	Transformatio
Speed of change	Incremental	Adaptation	Evolution
	Big Bang	Reconstructi	Revolution

Fig. 2. Sizing Up Change vs. the circular economy model
Source: Adaptation after [4].

The strategic process of circular economy

Given the strategic importance of circular practices in the near future, the circular economy must be considered in strategic decision-making. Executives willing to accept that businesses operate in an ever-changing environment where strategies must be continually reshaped based on the latest industry opportunities and threats will focus on monitoring the complex context in which businesses operate them, both at the business level and at the societal level.

The most important stages of the strategic process are [46]:

-Identifying the current situation: although not common, the situation of businesses approaching a circular path may already include components of circular economy practices and objectives. An in-depth assessment of the current strategy is essential to understand where a business stands in its circular journey and what steps need to be prioritized when establishing a preferred strategy for the circular economy.

-Data analysis: the analysis part of the strategic process involves data collection, careful examination, given priorities and integration with chosen circular economy principles, business objectives and areas of intervention. Business strategies will be built on trends, strengths, weaknesses, opportunities and threats derived from information gathered at company, industry and macro levels using methods such as value chain, PEST and SWOT. When trying to define a new circular economy strategy, attention should mainly be paid to the often-unexplored aspects of business, such as materials management, sustainable design, opportunities for reverse cycles, supplier and customer attitudes towards the circular economy, etc. This type of data will be used to identify the critical points for the implementation of the circular economy.

-**Determining the preferred position of the circular economy:** the scenario resulting from the examination, prioritization and integration of all data will reveal the strategic options of the circular economy available. At this stage, the strategic quadrant can help a company choose its ideal position in the industry, thus determining its preferred attitude in the circular economy.

-**GAP Analysis:** a company's current and ideal positions don't quite coincide, especially when circular principles are at play. Therefore, there will be a gap that will be closed. In those cases where the gap is too large, given the real readiness of society in terms of the circular economy, the data will need to be rearranged (in terms of prioritization) so that a "circular economy reality" can be imagined and assessed favourites" alternative.

-**Strategy formulation and planning:** the final steps of the process involve deciding on a circular economy strategy, so moving on to its formulation and planning.

In [29], the data analysis segment highlights the state of agriculture in Romania from 2013 to 2022. Using statistical methods like regression equations and graphical comparisons, it was found that although Romania's GDP grew significantly, agriculture's share remained relatively minor at 4.5%. Ionitescu shows that despite a substantial increase in Gross Value Added (GVA) in agriculture, its Gross Fixed Capital Formation (GFCF) and Net Investment Rate (NIR) were disproportionately low, reflecting underinvestment and a lack of modern technological integration. These insights emphasize the need for enhanced investment in agriculture to support sustainable growth and reduce import dependency in a circular economy context.

Circular economy and the organisational culture

Being an economic model that aims to minimize waste, maintain the value of products and materials and reduce the resource consumption by keeping resources in use for as long as possible, circular economy requires a significant shift in organizational culture. The organisational culture concept began to take shape in the 1970s, when some specialists noted certain differences between the same type of organization that could not be explained either from the point of view of the organizational system, the way of implementing strategies, or from the point of view of human resources [38]. Leavitt's model, developed in 1964, predicted the existence of four variables within any organization: the objectives to be achieved, the structure of the organization - composed of communication systems, authority, status and rewards, technology and human resources.

The concept of organizational culture is introduced by Pascale and Athos [40], based on studies undertaken by Geert Hofstede [27]. According to the two, in the analysis of the difficulties that arise in the implementation of strategies, within some American, European and Japanese companies, the organizational culture stood out as that element that contributes significantly to the functioning of the organization and differentiates it from the competition.

Knowing the organizational culture is necessary and useful, as it is probably the only and most useful long-term anticipatory element of an organization. It can be difficult for both insiders and outsiders to penetrate the culture of the organization, which is often considered a universe of beliefs, values and concepts given once and for all and which is rarely stated or questioned, especially by those who have a limited experience of other organizations or cultures.

To do so, companies need to put an accent on sustainability and adopt new business models that prioritize reuse, refurbishment, and recycling of products and materials. This requires a shift from the traditional linear, "take-make-dispose" model of production and consumption to a circular model that prioritizes resource efficiency and waste reduction. Organizations that do so will be more likely to develop innovative products and services and they will also be more likely to attract and retain employees who are committed to sustainability and social responsibility, reinforcing a circular culture.

Resistance to change, however, is a real problem that many organizations face and that hinders the process of transitioning to circularity. Change requires not only coherent management, but also the existence of effective leadership, successfully introduced and sustained [26]. On the other hand, the values that constitute an organizational culture are also influenced by external factors, such as those from the socioeconomic, political or institutional environment [33].

The reality shows that the organizational culture is often seen as a barrier, especially in organizations paying tribute to the principles and way of thinking specific to the linear economy. Recent studies, such as the one undertaken by [8] analyses the role of organizational culture in the development and implementation of sustainable processes specific to the circular economy.

The choice, within organizations, of circular practices that match the values of the company also depends on the perspective, such as that of the producer or the consumer [44] but also the ability to find sustainable levels for the materials used and for the waste generated [34].

Specific strategies for the circular economy model

Economic challenges, especially in recent years, have made instability the new reality for companies and economies. Risks regarding the supply chain, delivery, those related to the right of ownership, incentives offered without real coverage and the liberalization of certain areas were determining factors for the strategies adopted by the companies [24].

Ensuring the transition from the linear economy to the circular system can be done by implementing research strategies, radical innovation (especially in the field of technology) and digitization [22]. Within the European Union, companies can access specific programs (e.g. Life, Horizon Europe or the Marie Sklodowska Curie Actions are just some of the programs dedicated to research, innovation and digitization in the EU), aimed at the development of production technologies, new products and materials, the replacement or elimination of harmful substances, up to the development of specific business models.

In an article published in 2023 [30], Ionitescu et al. show that having a robust digital infrastructure and effective human resource management is crucial for cultivating a workforce with high professional and digital skills, which is essential for future success across various economic sectors. In agriculture, digitalization should consider specific factors such as the size of farms, the age and education levels of farmers, and available financial resources. Enhancing communication between farmers and their customers is vital to strengthen the food value chain. Moreover, developing modern ICT infrastructure is essential for providing employees with digital skills, improving existing strategies for better results, and developing services and digital applications that adhere to EU regulations.

In Romania, implementing a circular economy faces challenges that can be mitigated through the development of rural, agritourism, and ecotourism sectors. In [45], Stanciu et al. show that these tourism forms help transform the rural image and bring numerous benefits, crucial for a sustainable economic model. Key advantages include preserving natural and cultural heritage, creating jobs, enhancing professional and digital skills, generating supplementary income to agriculture, and improving locality aesthetics. Moreover, they support biodiversity conservation, promote local gastronomy, and utilize local products registered under quality schemes. Such activities strengthen the local economy and foster short food supply chains, essential elements in building a resilient circular economy that reduces waste and promotes resource efficiency.

In the report published in 2019 [6] by the Circle Economy Organization, it talks about a series of elements that are basically the basis of the development of strategies specific to the circular economy and that companies can develop in order to be an active part of the global paradigm change process. These elements aim at actions such as: maintaining, repairing and updating resources to maximize their lifespan, rethinking the business model so that it provides greater value, using waste as a secondary source of resources, recovering waste through reuse and recycling, efficient use of resources renewable, reusable and non-toxic, intensive collaboration along the entire supply chain, between the private and public environment and increased transparency in activities specific to the circular economy.

Moreover, these actions are also found in the model presented by Potting et all [43] and taken over by Morseletto [37] (Fig. 3). According to the model adapted by Morseletto, the strategies, found in the specialized literature under the phrase "10R", are analysed starting from those with the lowest level of circularity to those with the highest level.

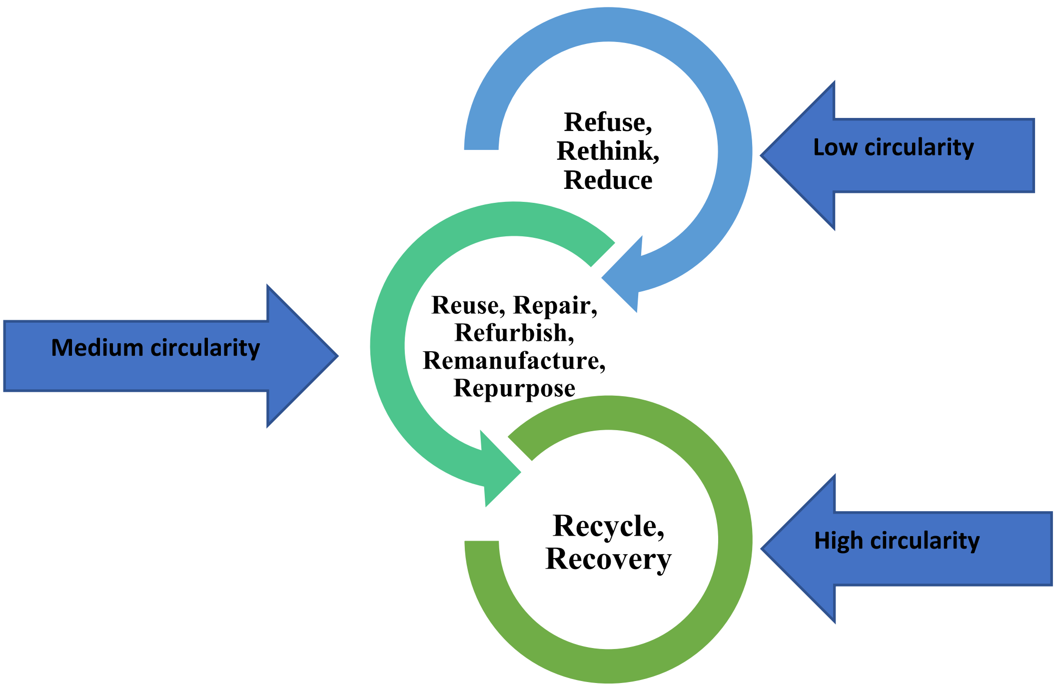

Fig. 3. Specific strategies for the circular economy
Source: adaptation after [37], citing [43]

It is noticeable that the strategies are divided into three distinct categories or groups, targeting activities with different degrees of integration of the principles of circularity. In the category with a ***low level of circularity***, there are strategies that are frequently chosen by decision-makers and represent a step in the transition from the linear economy to the circular one, by reducing, for the most part, the impact on the environment.

Strategies with a ***medium degree of circularity*** are intended to keep finished products and their component parts for a longer period in the economy, maintaining or increasing their value permanently. Specific actions can be from improving adjacent services (warranty extensions, repairs), to reducing costs by streamlining processes at company level or offering the consumer the option of spare parts, to improving design with a direct impact on efficiency.

The category of ***highly circular strategies*** targets processes such as the creation, design and development of products or services and involves significant investment in research, development and innovation. These strategies have the ability to transform, from the early stages, a linear system into a circular one, as long as they are implemented by the mass of those who have active roles in this transition, globally.

In the current context, the most common practices are, in many organizations, reduced to the 3 R's (reduce, reuse and recycle) [23].

Research methodology

In Romania, the circular economy, with everything it entails - at least at the level of vision, implementation - is still in the phase of fully understanding the concept, of "discovery". This opinion takes on a clearer meaning when we look at the area of application of the specific strategies; on a practical level, the circular economy is at a point of implementation within most companies. Obviously, this statement is not valid for all actors in the internal market, there are quite a few companies that come from experienced environments and that know how to use what the circular economy entails in a fair and efficient way. Even in this case, there is a risk that the business will not be successful, due to the lack of adaptation to the specifics of the local market and the use of strategic models that do not fit the Romanian market. In addition, we emphasize the importance of technological challenges. Like in the area of renewable energy, one of the most relevant technological issues is the none or limited availability of physical infrastructure and of transmission and distribution networks in promising locations of renewable energy supply, which leads to a scarce exploitation of their capacity [9].

Romania's economy is one of the least efficient on the European level from the perspective of how resources are used. From the point of view of the circularity rate of materials, Romania ranks last in the European Union, at a considerable distance from the member state in first place - the Netherlands (Fig. 4). It also ranks last in terms of resource productivity (Fig. 4). Also, the focus is on areas that register low degrees of circularity, investments in research-development-innovation, technology and human resources being very low. But as long as the cost of the original base raw materials is below that of raw materials and recycled materials, it is expected that things will not move in the right direction for quite some time.

To address the challenges of implementing a circular economy in Romania, it is important to reduce dependency on imports by stimulating agro-food exports. In [42], Popescu et al. point out that this can be achieved by increasing agricultural production to provide more high-value-added and superior quality products, thereby enhancing competitiveness.

Additionally, revising imports and improving resource allocation are essential strategies to bolster internal production and better meet domestic consumption needs.

These measures are integral to fostering a more sustainable and self-sufficient economic model in line with circular economy principles, which aim to minimize waste and maximize the reuse and recycling of resources.

According to the World Bank report published in 2022 [48], Romania and other three EU member states registered the lowest level of implementation of the circular economy, in terms of resource productivity and garbage disposal rates (Figure 4).

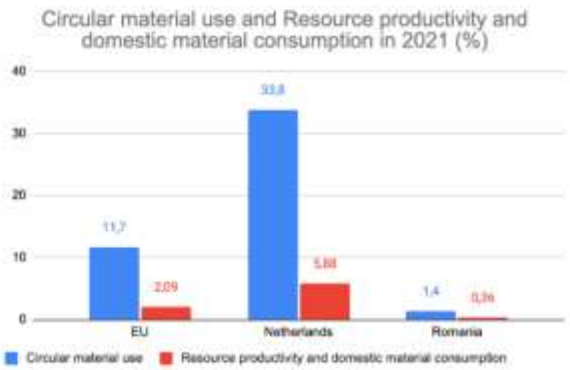

Fig. 4. Circular material use and Resource productivity and domestic material consumption in 2021 (%)
Source: [20].

Municipal waste landfill rates exceed 60%, investments in innovation and technology or human capital are very weak, and connections to circular economy specific production networks are weak or completely absent in certain areas.

In other words, on the Romanian market there are still companies that, not only have not incorporated this philosophy, but are also not oriented towards circularity except to the extent that they are obliged by the existing legal framework, which constitutes a negative factor in the evolution them and the market as a whole (Fig. 5). All the more so, since, in recent years, sustainability and circularity are concepts that have penetrated not only into the vocabulary of the business environment, but also into the actions taken.

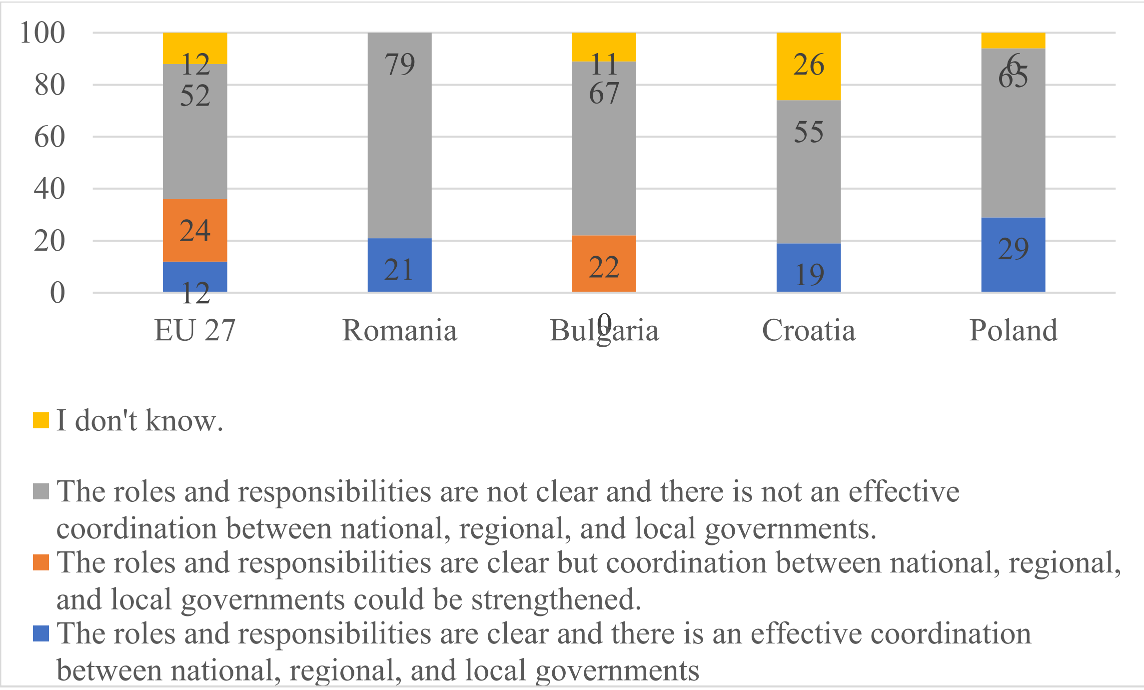

Fig. 5. Roles and responsibilities for circular economy implementation (%)
Source: Adaptation after [49].

As a result, the need to resort to circular economy strategies is more than necessary and obvious for companies on the Romanian market, which aim to participate in domestic and international economic exchanges.

From the previously presented aspects derives the need for a study, which aims to analyse the current stage of the implementation of specific circular economy strategies at the level of the domestic market. This research aims to determine the degree to which managers and specialists are concerned with the transformations of the business environment, with adaptation to market changes, with knowledge of the legislation in the field, as well as other elements.

The general objective consists in ***studying the opinion of economic agents regarding the circular economy and the challenges in implementing specific strategies on the Romanian market.***

The primary and secondary objectives can be summarized as follows:

(1)The **primary objective** of this study involves quantifying the degree of implementation of specific circular economy strategies at the level of companies operating in Romania. This means to assess the level of knowledge and implementation of the circular economy concept in practice in the country and, the degree of how the new strategic orientation of an organization to ensure coordination, integration and subordination of all company activities for customer satisfaction and sustainable development is perceived.

(2)Within the **secondary objectives**, which derived from the primary objective, the study aimed to:

-identification in each main field of activity in Romania how the concept of circular economy is known and implemented.

-emphasizing the role that organizational culture plays in implementing the circular economy at the organizational level.

-identifying in what proportion the concept of circular economy is known in the Romanian market.

-identifying which is the decision centre with the duty to develop and implement a circular economy strategy at the company level.

-quantifying in what measure the Romanian companies invest in the triad RDI- research-development-innovation, as a changing strategy within the circular economy.

-quantifying in what proportion companies are interested in circular economy strategies.

-identifying and selecting the main factors which could influence the implementation of circular economy specific strategies, in accordance with the profile of a company.

Considering all these aspects, the hypotheses of the proposed study were:

-In Romania, although there are clear and obvious concerns both in the academic and the economic environment, the application of the principles and strategies of the circular economy, with everything it entails, is limited, due to insufficient education of the business environment in this direction, the lack of budgets to support the implementation or investments in research-development-innovation or a deficient national legislation.

-most companies implement strategies specific to the circular economy in the category of those with a low or medium level of circularity.

-strategies with a high degree of circularity are implemented within medium and large companies that invest in research-development-innovation.

-the decision-making centre within companies, regarding the development and implementation of strategies specific to the circular economy, is the top management.

The study was carried out based on a survey that includes economic agents, who carried out their activity between January and February 2023. The survey carried out is simple random.

Inclusion criteria in the study:

-persons active in the economic-social environment, located in all regions of the country.

-specialists - people who have direct tangents with the studied field.

-legal entities that have expressed their desire to participate in the study.

Exclusion criteria: people who did not complete at least half of the questionnaire.

RESULTS AND DISCUSSIONS

The research undertaken and the results obtained (57 responses) made it possible to draw some conclusions regarding the degree of implementation of specific circular economy strategies at the level of Romanian companies, in the current conditions of the market economy. Thus, the results revealed the fact that, among the respondents, the vast majority are companies with private capital, Romanian or foreign, which operate mainly in Romania and the European Single Market, but also on other markets (USA or Asia).

Also, the vast majority (over 45%) are large and medium-sized companies, whose field of activity is services and trade and are in the maturity period from the point of view of the development stage, which implies a sufficient experience of great to understand the role that the circular economy plays in the development of any market.

Most of the companies under analysis have market shares below 15% and do not occupy important positions at the national level in terms of turnover, but they know their competitors very well, appreciating the level of competition on the market as very high. This can only be beneficial; the results being reflected in the quality of the products and services offered.

The company's clients are, in their vast majority, both legal and natural persons.

The **second section** presents the answers given by the respondents regarding the competitors. Thus, the majority appreciates the competitive environment as particularly strong. The respondents chose as the main sources of information regarding them, the information obtained from the mass media, the study of products/services, the analysis of the profile of actual and potential customers and their socio-demographic structure. Also, the competitive advantage of the company is seen as the low cost of the products or services offered, the level of training of the employees and the notoriety of the brands. It can be stated that the majority of respondents believe that they offer better value for money than the competition.

The **third section** refers to the organizational culture of the companies, as a support for the development of the activity. Following the results obtained, it is found that the majority of respondents know the specific values and ethics of the organization in which they work, considering that they are in perfect harmony with their own beliefs, this demonstrates the connection between the organization itself and its own employees. Also, to a very large extent, the organization is considered to offer prospects for professional and personal development.

Regarding the organization's values, the most important sources of information are regulations and periodic meetings with employees, followed by presentation websites. The future performance of the organization as a whole is obviously influenced by financial performance and adaptability to change. Human values and communication also play an important role. The prestige of the organization is given by the care it shows towards the environment, community initiatives, the importance given to ethics and financial transparency.

The **fourth section** sought to obtain answers related to the perception of the circular economy concept as an alternative to the linear model of the current economy and the extent to which this model is found in practice. Thus, the concept of circular economy is known and understood in a percentage of over 75%, companies being interested and having various concerns related to this aspect (47% of respondents); it should be noted here that the remaining 53% of respondents either believe that companies are not interested in activities specific to the circular economy, or do not know what this entails. The existence of clear strategies, specific to the circular economy, within the companies is confirmed by 24.6% of the respondents, and the decision-making centre in this regard is indicated as top management (69.6%) or middle management (26.8%), as a direct result of the fact that there are still areas/ sectors where there is no well-defined decentralization of decision centres to departments.

This confirms the hypothesis according to which the decision-making centre within companies, regarding the development and implementation of strategies specific to the circular economy, is the top management.

The main factors that prevent companies from developing and implementing circular economy strategies, as revealed by the study, are: allocated budget (46.4%), low level of education about circular economy activities (16.1%) and lack of understanding of the benefits circular economy system (14.3%). Other contributing factors are lack of experience in recycling activities, poor recycling legislation and poorly applied/implemented legislation (Fig. 6).

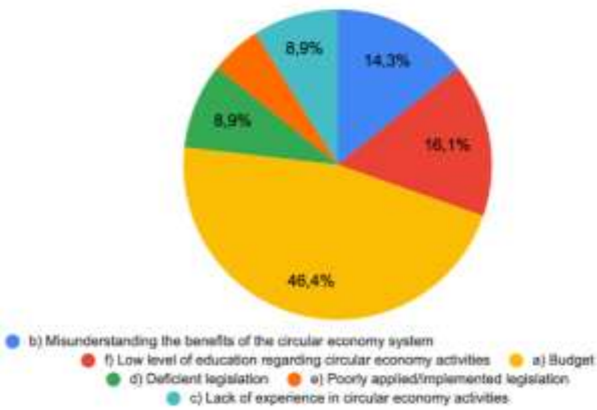

Fig. 6. Factors that influence the implementation of strategies specific to the circular economy
Source: own study based on empirical research.

We consider that this confirms the hypothesis according to which, in Romania, although there are clear and obvious concerns both in the academic and in the economic environment, the application of the principles and strategies of the circular

economy, with all that it entails, is limited, due to an education insufficient business environment in this direction, the lack of budgets to support the implementation or investments in research-development-innovation or a deficient national legislation.

The main aspects identified by respondents, regarding the actions that must carry out for applying the principles of the circular economy, have been: the reduction of the impact on the environment through the efficiency of energy consumption (60%) and the use of renewable energy sources (10%), repair (6,7%), recycling/recovery (13.3%), reuse (10%). ***Thus, the hypothesis according to which most companies implement strategies specific to the circular economy in the category of those with a low or medium level of circularity is confirmed (Fig. 7).***

Also, in the case of companies that implement strategies specific to the circular economy, it is noted that strategies with a low degree of circularity, aimed at reducing, for the most part, the impact on the environment, are most often used, regardless of the size of the company (Fig. 8).

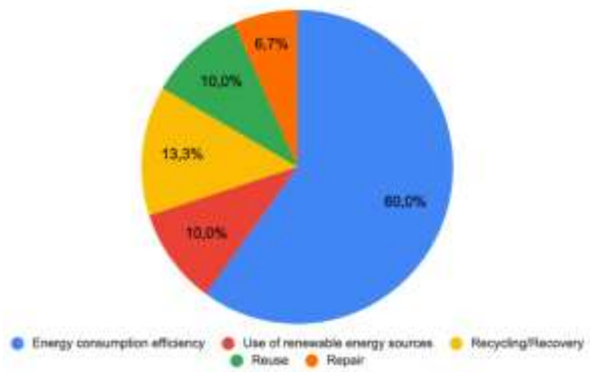

Fig. 7. Actions that can be found in the concerns of companies in the direction of applying the principles of circular economy
Source: own study based on empirical research.

At the same time, strategies with a medium degree of circularity, such as those aimed at reuse and repair, cannot be said to be specific only to large companies, as the study shows that smaller companies are also interested in this aspect.

Regarding strategies with a high degree of circularity, they are chosen by medium and large companies that also invest in research-development-innovation. We can say, therefore, that ***the hypothesis according to which strategies with a high degree of circularity are implemented within medium and large companies that invest in research-development-innovation is confirmed.***

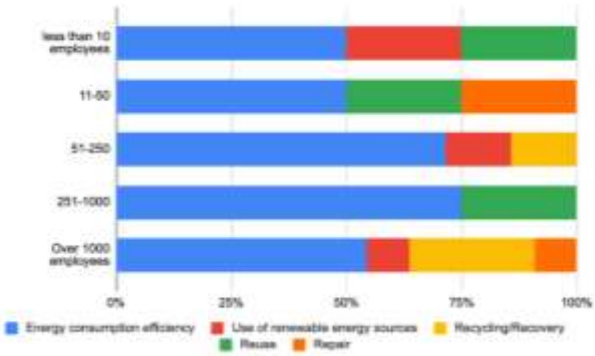

Fig. 8. Distribution of responses regarding the preference for a particular type of circular strategy by company size
Source: own study based on empirical research.

Investments in research-development-innovation are the basis of the transition to the circular economy. In the case of the companies in the study, just over half (52%) of them invest in research-development-innovation, as a necessity regarding the transition to circularity. The companies in this category are, as a rule, of medium to large size, and the distribution of investments, according to the structure of the social capital, is presented in Fig. 9.

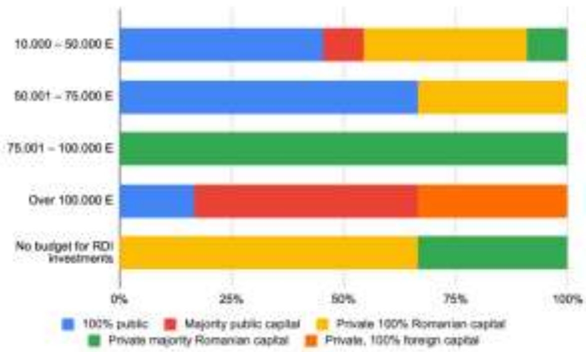

Fig. 9. Distribution of companies that invest in RDI according to the structure of the social capital
Source: own study based on empirical research.

Companies that have budgets greater than 100,000 euros for research-development-innovation investments are mainly state-owned or majority-owned or foreign-owned companies that know the advantages of such an approach. These companies are, as I stated, in their vast majority, of medium to large size, with a well-developed organizational culture and with an obvious orientation towards sustainability in the activity they carry out.

CONCLUSIONS

Shifting to a circular economy model is the most recommended solution to many of the today's environmental problems, although the costs are extremely high. Handled carefully, however, it would be the best chance for economic and industrial regeneration.

The instability of the international environment makes it difficult to change, for now, the perspective on the role and importance that the circular economy should have in the life of an organization.

Our research study revealed that, on the Romanian market, although the companies and institutions are familiar with the circular economy concept, there is still a long way to undertake until the concept would be fully applied.

The main setbacks are correlated with small to non-existing budgets for investment in research and innovation for most companies, a low level of education in this area and lack of understanding completely the benefits circular economy system.

The poorly applied legislation or even the lack of it, for some sectors of the economy, also influence the orientation towards circularity.

However, there are companies on the Romanian market that have understood that they must change in order to face the new challenges that constantly appear, regardless of their nature, and to be able to compete successfully on international markets.

Those companies have a strong organisational culture and care about the environmental problems, are involved in community initiatives and consider that ethics and financial transparency are mandatory in their activity.

At the level of the single European market, although the concern regarding the transition to the circular economy is clear and obvious, solutions must be found to reduce the gaps between the different member states, by increasing the degree of circularity in the case of the states at the bottom of the ranking (in this case, Romania).

This can be achieved through a series of measures adopted primarily at the national level, such as the development of strategies specific to the circular economy, where they do not exist or are underdeveloped, calling on specialists for the creation and implementation of a sustainable development vision, designing specific programs, implementing them and evaluating the results on a realistic basis, are just some of the recommendations that can be made.

Obviously, it is not solely up to companies to change their vision and certain mentalities, public institutions also play a decisive role. Changing the legislation to support investments in research-development-innovation by granting aid or tax exemptions (within the limits allowed, however, by the European Union, to create a fair competitive climate), giving up bureaucracy and setting up the infrastructure would encourage investors foreigners and, for that matter, any company that has activities here.

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A STATISTICAL STUDY ANALYSIS ON EXPLORING CONSUMPTION PATTERNS REGARDING FOOD LOSS AND WASTE

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Abstract

Food loss ans waste, referred next as FLW, has a great extent on the economic and behavioural patterns of consumption. In this paper, we aim to present statistical univariate and multivariate analyses based on a statistical study run during a period of several months in the Romanian territory. In this matter, the main purpose of the analysis developed in this paper is to determine several patterns of FLW phenomenon. This is made based on a methodology which comprises two main sections: the univariate analysis, consisting in statistical determinations of indicators and direct observation, and the multivariate analysis, related to the clustering analysis. The clustering analysis is based on the usage of hierarchical method, which has as final result the determination of clusters describing patterns of consumption related to food loss and waste. After the analysis was run, five main clusters related to food waste behaviour patterns were determined, with slight differences between food consumption habits, but with various combinations between the parameters taken into consideration. The obtained clusters offer important information for policymakers and stakeholders aiming to customize interventions and programs to target specific demographic groups or segments of the population.

***Key words**: food waste and loss, clustering, consumption pattern, Romania*

INTRODUCTION

Food loss and waste (FLW) represent a significant issue with far-reaching implications on both economic and behavioral aspects of consumption patterns [9]. FLW not only impacts the financial bottom line but also reflects broader societal trends [12] in how food is produced, distributed, and consumed [1]. Understanding the dynamics of FLW is crucial for addressing sustainability challenges and improving resource efficiency in the food supply chain [8, 10].

In this paper, we delve into a detailed analysis of FLW, focusing particularly on its prevalence and patterns within the context of Romania. Over the course of several months, we conducted a comprehensive statistical study covering various regions of the country. Our objective is to provide insights into the nature of FLW phenomenon and identify key trends and patterns.

MATERIALS AND METHODS

The characteristics of the statistical study

The main data used in the analysis which will be presented further in detail was obtained based on a statistical study. The study has several specific characteristics, such as the purpose, the methodology, the target group and the measurement instruments.

The purpose of the study was related to the investigation of the consumer behaviour related to food loss ans waste. The final aspects of the study were also related to suggesting countermeasures and prevention actions for FLW.

The main measurement instrument was a statistical questionnaire, which included as core features open and choice-based questions related to food consumption behavioural aspects.

The target group was considered to be formed of adults of various age groups and socio-economic environments. The online distribution of the questionnaire to the sample group also led to a relatively even geographical distribution of the responses.

The methodology of the study comprised of several phases:

(1)The questionnaire design: this phase consisted in the creation of the development of an online questionnaire composed of structured questions to assess food shopping frequency, storage methods, awareness of food waste, and other relevant factors.

(2)The sampling process: the sample group was selected through a convenience random sampling method, resulting in a sample volume of 364 respondents.

(3)The questionnaire implementation: The questionnaire was distributed online through a number of social media platforms and via email to a diverse sampling of participants from various geographic regions, delimited by the development regions of Romania (NUTS 2-level divisions).

The study also took into account ethical procedures; thus, the anonymity and the confidentiality of the respondents was ensured. In the end, several limitations were also delimited, including possible problems of sample representativeness and subjective reporting of consumer behavior related to food waste.

The analysis methodology

For this analysis, the determination of patterns was considered to be completed as several clusters which describe consumption patterns of respondents related to FLW were aimed to be generated. In this matter, we will establish the main methodology based on two main components: the univariate analysis and the multivariate analysis.

Regarding the univariate analysis, the main purpose is related to the description of the main indicators taken into account in the analysis in order to draw several preliminary conclusions of the study. The analysis starts by describing the independent variables in the questionnaire, such as the frequency of responses and their distribution. In this phase, tables, graphs, and measures of central tendency (such as median, mean) and dispersion (such as standard deviation) are determined to illustrate and interpret this data.

As for the multivariate analysis, the main purpose is to identify and establish correlations between several indicators, in order to define patterns within the responses and to extrapolate based on the sample. The method used for the multivariate analysis is the Hierarchical Cluster Analysis (HCA) method [4, 13]. The phases used for the multivariate analysis methodology are related to:

(1)The selection of the variables: the variables that were taken into consideration were:

(a)the food purchase frequency (FPF), determined as the number of food purchase events per month;

(b)the amount of money used for food purchase (FPM), expressed in lei per month;

(c)the cause of food waste (FWC), as grouped by categories;

(d)the perceived percent of food thrown away monthly (FWP);

(e)the responses to specific affirmations: „At the end of a meal, I throw away leftovers.” (A1); „I freeze the leftovers from the meal and will eat them later or prepare other products from them.” (A2);„The leftovers from the table are used in pet food.” (A3);„I check the expiry date of the food at the time of purchase and will buy products with a longer shelf life.” (A4);„I do selective recycling.” (A5), with three possible answers: „Frequently”, „Rare” or „Never”.

(2)The encoding of data: the variables are encoded for integers. Thus, all the variables were transformed in numerical data using the Ordinal Encoding (OE) method (map values to integers).

(3)The choice of clustering method: the specific methods taken into consideration were the HCA method and the DBSCAN approach. The HCA method was chosen for the specific set of data.

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(4)The determination of the optimal number of clusters: this will be made based on the specific method of HCA called dendrogram cut.
(5)The run of clustering algorithm: the steps of the algorithm will be presented further.
(6)The interpretation of the results: the generated clusters and their main characteristics will be presented.
(7)The validation of the clusters: this will be made using dendrogram analysis.
The HCA approach consists in the development of several steps:
(1)The determination of the distance matrix: a matrix of distances between all pairs of observations in the data set is computed. Distance will be calculated using a metric such as Euclidean distance.
(2)The determination of the dendrogram: the distance matrix is used to construct the dendrogram, which is a graphical representation of the similarity relationships between observations.
(3)The cutting of the dendrogram: cutting dendrograms at a certain height allows the determination of a specific number of clusters. This can be done by selecting a cut height that separates the dendrogram into an appropriate number of clusters, based on criteria such as maximizing the inter-cluster distance or analyzing the structure of the dendrograms.
(4)The final clustering: based on the selected cut height, each observation will be classified into a corresponding cluster.
Using the specified approach, the final result will consist in the clusters obtained, which will be defined by specific characteristics of the variables taken into account.

RESULTS AND DISCUSSIONS

The univariate analysis

For the univariate analysis, we will determine specific observations related to several indicators extracted from the responses of the sample participants. Firstly, we will present them.
The presentation starts with the demographic data of the respondents. Fig. 1 presents the data related to age group.

We can observe that the majority of the respondents (approximately 73%) are part of the 18 – 35 years age group.

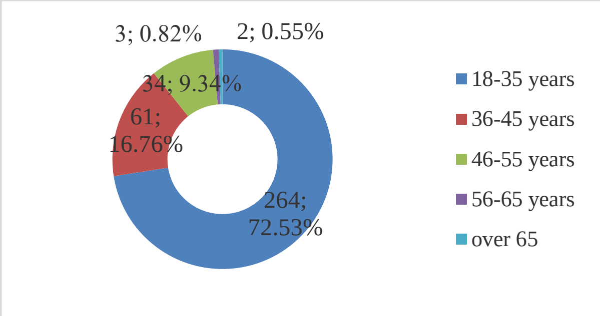


Fig. 1. The classification of respondents by age group
Source: data processing from online questionnaire.

Next, Fig. 2 presents the data related to gender.

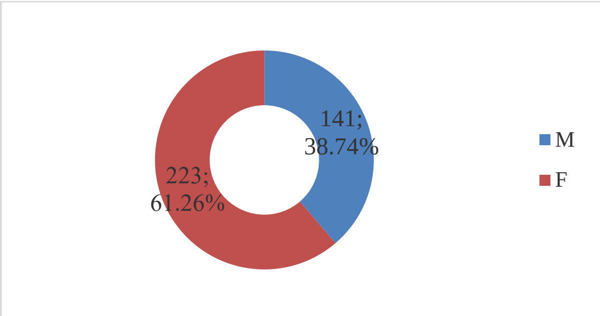


Fig. 2. The classification of respondents by gender
Source: data processing from online questionnaire.

The structure of the respondents related to gender shows a balanced proportion of responses, slightly higher for the feminine respondents.
Next, Fig. 3 presents the data related to the latest form of education of the respondents.

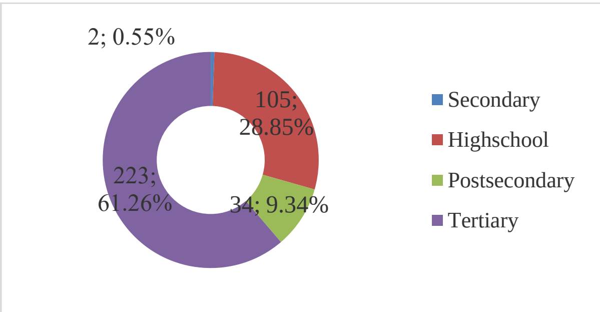
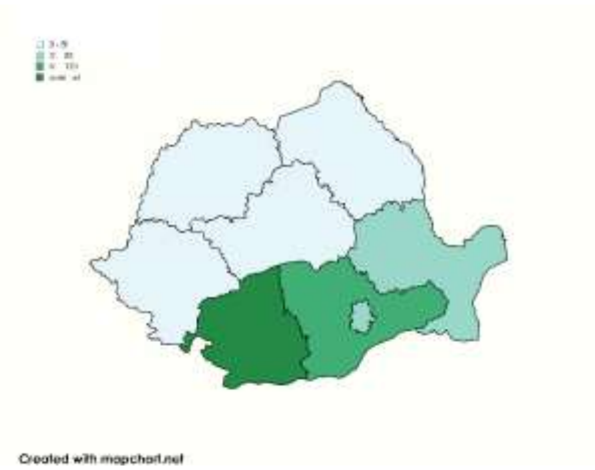


Fig. 3. The classification of respondents by latest form of education
Source: data processing from online questionnaire.

We can observe that the majority of the respondents has as latest form of completed education tertiary levels, related to university

education (e.g., bachelor's degree, master's degree).
Next, Map 1 presents the data related to the geographical distribution of the respondents.



Map 1..The classification of respondents by NUTS-2 regions
Source: data processing from online questionnaire.

We can observe that the majority of the respondents, approximately 50% of the respondents (171 responses), is established in RO41 region (South-West Oltenia Region). Next, Fig. 4 presents the data related to the socio-professional status of the respondents.

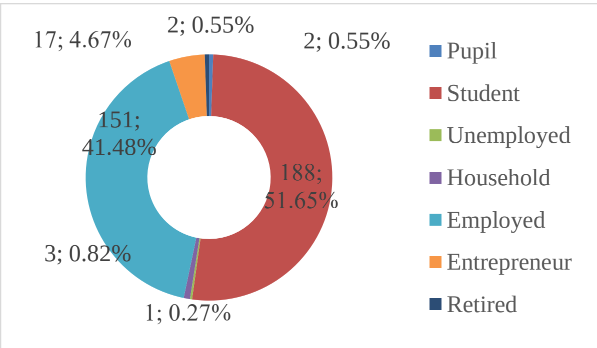


Fig. 4. The classification of respondents by socio-professional status
Source: data processing from online questionnaire.

We can observe that the main socio-professional statuses of the respondents are related to studentship (in a higher form of education) and employed.
Next, 5 presents the data related to the income of the respondents.

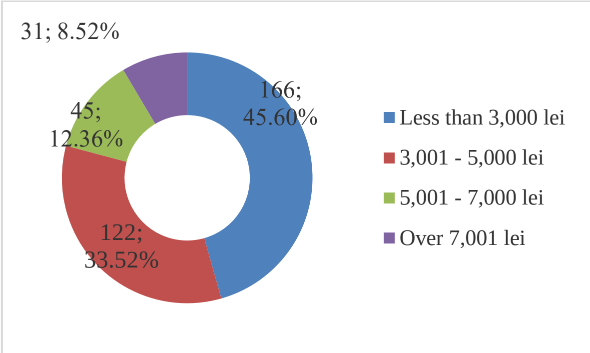


Fig. 5. The classification of respondents by income
Source: data processing from online questionnaire.

We can observe that the main two categories of income of the respondents are related to a medium level, between 3,000 and 7,000 lei. Next, 6 presents the data related to the residence of the respondents.

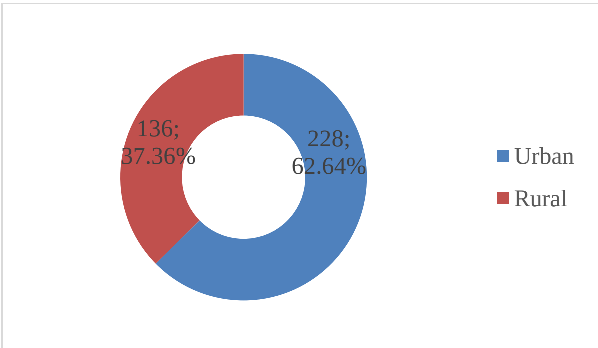


Fig. 6. The classification of respondents by residence
Source: data processing from online questionnaire.

We can observe that a slightly majority of the respondents is established in the urban environment (approximately 65%).
Next, Fig. 7 presents the data related to the frequency of food purchase events of the respondents.

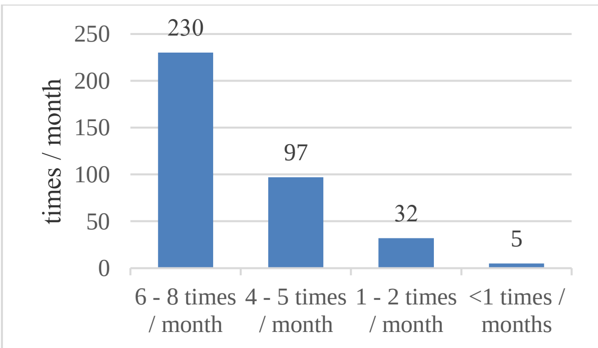


Fig. 7. The frequency of food purchase events
Source: data processing from online questionnaire.

We can observe that many respondents have a frequent habit of buying food, resulting a predominant frequency of 6 to 8 food purchasing events per month.
Next, 8 presents the data related to the amount of financial resources spent monthly on food.

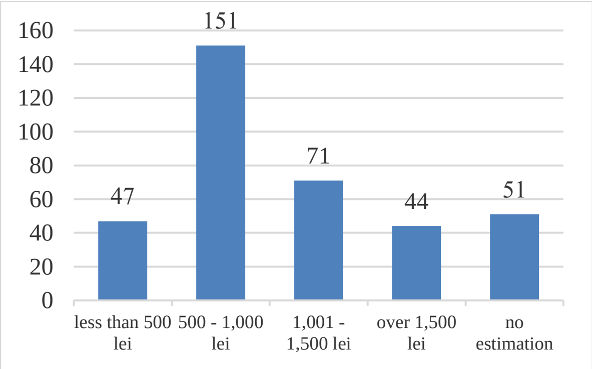


Fig. 8. The amount of money spent on food monthly
Source: data processing from online questionnaire

The majority of the respondents spend an amount of money between 500 and 1,000 lei per month on food, with sensibly equal amount of money for other categories, including the respondents that could not estimate the sum spend monthly on food. Regarding the causes of food waste, Fig. 9 presents the data related to the main causes of FLW identified among the respondents.

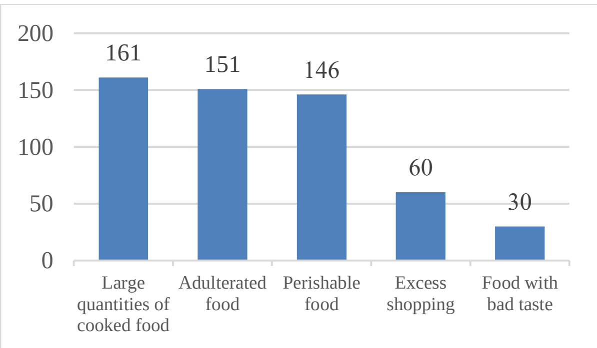


Fig. 9. The main causes of the food waste identified among the respondents
Source: data processing from online questionnaire.

The three main causes chosen by the respondents were related to the large quantities of cooked food, the perishability of the food and the natural processes of the degradation of the food that is not consumed. Next, 10 presents the data related to the perceived amount of food waste rationed by the total amount of purchased food.

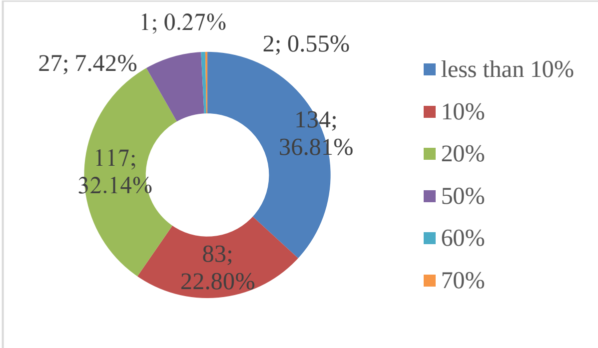


Fig. 4. The perceived percent of food waste monthly
Source: data processing from online questionnaire.

The majority of the respondents (over 90%) perceived the amount of wasted food between none and 20% of the total amount of purchased food, with two thirds of this majority perceiving the amount below or equal to 10%.
Finally, 11 shows several responses given to specific affirmations regarding food waste.

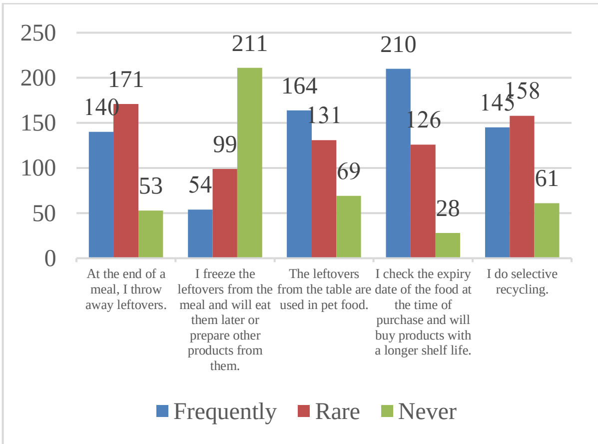


Fig. 5. Responses given to specific affirmations related to food waste
Source: data processing from online questionnaire.

As we can see, the respondents seldom throw away leftovers at the end of the meal. Regarding later usage of the leftovers, a large majority never freezes them in order to reuse them. A large part of the respondents uses the leftovers for the pets in the household and many respondents try to avoid food waste by purchasing food with a larger shelf time. Finally, the respondents do selective recycling of the food rarely to frequently.
As a preliminary conclusion, the profile of the respondent comprises the next demographic and behavioural patterns: the main age group

is between 18 and 35 years, mainly with studies up to tertiary education. Also, the majority of the respondents were concentrated geographically in the NUTS-2 regions South-West Oltenia and South. The main socio-professional statuses are related to employed people and students, with predominant incomes between 3,000 and 5,000 lei or under 3,000 lei. Also, a slight majority of the respondents have the residence in the urban area, with a frequent habit of purchasing food with a frequency of 6-8 times per month. The main amount of money used to purchase food is situated between 500 and 1,000 lei. The main self-identified causes of food waste are large quantities of purchased food and the perishability character of food, with a perceived amount of food waste up to 20%. Finally, respondents have a frequent habit of reusing leftovers, either by preservation or consumption by pets. Also, the respondents have a frequent habit of purchasing food with a higher expiry date and do selective recycling of food.

The multivariate analysis

The methodology presented in the previous sections regarding the multivariate analysis was conducted on the resulted data. The enumerated variables were encoded using two methods: categorical encoding, in case of questions with unique answers, and One-Hot Encoding (OHE) [6], related to multiple-choice answers. For the latter case, each choice was encoded with binary data (digits 0 and 1), 0 having the significance of not being chosen and 1 otherwise. Regarding the variables denoted by A#, the encoding was made by the response given by the user (0 – Never, 1 – Rare, 2 – Frequently). The encoding results are shown in **Error! Reference source not found.**.

Table 1. The variable encoding chart

No.	Variable		Abbreviation	Possible values set
1.	The food purchase frequency		FPF	{1..4}
2.	The amount of money used for food purchase		FPM	{1..5}
3.	The cause of food waste – choice	Excess shopping	FWC - 1	{0,1}
4.		Perishable food	FWC - 2	{0,1}
5.		Food with bad taste	FWC - 3	{0,1}
6.		Adulterated food	FWC - 4	{0,1}
7.		Large quantities of cooked food	FWC - 5	{0,1}
8.	The perceived percent of food thrown away monthly		FWP	{1..6}
9.	„At the end of a meal, I throw away leftovers."		A1	{0,1,2}
10.	„I freeze the leftovers from the meal and will eat them later or prepare other products from them."		A2	{0,1,2}
11.	„The leftovers from the table are used in pet food."		A3	{0,1,2}
12.	„I check the expiry date of the food at the time of purchase and will buy products with a longer shelf life."		A4	{0,1,2}
13.	„I do selective recycling."		A5	{0,1,2}

Source: own processed data.

After the encoding, the values were used in the HCA approach of clustering.

A specific Machine-Learning based software was used (Orange [3]).

Various results were obtained, with the main results being the dendrogram chart, which is presented in **Error! Reference source not found.** and shows the main clusters obtained after the data analysis.

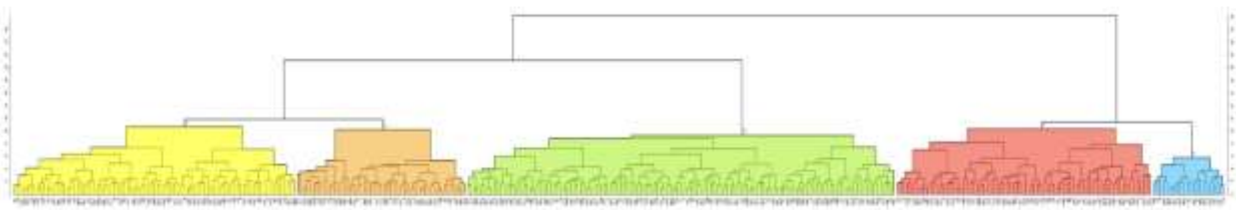


Fig. 12. The obtained dendrogram for the variables taken into account

Source: Own determination.

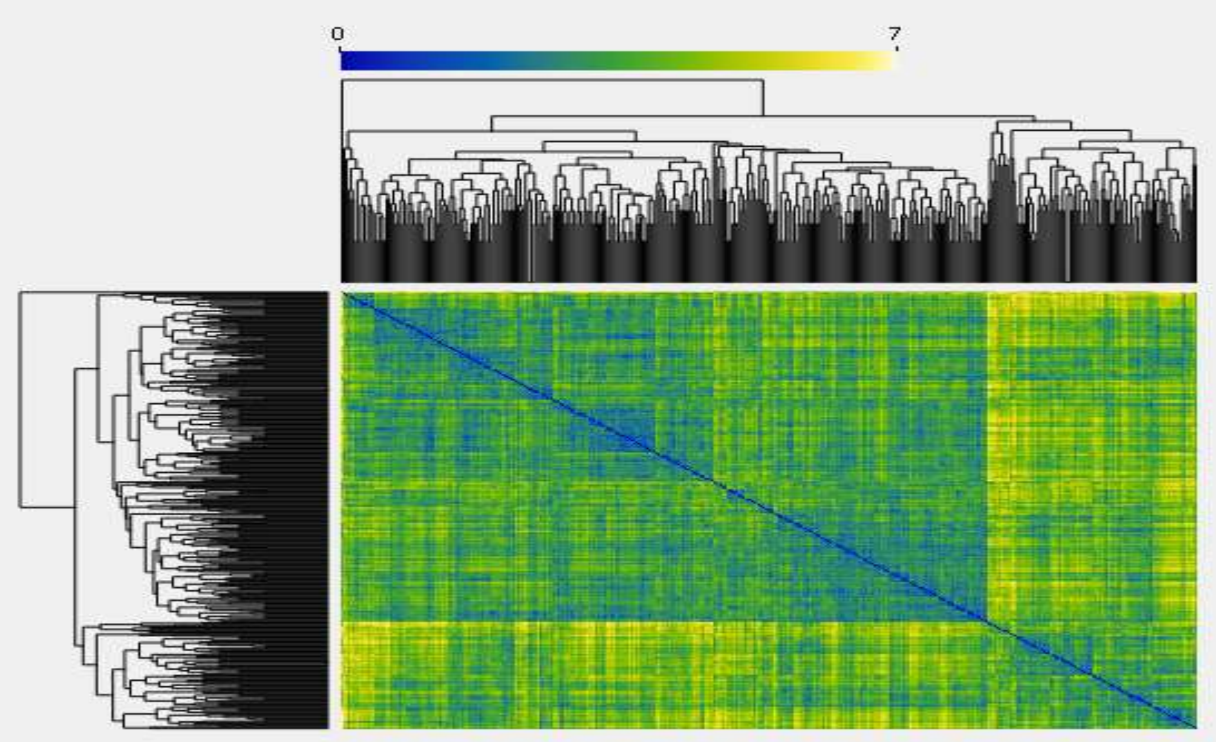


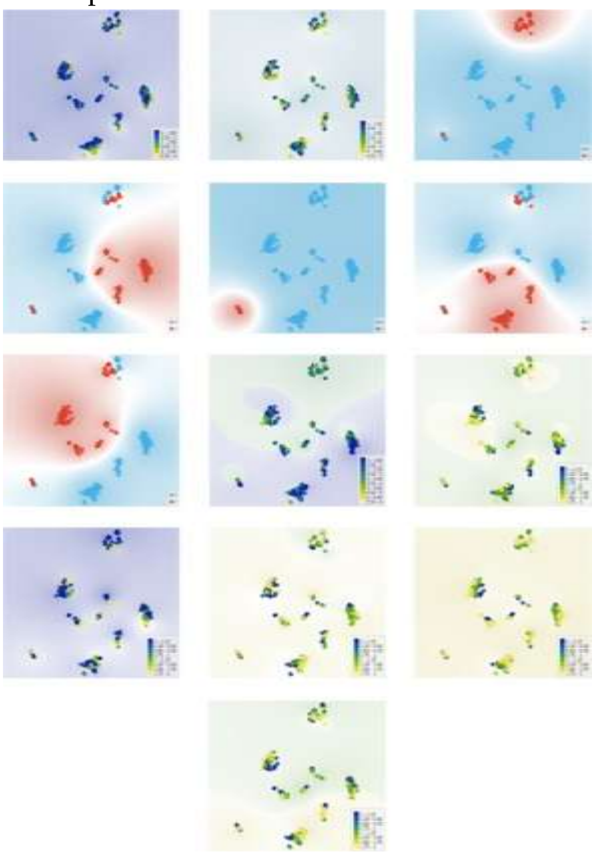
Fig. 13. The distance map correspondent to the obtained distance matrix
Source: own determination.

The distance matrix, whose corresponding distance map is presented in the next Figure 13 presents the corresponding distance map which determines the differences between each response.

Also, a Louvain clustering algorithm was applied and 8 clusters were obtained automatically. A Louvain clustering algorithm is a graph clustering method used to identify communities or groups of nodes with greater connectivity to each other than to nodes outside the group in a graph [2].

Further, an empirical DBSCAN analysis (i.e., an alternative method of clustering) [5] was run. A detailed analysis of the appliance of this method will be detailed in future papers. After the run of the analysis, two main clusters were obtained.

For a more detailed and visually-aid analysis of data, a t-SNE (t-Distributed Stochastic Neighbor Embedding, i.e., a dimensionality reduction and data visualization technique [14]) was used (perplexity of 30, exaggeration of 2 and 13 PCA components). Usually, a t-SNE analysis is made in order to reduce the multi-dimensional character of the data in a 2D space. The results are shown in



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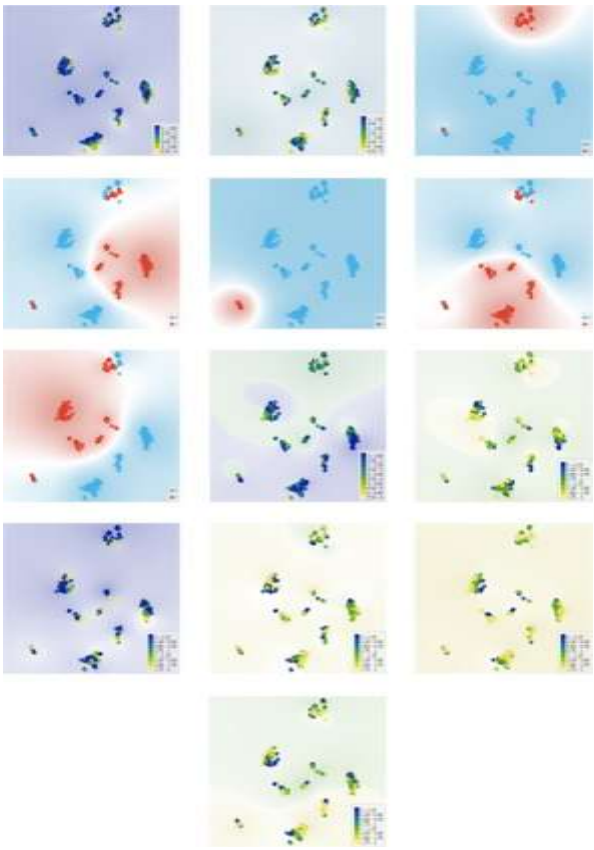

Fig. 14. The t-SNE data visualisations by variables (in order, FPF, FPM, FWC1-FWC5, FWP, A1-A5, clusters)
Source: data processing from online questionnaire.

The data was obtained after the appliance of the distance matrix calculated using Euclidean distance [9] and the options of the dendrogram were considered as shown in **Error! Reference source not found.**, with no pruning appliance (i.e., taking into account all input data, with no filtering process) and the manual selection of the number 5 for the cluster. The number was chosen after a process of direct observation, with a purpose of a balanced set of obtained clusters. Finally, the method chosen for the linkage was the Linkage Ward [7], which is a linkage method used in agglomerative clustering, a type of hierarchical clustering. This method focuses on minimizing the variation within the clusters formed at each step of the clustering process.

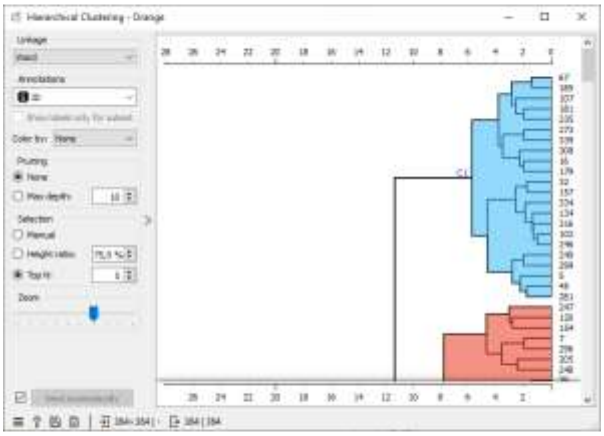

Fig. 15. The HCA parameters in the software
Source: data processing from online questionnaire.

Based on the results, five clusters of responses were obtained. The description of the clusters is made in the next paragraphs.

The C1 cluster (the hungry caring spenders), coloured in blue in the dendrogram, contains 22 respondents. This cluster is characterized by respondents which buy very frequently food (6-8 times per month), who cannot estimate the amount of money used for food purchasing, with a perceived amount of food waste under 10% of purchased food, with an antagonist behaviour related to food waste reuse, as they rarely throw away leftovers and use them predominantly for pets. They are more inclined to purchase food with longer shelf life and do more often selective recycling. As for the main cause of food waste identified by this cluster, the process of food adulterating after being cooked (FWC – 4) was one of the most predominant.

The C2 cluster (the unpredictive frequent food buyers), coloured with red in the dendrogram, is formed of 77 respondents. These respondents are frequent buyers of food (6-8 times per month) and the amount of money spent on food is either above 1,500 lei or cannot be estimated. The perceived amount of food waste is estimated to be between 10% and 20% of the purchased food. Also, they are throwing away leftovers at a moderate frequency (rare or frequently), but the ones that are not thrown away are preserved and used with a large probability in future meals or less probably for pets. They are also inclined to purchase products with longer shelf life and have an unpredictive behaviour related to selective recycling. The main identified causes for the food waste for this cluster were the perishability of the food or large quantities of cooked food which were not consumed.

The C3 cluster (the balanced no-left over purchasers), coloured with green in the dendrogram, is formed of 129 respondents. They also buy very frequently food (6-8 times per month), with a monthly food budget mainly situated between 500 and 1,000 lei. They perceive to waste approximately 20% of the purchased food. They rarely of frequently throw away leftovers and they almost never preserve them in order to reuse. The food waste is rarely or frequently used for pets. Also, they are extremely inclined to buy food with longer expiry dates and their tendency to do selective recycling is moderate. The main causes selected for food waste were determined as large quantities of cooked food which is then altered.

The C4 cluster (the less-hungry non-waster wasters), coloured in orange in the dendrogram, contains 51 respondents. The frequency of their purchase events is unpredictively situated between 4 and 8 times per month, with a food budget below 1,000 or even 500 lei per month. They perceive to waste food in a proportion of less then 10% of the purchased food products. They rarely or frequently throw leftovers and they almost never preserve them for reuse, the ones that eventually are not thrown are used as pet food. In order to limit the food waste, they are also inclined to buy food which lasts longer, as they have unpredictive behaviour related to selective recycling, made rarely or frequently. The main cause of food waste is considered to be the food alteration after large quantities of it were cooked.

Finally, the C5 cluster, (the uncertain food habit consumers), coloured in yellow in the dendrogram, contains 85 respondents. The majority of the respondents also buy food very frequently (6 to 8 times per month), with a budget situated with a greater probability between 500 and 1,000 lei, rarely up to 1,500 lei. They claim to waste food to a proportion closer to 10%, with tendencies up to 20%. They tend to keep leftovers, rarely throwing them away, with a totally unpredictive behaviour related to their preservation. There may be a higher chance of using them as pet food. Most commonly, food with longer availability periods is chosen, with an uncertain behaviour related to selective recycling, but more inclined to have habits related to this process. The main causes related to food waste are selected to be food categories that are easily perishable.

In conclusion, food waste is a generalized phenomenon in Romania, but with very specific aspects related to food waste patterns among the consumers.

CONCLUSIONS

The findings presented in this paper shed light on the intricate dynamics of food loss and waste (FLW) within the Romanian context, offering valuable insights into its prevalence, determinants, and potential interventions. Through a comprehensive statistical analysis spanning several months, we have identified several key patterns and trends that characterize FLW behavior in the country.

One of the key contributions of our analysis is the identification of distinct clusters representing different consumption patterns related to FLW. Through hierarchical clustering analysis, we have delineated several clusters that capture the diverse range of behaviors and attitudes towards waste within the Romanian population. These clusters provide valuable insights for policymakers and stakeholders seeking to tailor interventions and initiatives to specific demographic groups or segments of the population.

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RESEARCH ON THE INFLUENCE OF FEED RATION ON THE PRODUCTIVITY OF THE HOLSTEIN-FRIESIAN BREED IN INTENSIVE FARMS IN SOUTH-EASTERN ROMANIA, CASE STUDY

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Abstract

Cattle breeding is a very important branch of agriculture because it provides a large volume of animal products needed by humans, a large share of raw material for the food industry and light industry. The achievement of increased production and higher quality in line with market requirements is the focus of livestock specialists who, through their research work, contribute to the improvement and refinement of breeding, maintenance, feeding and breeding technologies. The present study aimed to analyse the influence of the feed ration administered to cattle, in a dairy cow breeding farm in the South-Eastern Romania, on milk production but also the economic calculation of feed costs to obtain one litre of milk. The ration is designed and formulated according to the needs of the cattle categories, their health, productive performance and age.

Key words: *dairy sector, fodder ration ,milk cost, productivity, price*

INTRODUCTION

Milk is an important component of the human diet [9], dairy products are vital sources of nutrition (OECD-FAO, 2022) with implications for health [1, 4, 8], it also indicates the development level of a country [1, 2, 24].

Liquid milk value have the largest share on the dairy market [3, 5, 7]. The EU is one of the most important milk producer in the world and in 2022, it carried out 159.34 million tonnes raw milk, of which 154.3 million tonnes (96.43%) came from cows. Milk is produced in each member state, but the top producers are Germany, France, Poland, Netherlands and Italy and the lowest one Malta. Cow milk delivered to dairies accounted for 145.6 million tonnes, meaning 97.13%, the rest being supplied by buffaloes, sheep and goats [5, 7, 17]. Romania is situated on a lower position in the EU, producing a smaller milk amount for consumption (400 thousand tonnes). [16, 20, 21, 24].

Milk is a basic food and also a strategic food for the whole population of the world [1, 15]. About 6 billion people, that is more than 80 percent of the world's population, regularly consume fresh milk or other dairy products [3, 7, 16]. Milk and dairy products have a high nutritive value being an import source of protein and lactose, a large variety and minerals and vitamins, and this is a reason to be more and more produced [9, 13]. Dairy cows are responsible of the highest part of milk produced in the world. From 996.36 million cattle population existing in the world in 2018, about 270 million are dairy cows [27, 9]. The EU is an important contributor to the world milk production and dairy farming and processing is an important sector in the EU agriculture and food industry [20, 21, 22]. Europe produced 226.4 million tonnes of milk, representing 26.8 % of the world production, and by 0.9 % more than in 2017 [20]. The EU-28 contributes by 28 % to the world milk production, coming on the 2nd position after Asia (30%), and being followed by Americas (27%), other European countries (9%), and Africa and Oceania, each with 5 %. Milk production is stimulated by the population and consumption growth [5, 7, 22]. In the E.U. countries the current trend is to reduce the number of cattle and compensate for animal production by increasing production, using modern breeding methods and improving exploitation technologies. As a result, world agriculture has seen a development in all fields in recent years, marked by a process of intensification, specialization by branch, concentration on production direction, increase in labor productivity, reduction of specific consumption [13, 15, 16, 17].

Milk production is a long traditional activity in Romania [4, 8]. The percentage of milk delivered to processors decreased because only a few farms managed to cover the EU requirements regarding the production and quality of the delivered milk.
[13, 19, 20].

The reasons why Romania was a modest milk producer are: a big number of small holdings, the decreasing number of milking cows, the low number of dairy cows per farm, extensive technologies, difficulties in assuring a normal feeding, high production cost, low producer's price, problems with milk quality. All these reduced the profit obtained and reduced the interest of the Romanian farmers.During the interval 2018-2022, in Romania , the evolution of the cattle herd was in decrease. [14, 15]. For this reason, in order to cover the needs of the population, it was necessary to import both, milk and dairy products. [19, 22, 24]. The highest proportion of milk comes, in Romania, from dairy cows [8, 16].

In Romania, the highest contribution at milk production are in the Central region and North East region. For fresh dairy products, the Central and South Muntenia and Bucharest and Ilfov County are the most important. The areas where the largest amount of cheese is produced are North-West, Central and North Eastern Romania [2, 22, 24].

Milk production cost is influenced by a large range of environment factors, but the main ones are represented by feeding cost, labor cost, heifer for replacing the culled cow, medicines and veterinary services, frozen semen from the highest breeding value bulls and artificial insemination service, depreciation of sheds and specific equipment, water and electricity cost, rental value of land owned by dairy farmer [1, 2, 6, 23].

The highest share in milk production cost is represented by feeding, labor and veterinary services cost [10, 15, 23] The basic food in animal feeding is corn, either as concentrated feed or as corn silage during the winter [10, 18, 21].

Provided the imperative implementation of sustainable development, the improvement of the forage quality for silo maize is a major objective [11, 12,18].

In Romania, maize occupies the largest grown area due to its high productivity and high yields per unit area [10,11,18]. The area grown with maize varies between 2.5-3.1 million ha depending on the level of precipitation in the cold season or as a result of the compromise of the autumn crops during the winter [10,11,12].

Among environmental factors, nutrition is the basic factor (60-70% of all factors) influencing milk production. Using well-balanced rations, satisfying the nutritional requirements of cows always have a positive effect on productivity [10, 11, 12].

Insufficient level as well as overfeeding negatively influence milk production.

In this context, the goal of the paper is to study the influence of the feed ration administered to cattle, in a dairy cow breeding farm in the South-Eastern Romania, on milk production but also the economic calculation of feed costs to obtain one litre of milk

MATERIALS AND METHODS

The case study was carried out at one of the competitive agricultural companies in Călărași County, at the contact area between the Bărăgan Plain and the Danube Valley, more precisely at the eastern limit of the second terrace of the Danube. During 2022, the structure of feed rations, the quantities fed per day and per total period, and the cost of obtaining a litre of milk were monitored.

The exploited breed is the *Holstein Friesian* known as the most productive but demanding dairy breed. If a balanced ration and good management is not provided, health problems can easily occur. The breed originates from the Netherlands and is black and white in colour. However, through the improvement process, the white and red and uniform red colour has subsequently appeared. On intensive farms where feeding is carefully monitored and stress is reduced, the Holstein Friesian breed can reach a productivity of 10,000-13,000 litres of milk/lactation (lactation = 305 days) and if no attention is paid to feeding, productivity can drop below 5,000 litres/lactation.

Table 1 shows that the farm has a total of 406 livestock units, of which more than 50% are dairy cows.

Table 1. The structure of cattle livestock in 2022

Cows prod. > 25 litres	Cows prod. <25 litres	Heifers + Weaned cows	Calves 0-6 months	Young female cows 6-18 months	Total
126 LSU	90 LSU	67 LSU	58 LSU	65 LSU	406 LSU

Source: company documents

**LSU = livestock unit*

RESULTS AND DISCUSSIONS

The animals are provided with fodder twice a day, consisting of grain maize, barley grain, wheat grain, peas, wheat bran, which are ground in the single feed technology trailer (Table 2).

In addition to these grains, maize silage, alfalfa hay and wheat straw are also fed into the technology trailer. Watering is done automatically through constant level watering troughs, so the animals have water at their discretion.

Calves are suckling twice a day. Calves are fed on powdered milk until they are three months old. Until weaning, calves are kept in four-units collective stalls respecting the rules of animal welfare, watering and feeding at discretion.

Table 2. Total feed consumption during 2019-2022 (tonnes)

Item no.	Product	2019	2020	2021	2022
1	Barley	260	256	301	252
2	Maize	320	350	370	277
3	Peas	137	128	120	131
4	Maize silage	2,700	3,300	3,580	3,400
5	Alfalfa	300	490	310	450
6	Wheat bran	60	52	75	30
7	Wisan	138	166	140	143
8	Panto R-60 (premix)	13.62	14.4	14.7	14.84
9	Panto R-56 (premix)	2	1.4	1.75	0.6
10	Power mix (premix)	10	11	18	21
11	Calcium carbonate	8	8	6	5
12	Ascomilk (milk powder)	6	8	7	7
13	Wheat	123	123	126	131
14	Straw	180	178	182	185
15	**Total consumption**	**4,257.62**	**5,085.8**	**5,251.45**	**5,047.44**

Source: Own calculation based on the company documents.

During the first 20 days, the calves are disbudded and tagged. Special attention is paid to the dry period because it is very important both in the growth and development of the calf and in the milk production of the future lactation. The optimal dry period is 60 days.

Feeding cows during the first dry period is based on a ration with more fibrous and juicy feed, about 1/3 dry matter. In the second part of dry period, the ration is supplemented with mixed feed. Cows having calved are kept together with calves until 7 days of age, then transferred to the group of lactating cows >25 litres and the calves go to the nursery group.

Table 2 shows that the largest amount of feed consumed during the period analysed is corn silage, which is also the basic feed in the cows' ration during the cold weather. Along with this, barley and maize grains, alfalfa, premixes, straw are also included in the ration. The quantities consumed were lower in 2019, namely 4,257.62 to compared to the quantities consumed in 2020, 2021, 2022- over 5,000 to. The differences were due to the livestock and age categories existing at that time. Feed rations are made up according to productive performance and age.

Ration for cows producing more than 25 litres/day (126 livestock units)

The daily feed consumption is 6,432.3 kg which means a consumption of 51.05 kg feed/livestock unit/day. This is a balanced ration that is fed to recently calved cows and cows that are in early gestation (up to the fifth month of gestation) with yields of more than 25 litres/day.

Table 3. Expenditure on feed ration for dairy cows with production >25 litre/lactation/day (126 livestock units)

Item no.	Fodder	Kg/LSU/day	Total kg /day	Lei/kg feed	Lei/day
1	Grain maize	2.7	340.2	1.20	408.24
2	Barley grain	2.7	340.2	0.48	163.29
3	Grain wheat	1	126	0.92	115.92
4	Peas	1	126	0.70	88.2
5	Wheat bran	0.5	63	1.10	69.3
6	Panto R-60 (premix)	0.200	25.2	5.75	144.9
7	Panto Power mix	0.400	50.4	8.90	448.56
8	Wissan	2	252	3.32	836
9	Wheat straw	0,5	63	0.05	3.15
10	Alfalfa hay	2	252	0.40	100.8
11	Corn silage	24	3,024	0.31	937
12	Alfalfa semi-silage	10	1,260	0.40	504.8
13	Calcium carbonate	0.050	6.3	0.57	3.65
14	Water	4	504	-	-
15	**Total consumption**	**51.05**	**6,432.3**		**3,823.81**
16	**Cost/LSU/day**				**30.34**

Source: Own calculation based on the company documents.

In this category of animals, the ration is divided into two meals, with half of the ration being fed in each meal. The feed expenditure for each animal in this category are 30.34 lei/day (Table 3).

Ration for cows producing less than 25 litres/day/90 LSU

This ration is fed to cows in the second part of gestation and to cull cows with less than 25 litres/lactation/day. The consumption of this group is 3,944.7 kg/feed/day which means a consumption of 43.83 kg of feed per cow. In this category, the daily feed cost per animal is lower at 20.20 lei (Table 4). The ration is divided into two portions, half in the morning and half in the afternoon.

Ration for cows in dry period and heifers 67 livestock units

This ration is fed to heifers and animals in dry period, the fodder is fed in one meal, in the morning. From what can be seen in the ration shown in Table 5, it is a fodder richer in fibrous and succulent cereals. The total feed consumption in this category is 1,323.25 kg/day which means a consumption of 19.75 kg/LSU/day.

Table 4. Expenditure on feed ration for dairy cows with production <25 litre/lactation/day (90 LSU)

Item no.	Fodder	Kg/LSU/day	Total kg /day	Lei/kg feed	Lei/day
1	Grain maize	2	180	1.20	216
2	Barley grain	1.5	135	0.64	87.75
3	Grain wheat	1.2	108	0.92	99.36
4	Peas	0.6	54	0.70	38.88
5	Wheat bran	0.5	45	1.10	50.4
6	Panto R-60	0.160	14.4	5.75	82.8
7	Panto Power mix	0.120	10.8	8.90	96.12
8	Wissan	1.2	108	3.23	348.84
9	Wheat straw	0.5	45	0.05	2.25
10	Alfalfa hay	2	180	0.40	72
11	Corn silage	22	1,980	0.31	613.8
12	Alfalfa semi-silage	8	720	0.40	288
13	Calcium carbonate	0.050	4.5	0.57	2.56
14	Water	4	360	-	-
15	**Total**	**43.83**	**3,944.7**		**1,998.76**
16	**Cost/LSU/day**				**22.20**

Source: Own calculation based on the company documents.

Table 5 .Expenditure on feed rations for heifers and cows in dry period (67 LSU)

No.	Fodder	Kg/LSU/day	Total kg /day	Lei/kg fodder	Lei/day
1	Grain maize	0.200	13.4	1.20	16.08
2	Barley grain	1	67	0.64	42.88
3	Grain wheat	1	67	0.92	60.3
4	Peas	0.500	33.5	0.70	23.45
5	Calcium carbonate	0.050	3.35	0.57	1.90
6	Straw	4	268	0.05	13.4
7	Alfalfa	3	201	0.40	80.4
8	Corn silage	10	670	0.31	207.7
9	**Total**	**19.75**	**1,323.25**		**446.11**
10	**Cost/head/day**				**6.65**

Source: Own calculation based on the company documents.

Figure 1 shows an increase in milk production over the period analysed. In 2019 the farm achieved a production of 1,749,999 litres of milk, in 2022 it recorded a production of 1,949,121 litres of milk which means that the production increased by 199,122 litres of milk compared to 2019. Figure 1 shows that milk production fluctuates from year to year. This is due to the number of milked livestock units and the fodder quality. The factors that caused these fluctuations were the higher number of milked cows, the genetics used on the farm, the higher quality of the feed administered and the balanced and scientifically composed rations.

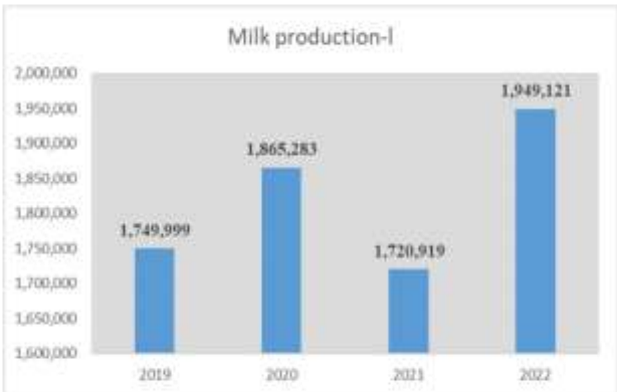

Fig. 1. Milk production during 2019-2022
Source: own design and calculation.

Figure 2 shows that in 2019, the cost of fodder to obtain one litre of milk was 0.80 lei and in

2022 we have a cost of 1.44 lei. This means that we have an increase of 0.64 lei, and this is due to the increase in cereal prices. Milk was valued in 2022 at 2.25 lei/l to which the fat and protein bonuses are added reaching 2.5 lei/l.

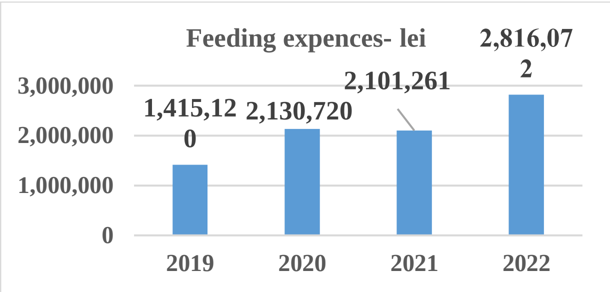

Fig. 2. Feeding expences
Source:own calculation.

CONCLUSIONS

The farm under review manages to make a profit every year. This is possible due to the good management practised at the farm level, with the management staff applying in practice the latest trends in animal breeding. It aims to get more value from the fodder for the animals by using artificial seeding with bulls that imprint these traits. The aim is for the animals to have a smaller waist and consume a reduced amount of fodder without affecting productivity. If in 2019 the cost of obtaining a litre of milk was 0.80 lei, in 2022 it reached 1.44 lei. This increase is the result of the increase in the price of fodder, taxes, electricity, etc.

Milk production is increasing year by year, if in 2019 milk production was 1,749,999 litres of milk, in 2022 the farm recorded a production of 1,949,121 litres resulting in an increase of 199,122 litres of milk. This is due to breed improvement, fodder quality, increase in livestock units, etc.

2022 has brought 50% increases in all areas of activity, including the bovine sector. Due to substantial increases in supplies and the rate of inflation, raw milk production costs have risen substantially. Without a balanced adjustment of the price ratio between the processing and production sectors, there is a risk of a decline in livestock numbers. A revival of the cattle breeding sector is needed to boost cow milk production and financial support for milk production to balance the farm gate price in line with the EU.

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ANALYSIS OF ENTREPRENEURIAL BEHAVIORS OF GREENHOUSE VEGETABLE FARMERS: A CASE STUDY IN TÜRKİYE

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Abstract

The purpose of this study is to determine the factors affecting the entrepreneurial behaviours of the farmers producing vegetables in the greenhouse in the Menderes district of Izmir province-Türkiye. The data were collected from 94 farmers using proportional sampling and face-to-face survey method. Five-point Likert scale was used in the analysis of the entrepreneurial behaviours of the farmers. Fuzzy Paired Comparison Method was used in the analysis of the criteria that the farmers give importance to when deciding on greenhouse vegetable growing. According to the results of the study, the average age of the farmers is 46.94 years, and the average education period is 9.30 years. The average greenhouse land size of the farmers is 5.78 decares. Farmers consider the profitability level and sustainability of the activity, financing opportunity and total cost as important factors in agricultural entrepreneurship. Farmers also consider water supply, marketing opportunities and seed-seedling supply as the most important factors in greenhouse vegetable entrepreneurship. The most important criterion in greenhouse vegetable growing is production costs, followed by marketing opportunities and price. The most important future goals of the farmers, who produce two vegetables: cucumbers and lettuce in the greenhouse per year are minimizing the hazards during production and marketing and sustaining greenhouse vegetable production.

Key words: *greenhouse production, farmers decisions, entrepreneurial behaviour, agricultural investment*

INTRODUCTION

Considering the climate changes caused by global warming, which is felt more today, the importance of greenhouse production, which is realized by controlling the growing conditions partially or completely, in eliminating these problems is better understood [39]. Greenhouse production consists of different methods such as surface covers, covers laid on plants, low or high tunnels and greenhouses. One of the mentioned methods, greenhouse production is a type of production that creates high economic benefit from the unit area compared to other methods; greenhouses can be defined as facilities that provide the production of plants outside of their natural growing periods, where climatic conditions are partially or completely suitable for plant production, and are covered with light-transmitting materials such as glass or plastic [45, 50].

In Türkiye, after 1970, with the use of transparent plastic (polyethylene) as a covering material, greenhouse production has shown great development. Production in greenhouses has become widespread today along the Mediterranean, Aegean, and Marmara coasts. According to 2022 data, the total land under protective cover in Türkiye is 81,088 hectares. Production was carried out in plastic greenhouses on an area of 47,128 ha, in a low tunnel on an area of 16,954 ha, in a high tunnel on an 11,043 ha area, and in a glass greenhouse on a 5,963 ha area. The provinces where the greenhouse agricultural area is dense in Türkiye are respectively;

Antalya, Mersin, Adana, Mugla and Izmir. In 2022, a total of 8.18 million tons of vegetables, 1.15 million tons of fruits and 1.6 billion ornamental plants were produced in land under protective cover in Türkiye. The most produced products in greenhouses are vegetables. Among the vegetables produced in the greenhouse, tomatoes take the first place, followed by cucumber, pepper and eggplant, respectively. According to the 2022 data of TURKSTAT, 4.14 million tons of tomatoes, 1.18 million tons of cucumber, 464,574 tons of green pepper and 346,667 tons of eggplant were produced on land under protective cover in Türkiye [48].

The most important goal for the farmers in greenhouse vegetable growing is to make the production profitable and to increase the income. To achieve this and economic sustainability, it is necessary to reduce the production cost and to perform the marketing with a high price. Yield and price increases will be important to make production profitable. To reduce the cost in vegetable production, it is necessary to go for input support in production or to increase product yield. To increase the efficiency obtained from the unit area; it is necessary to choose suitable and high-quality seeds, to apply alternation, to ensure efficiency in the use of fertilizers and pesticides, and to apply appropriate cultivation techniques on time. Therefore, it is necessary to analyze the farmer practices and entrepreneurial decisions in different regions and to guide the farmers in this direction [6].

It is seen that there are many studies that analyze the economic aspects of vegetable growing in greenhouses in Türkiye [35, 15, 16, 17, 49, 21, 36, 33, 22, 55, 26, 37, 27, 34]. However, entrepreneurial decisions of farmers were not examined in these studies.

Greenhouse vegetable farmers need to improve their production with entrepreneurial behaviours to meet the increasing vegetable needs of the society. Entrepreneurship makes an important contribution to the correct application of growing methods, the realization of the objectives in the growing plan, the provision of economic efficiency and the follow-up of technological developments [18].

In addition to having advantages over other agricultural activities in terms of product yield and agricultural income, farmers must be able to compete in the world agricultural market to ensure sustainable development in greenhouse production, which also requires higher facility and operating costs, higher technical knowledge and skills compared to other production methods. A detailed analysis of technological and innovation initiatives on issues such as technical inadequacies encountered during production in greenhouse production in Türkiye, problems encountered during product marketing and logistics will make significant contributions. For this reason, it is necessary to analyze the entrepreneurial trends for the framers to switch from the traditional aquaculture-oriented approach to the market-oriented approach. Entrepreneurship is also effective in increasing the accessibility of farms in the market and increasing their share in the market. In this respect, it is important and necessary to evaluate the effects of the innovative perspectives and personal characteristics of the farmers on their attitudes and behaviours within the framework of entrepreneurship [54].

It is seen that farmers in different sub-sectors of agriculture in different countries of the world [31, 40, 52, 44, 24, 53, 42, 5, 28, 29, 30] and in Türkiye are handled in terms of entrepreneurship behaviors [9, 25, 51, 1, 7, 3, 8, 54, 4, 12, 2]. However, it would be beneficial to carry out these studies for greenhouse vegetable farmers as well.

One of the important greenhouse vegetable production centers of Türkiye is Izmir province. When examined by districts in Izmir, Menderes district is the district where the most greenhouse vegetables are produced. The most important greenhouse vegetables grown in this district are cucumber, tomato, and lettuce. With the research to be conducted in this district, the information and other needs of the farmers can be determined, as well as the data that can be used in the formation of effective policies to ensure sustainability. In addition, an ecosystem suitable for entrepreneurship strategies will be developed and a framework will be formed. The purpose of this study is to determine the factors affecting the entrepreneurial behaviours of the farmers producing vegetables in the greenhouse in the Menderes district of Izmir province-Türkiye.

MATERIALS AND METHODS

The data constituting the main material of the research were obtained by face-to-face survey method from the farmers producing vegetables in the greenhouse in the Menderes district of Izmir province. In addition to the survey data, the results of previous studies and statistical data published by different institutions were also used. According to the data of Izmir Provincial Directorate of the Ministry of Agriculture and Forestry, 80% of the greenhouse areas (11,328 decares) where vegetables and fruits are produced in the province are in Menderes district. For this reason, it is planned to include the Menderes district. Cucumber and lettuce are produced mainly in greenhouses in Menderes district.

According to the information received from the Menderes District Directorate of the Ministry of Agriculture and Forestry, 90% of the greenhouse areas in the district are located in Altintepe, Atakoy, Camonu, Cileme, Degirmendere and Develi neighborhoods, and approximately 90% of vegetable production is carried out in these neighborhoods. Therefore, these neighbourhoods were included in the scope of the study. The total number of farmers registered in the Farmers Registration System in these neighbourhoods was determined as 831. It was decided that it would be appropriate to include some of the farmers by sampling in the study. For this purpose, the following Proportional Sample Size Formula was used (Newbold, 1995) [32]. It is seen that this formula is used in the sampling phase of many studies [14, 47, 19, 20, 4].

$$n = \frac{Np(1-p)}{(N-1)\sigma^2_{px} + p(1-p)} \quad (1)$$

where:
n = Sample size
N = Total number of farmers
p = Proportion of farmers producing vegetables in greenhouse (0.5 was taken for the maximum sample size)
$\sigma^2 px$ = Variance

In the study, calculation was made based on 90% confidence interval and 8% margin of error and the sample size was determined as 94. In determining the number of farmers to be interviewed in each neighbourhood, the shares of the neighbourhood in the total number of farmers were taken as a basis. Farmers to be interviewed in the neighbourhoods were determined by using the random numbers table. In the research, the production period of 2021/2022 was taken as a basis, and the survey studies were carried out in July and August of 2022.

The study was found ethically appropriate with the decision of Ege University Scientific Research and Publication Ethics Committee dated 25/04/2022 and numbered 04/05. During the survey studies, the aims of the study and how they can benefit from the results were explained to each farmer. In this way, they were allowed to participate in the study voluntarily and the consent form was filled.

In the analysis of data, the farmers were divided into three groups according to the size of the greenhouse production area. At this stage, decare (1,000 m^2=0.1 hectare) was used. The first group is farmers with a greenhouse production area of ≤3 decare (30 farmers), the second group is farmers with a greenhouse production area of 3-6 decare (37 farmers), and the third group is farmers with a greenhouse production area of 6≤ decare (27 farmers). In the study, first, the socio-economic characteristics of the farmers were determined and at this stage. The age of the farmers, education level, family population, land size, family labour potential, capital and cooperatives levels were examined. Then, the annual activity results of the farmers were analyzed and the entrepreneurial characteristics and the factors affecting the entrepreneurial decisions were determined.

A five-point Likert scale was used to evaluate the entrepreneurial knowledge level and behaviour of the farmers, their sources of information, the factors they attach importance to, and their future tendencies and expectations [10].

Fuzzy Paired Comparison method was used in the analysis of the factors affecting the farmers' decision to produce vegetables in the greenhouse. This method is like the simple paired comparison method. In both, farmers compare the two purposes. On the other hand, in this method, the degree of preference of one goal over the other is revealed and it is also ensured that the farmers remain indifferent between the two goals. Six different criteria were presented to farmers to determine their decision preferences. These criteria are price, marketing opportunity, cost, soil characteristics, climatic conditions, and yield level. Method steps may be summarized as follows [43, 46, 38].

First, pairwise comparisons were presented to indicate individual preferences. The total distance in comparison is follow equal.

If G_{KH}=0.5 then K≈H; if G_{KH}>0.5 then K>H and if G_{KH}<0.5 then K<H.

The number of paired comparisons of the objectives (C) were determined as C= [(Z.(Z-1))/2]. Z refers to the preferred number of objectives in the formula.

In the study, each farmer was presented with 15 comparisons of six different criteria. Influencing factors are listed according to their weights, from largest to smallest. For each pairwise comparison, g_{cr} preference was obtained. Measurement of the preference degree of r according to c can be expressed as $g_{cr}=1-g_{rc}$. Then, fuzzy preference matrix was as follow generated as follow.

$$\text{Gcr} = \begin{cases} 0 & if\ \ c = r\ \forall\, c, r = 1, \ldots .n \\ g_{cr} & if\ c \neq r\ \forall\, c, r = 1, \ldots ..n \end{cases}$$

....(2)

In this study, 6x6 fuzzy preference matrix was created for everyone as follow (G):

$$\text{G} = \begin{bmatrix} g_{11}g_{12}g_{13}g_{14}g_{15}g_{16} \\ g_{21}g_{22}g_{23}g_{24}g_{25}g_{26} \\ g_{31}g_{32}g_{33}g_{34}g_{35}g_{36} \\ g_{41}g_{42}g_{43}g_{44}g_{45}g_{46} \\ g_{51}g_{52}g_{53}g_{54}g_{55}g_{56} \\ g_{61}g_{62}g_{63}g_{64}g_{65}g_{66} \end{bmatrix}$$

....(3)

Separately preferred density of each objective (μj) was obtained using the following equation.

$$\text{μj} = 1 - \left(\sum_{c=1}^{n} G_{cr}^{2} / (n-1) \right)^{1/2}$$

....(4)

The value of μj ranges between 0 and 1. Whether the purpose of comparison was equally important was determined by the Friedman Test. In addition, Kendall's coefficient of agreement was used for the rows.

It was tested whether the results obtained differed between the groups. At this stage, One-Way Anova test was used for normally distributed variables and Kruskal Wallis test was used for non-normally distributed variables. Chi-square test was applied to the data obtained by counting.

RESULTS AND DISCUSSIONS

The average age of the farmers is 46.94 years, and the average education period is 9.30 years. While the farmers in the first group are younger, the farmers in the third group have longer training periods. The average greenhouse experience of the producers is 16.20 years. The average household size is 3.88 people. The household size of the second group farmers is higher. The family labour potential of the farmers was calculated as 2.77 Male Labor Units (MLU). The average land size of the farmers is 40.50 decares and 5.78 decares are greenhouse lands. Equity constitutes 94.40% of the farmers' capital. 41.49% of the farmers are partners in any agricultural cooperative (Table 1).

Table 1. Socio-economic characteristics of farmers

Characteristics	Farm groups			
	Group 1 (≤3da)	Group 2 (3-6da)	Group 3 (6da≤)	General
Age of farmers	45.48	48.57	46.34	46.94
Education level of farmers (years) (*)	7.10	9.51	11.48	9.30
Greenhouse experience of farmers (years)	18.00	17.00	15.00	16.20
Household size (*)	3.88	4.38	3.27	3.88
Family labour potential (MLU)	2.56	2.93	2.44	2.67
Land size (da)	32.40	39.70	50.60	40.50
Greenhouse land size (da)	2.60	5.20	10.10	5.78
Equity ratio (%)	93.56	94.45	94.65	94.40
Cooperative partnership rate (%) (*)	20.00	32.43	81.48	41.49

(*) The difference between groups is statistically significant at the 0.05 level.
Source: Results of this research.

When the farmers were asked about their educational status on agricultural entrepreneurship, 34.04% of the farmers stated that they received training, while 65.96% stated that they did not receive any training on this subject. The farmers in the second group have a higher education rate (45.95%) than the other groups (Table 2). In a study conducted in Konya province-Türkiye, it was determined that 79.69% of the farmers received such training [1], while in a study conducted in Odemis district of Izmir province-Türkiye, this rate was determined as 16.67% [12].

Table 2. The status of farmers receiving agricultural entrepreneurship training

Answers (*)	Farm groups			
	Group 1 (≤3da)	Group 2 (3-6da)	Group 3 (6da≤)	General
Yes	10	17	5	32
No	20	20	22	62
Total	30	37	27	94

(*) The difference between groups is statistically significant at the 0.05 level.
Source: Results of this research.

The information sources they use when deciding on an agricultural entrepreneurship were asked to the farmers and their importance level was examined. The most frequently used information sources by the farmers are respectively; Ministry of Agriculture and Forestry (MAF) Provincial and District Agriculture Directorates, internet, and written resources. Responses are similar in all groups (Table 3).

Table 3. Information sources of farmers for agricultural entrepreneurship*

Sources	Farm groups			
	Group 1 (≤3da)	Group 2 (3-6da)	Group 3 (6da≤)	General
MAF Provincial and District Directorates	4.50	4.43	4.44	4.46
Universities	2.57	2.59	2.33	2.51
Farmer associations	2.47	2.32	2.37	2.38
Cooperatives	3.47	3.22	3.19	3.29
Internet	4.10	4.27	4.41	4.26
Written sources	3.60	3.84	3.93	3.79
Banks	2.37	2.46	2.56	2.46
Traders	3.17	3.22	3.00	3.14
Small and Medium Enterprises Development Organization	2.80	2.89	2.78	2.83
Pesticide-fertilizer dealers	2.87	2.76	3.04	2.87

*1.Not important, 2. Slightly important, 3. Undecided, 4. Important, 5. Very important
Source: Results of this research.

Similar results were obtained in studies conducted in Konya and Izmir provinces-Türkiye. The most important source of information has been determined as Provincial and District Agriculture-Forest Directorates [1, 12].

The factors affecting the agricultural entrepreneurial personality were asked to the farmers and they were asked to score according to the level of importance. According to farmers, the most important factors are technical knowledge, wish for success and willingness. It is seen that the farmers in the second group consider personal experiences also important (Table 4).

Table 4. Factors affecting agricultural entrepreneurial personality according to farmers*

Factors	Farm groups			
	Group 1 (≤3da)	Group 2 (3-6da)	Group 3 (6da≤)	General
Family	3.80	4.00	4.00	3.94
Wish for success	4.20	3.92	4.63	4.21
Environment	3.27	3.51	3.15	3.33
Education level	3.87	3.97	3.89	3.91
Personal experiences	3.97	4.41	3.78	4.09
Willingness	4.40	4.03	3.93	4.12
Age and gender	4.17	3.84	4.19	4.04
Technical information	4.27	4.59	4.52	4.47

*1. Not important, 2. Slightly important, 3. Undecided, 4. Important, 5. Very important
Source: Results of this research.

When the farmers were asked about the factors that they attach importance to in agricultural entrepreneurship, it was determined that the profitability level and sustainability of the activity, financing opportunity and total cost were the most important factors. It is seen that the farmers in the second group consider input supply and personal tendencies and preferences as important (Table 5).

The farmers were asked to evaluate the reasons that are effective in choosing agricultural entrepreneurship according to the level of importance. Farmers stated that earning money and the increase in demand for agricultural products are the most important reasons. The farmers in the second group consider land acquisition by inheritance as an important reason (Table 6).

Similar results were obtained in studies conducted in Konya and Izmir provinces-Türkiye. According to the farmers, the most important reason for agricultural entrepreneurship is to earn Money [1, 12].

When the farmers were asked about the factors they considered when establishing a farm, they indicated marketing opportunities and climatic features as the most important factors

Table 5. Factors that farmers consider important in agricultural entrepreneurship

Factors	**Farm groups**			
	Group 1 (≤3 da)	Group 2 (3-6 da)	Group 3 (6 da≤)	General
Level of knowledge about the agricultural activity	3.70	4.11	4.00	3.95
Choosing the production area	2.97	3.73	3.37	3.38
Profitability level and sustainability of activity	4.33	4.41	4.52	4.41
Market conditions and price change	3.53	3.05	3.33	3.29
Personal tendencies and preferences	3.63	4.22	4.00	3.97
Total costs	4.27	4.14	4.26	4.21
Input supply	4.07	4.27	4.22	4.19
Financing opportunity	4.17	4.51	4.15	4.30

*1. Not important, 2. Slightly important, 3. Undecided, 4. Important, 5. Very important
Source: Results of this research.

Table 6. Reasons for farmers to engage in agricultural entrepreneurship

Reasons	Farm groups			
	Group 1 (≤3 da)	Group 2 (3-6 da)	Group 3 (6 da≤)	General
Insufficient employment opportunities	3.37	3.49	3.26	3.38
The emergence of opportunities	3.67	3.41	3.41	3.49
Increase in demand for agricultural products	4.50	4.57	4.37	4.49
To earn money	4.60	4.65	4.56	4.61
Land acquisition by inheritance	3.63	4.11	4.04	3.94
Increasing the grant and incentive opportunities	3.80	3.57	3.81	3.71
Providing suitable loans to entrepreneurs	2.90	3.35	3.70	3.31

*1. Not important, 2. Slightly important, 3. Undecided, 4. Important, 5. Very important
Source: Results of this research.

Farmers in the first group consider surrounding water resources as an important factor (Table 7). In a study conducted in Konya province-Türkiye, the most important factor for the farmers when establishing a farm was the land size [1], while in a study conducted in Izmir province-Türkiye, the most important factor was determined as socio-economic conditions [12].

Table 7. Factors that farmers take into account when establishing a farm

Factors	Farm groups			
	Group 1 (≤3 da)	Group 2 (3-6 da)	Group 3 (6 da≤)	General
Land and soil structure	3.57	3.68	3.30	3.53
Geolocation	3.63	3.62	3.56	3.61
Input supply	3.13	4.00	3.52	3.59
Climatic features	4.23	4.30	4.15	4.23
Labor opportunity	3.10	3.03	3.11	3.07
Surrounding water resources	4.20	4.05	3.41	3.91
Marketing opportunity	4.47	4.62	4.30	4.48

*1. Not important, 2. Slightly important, 3. Undecided, 4. Important, 5. Very important
Source: Results of this research.

When asked about the expectations of the farmers from agricultural entrepreneurship, it was determined that the most important expectations were to increase income and to be respected in the society (Table 8). In a study conducted in Konya province-Türkiye, the most important future goal of the farmers was determined as producing at the lowest cost [1], while in a study conducted in Izmir province-Türkiye, the most important future goal of the farmers was determined as preserving the land and capital and transferring it to the next generations [12].

Table 8. Expectations of farmers from agricultural entrepreneurship

Expectations	Farm groups			
	Group 1 (≤3 da)	Group 2 (3-6 da)	Group 3 (6 da≤)	General
Increasing income	4.63	4.70	4.74	4.69
Creating new employment opportunities	2.97	3.03	2.89	2.97
Implementing agricultural innovations	3.37	3.14	2.85	3.13
Providing consumers with natural products	3.03	2.92	2.89	2.95
Respect in society	4.20	4.11	4.04	4.12

*1. Not important, 2. Slightly important, 3. Undecided, 4. Important, 5. Very important
Source: Results of this research.

Farmers were asked about the level of importance they attach to various factors in greenhouse vegetable entrepreneurship. Farmers stated water supply, marketing opportunities and seed-seedling supply as the most important factors. The farmers in the second group also consider energy supply as an important factor (Table 9).

Table 9. Effective factors in greenhouse vegetable entrepreneurship

Factors	Farm groups			
	Group 1 (≤3da)	Group 2 (3-6 da)	Group 3 (6 da≤)	General
Farm location selection	3.73	3.62	3.41	3.60
Capital and credit opportunities	3.33	3.30	3.44	3.35
Government supports and grants	4.07	3.68	3.85	3.85
Climatic and soil conditions	4.00	3.97	4.00	3.99
Marketing opportunities	4.40	4.35	4.56	4.43
Transportation and handling	3.63	3.86	3.59	3.71
Labor supply	3.07	3.32	2.89	3.12
Seed-seedling supply	4.33	4.05	4.41	4.24
Energy supply	4.17	4.28	4.15	4.21
Water supply	4.80	4.62	4.52	4.65

*1. Not important, 2. Slightly important, 3. Undecided, 4. Important, 5. Very important
Source: Results of this research.

The Fuzzy Paired Comparison method was used in the analysis of the factors affecting the farmers' decision to produce vegetables in the greenhouse. Six different criteria are presented to farmers to determine their decision preferences. These criteria are vegetable prices, marketing opportunities, production costs, soil and water characteristics, climatic conditions, and yield. It has been determined that the most important criterion in the decision of the farmers to produce vegetables in the greenhouse is the production costs. Other important criteria are marketing opportunities, vegetable prices, climatic conditions, yield, and soil-water characteristics, respectively. According to the Friedman test results, the difference between the preferences is statistically significant (Table 10).

Table 10. Fuzzy Paired Comparison Method results

Factors	Min.	Max.	Mean	Std. error
Production costs	0.420	0.730	0.594	0.059
Marketing opportunities	0.400	0.720	0.561	0.065
Vegetable prices	0.410	0.670	0.560	0.055
Climatic conditions	0.360	0.670	0.528	0.064
Yield	0.300	0.620	0.456	0.063
Soil-water characteristics	0.280	0.590	0.418	0.074

Friedman test is significant for $p<0.01$. Kendall's W: 0.445
Source: Results of this research.

Farmers produce cucumbers in the greenhouse in the spring. It was determined that some farmers grow autumn cucumbers after spring cucumbers, while some farmers grow lettuce after spring cucumbers. However, it has also been determined that the automation systems required for the creation of artificial conditions such as heating, ventilation, irrigation, fertilization, and spraying are limited. Farmers usually market cucumbers and lettuce to brokers and traders on the farm. Average yields obtained in cucumber and lettuce production and average prices obtained by farmers are presented in Table 11.

89.36% of the farmers think that the government supports in greenhouse vegetable growing are insufficient. It was determined that 64.15% of the farmers had agricultural insurance. 97.87% of the farmers do not consider organic production, and 80.85% of the farmers do not consider production with good agricultural practices.

Table 11. Economic results of greenhouse vegetable production of farmers

Vegetable yield and price	Farm groups			
	Group 1 (≤3da)	Group 2 (3-6 da)	Group 3 (6 da≤)	General
Spring cucumber yield (kg/m^2)	24.05	26.88	27.58	26.18
Spring cucumber price (USD/kg) (*)	0.12	0.12	0.12	0.12
Autumn cucumber yield (kg/m^2)	16.29	16.80	17.63	16.87
Autumn cucumber price (USD/kg) (*)	0.30	0.31	0.32	0.31
Lettuce yield (kg/m^2)	5.00	5.08	5.40	5.15
Lettuce price (USD/pcs) (*)	0.28	0.29	0.29	0.29

(*) 1 USD was 16.57 Turkish Lira in 2022.
Source: Results of this research.

When the farmers were asked about their future goals in greenhouse vegetable entrepreneurship, they stated minimizing the hazards during production and marketing and sustaining greenhouse vegetable production as the most important goal (Table 12).

Table 12. Future targets of farmers in the greenhouse vegetable entrepreneurship

Targets	Farm groups			
	Group 1 (≤3da)	Group 2 (3-6 da)	Group 3 (6 da≤)	General
Production by reducing costs	3.77	3.81	3.78	3.79
Setting up new farms	3.87	3.76	3.96	3.85
Preserving the farm and passing it on to future generations	3.37	3.08	2.78	3.09
Using greenhouse automation systems	3.57	3.30	3.63	3.48
Pay off debts	3.80	3.46	4.11	3.76
To sustain greenhouse vegetable production	4.00	3.86	3.93	3.93
Minimizing hazards during production and marketing	4.43	4.35	4.33	4.37
Using ecological farming methods	3.27	3.24	3.11	3.21

*1. Not important, 2. Slightly important, 3. Undecided, 4. Important, 5. Very important
Source: Results of this research.

CONCLUSIONS

Unlike other business lines, agriculture has a distinct position in society and therefore it is not correct to see farmers as one with other entrepreneurs. It is also seen that entrepreneurship includes features that are not compatible with traditional agricultural values and lifestyle. To understand the entrepreneurship of farmers, it is necessary to examine the relationship between their goals, objectives and attitudes and their strategic entrepreneurial behaviours. The definition of entrepreneurship in agriculture has changed over the years. Research to date shows that traditional or production-oriented identities dominate among farmers [13], but there is some evidence of the emergence of new identities such as entrepreneurial identity, especially among small farmers [11, 23].

In this study, entrepreneurship perspectives, expectations and factors affecting entrepreneurial behaviours of greenhouse farmers were analyzed. According to the results of the study, 66% of the farmers did not receive training on agricultural entrepreneurship. It has been determined that the most important information sources are the Ministry of Agriculture and Forestry (MAF) Provincial and District Agriculture Directorates, internet, and written resources. Knowledge transfer in greenhouse activities is possible by learning traditional greenhouse information from the father or from the father. Farmers see the profitability level and sustainability of the activity, financing opportunity and total cost as important factors in agricultural entrepreneurship. The two most important reasons for their agricultural entrepreneurship are earning money and the increase in demand for agricultural products. Marketing opportunities and climatic features are considered when establishing a farm. The most important expectations from agricultural entrepreneurship are increase income and to be respected in the society.

Farmers see water supply, marketing opportunities and seed-seedling supply as the most important factors in greenhouse vegetable entrepreneurship. The most important criterion in greenhouse vegetable growing is production costs, followed by marketing opportunities and price. The most important future goals of the farmers, who produce two vegetables a year by producing cucumbers and lettuce in the greenhouse, are minimizing the hazards during production and marketing and sustaining greenhouse vegetable production.

In other studies, conducted in Türkiye and other countries, the effects of entrepreneurial behaviours and influential factors on greenhouse farmers were analysed. In a study on greenhouse farmers in Antalya, it was determined that the farmers believed that entrepreneurial behaviour could enable them to apply production techniques that are more suitable for human health. In addition, farmers think that they can use various new production techniques or pesticide types that can increase yields, that they can have new technologies by being entrepreneurial, and that they can take more risks in their investments [54]. In a study conducted in the Jiroft region of Iran, the effect of entrepreneurial orientation and marketing abilities on the performance of greenhouse farmers was investigated. As a result of the research, it was concluded that entrepreneurial orientation and marketing abilities have a significant and positive effect on the greenhouse enterprise performance. It has been determined that planning and development efforts increase performance and continuity in activities in a competitive environment [41].

Greenhouse vegetables are among the agricultural products that Türkiye exports the most. In recent years, greenhouse areas have been increasing rapidly. There is a need to increase the number of entrepreneurs in this sector so that Türkiye can produce at a level that meets its own needs and increase its exports. For this reason, training and extension support should be offered to entrepreneurs who will invest in this sector. Technical support should be offered to investor candidates in terms of consultancy and mentoring services. Access to agricultural information should be facilitated. Support for marketing and storage should be provided. Today, important supports related to greenhouse production should be provided to farmers and private sector entrepreneurs by the government in Türkiye. Support for modernizing greenhouses and improving them in terms of technology should be provided and increased. It would be beneficial for farmers to increase their risk insurance practices. On the other hand, the use of different production techniques in greenhouses may reduce costs as well as increase farmer incomes.

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ELEMENTS OF PRODUCTIVITY AND FIBER QUALITY IN INDUSTRIAL HEMP, *Cannabis sativa* L.

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Abstract

*The study analyzed three genotypes of industrial hemp, Cannabis sativa L., under the aspect of fiber productivity indices in relation to plant parameters. The study took place in ARDS Lovrin, Romania. The genotypes Silvana (control), Teodora and Lv-300 were evaluated. The experiment took place under the conditions of a chernozem type soil, non-irrigated system. Several parameters and indexes were analyzed: total plant weight (TPW), stem length (SL), inflorescence length (IL), technical length (TL), middle stem diameter (MSD), dry sample weight (DSW), dry fiber content (DFC), pure fiber weight (PFW), and technical fiber (TF). The DFC index showed positive correlations with SL (r=0.708***), with MSD (r=0.712***), with DSW (r=0.739***), with TPW (r=0.546**), and with TL (r=0.399*). The PFW index showed negative correlations with TPW (r=-0.493**) and with DSW (r=-0.373*). Technical fiber (TF) showed very strong, positive correlations with PFW (r=0.999***) and negative correlations with other parameters (e.g. with TPW, r=-0.493**, with DSW, r=-0.373*). From the comparative analysis of Teodora in relation to Silvana, average values TF_T=31.355 (Teodora) and TF_S=28.388 (Silvana) resulted, and the differences showed statistical certainty (t=2.5948, with p=0.013; U=72, p=0.0045; p<0.05). From the comparative analysis of Lv-300 in relation to Silvana (control), mean values TF_T=29.357 (Lv-300) and TF_S=28.388 (Silvana) resulted, but the differences did not show statistical certainty (t=0.763, with p=0.451; U=117, p=0.158; p>0.05). The regression analysis led to equations and graphic models that described the variation of fiber productivity indices in relation to plant biometric parameters.*

Key words: *biometric parameters, industrial hemp, multifunctional crop, productivity indices, technical fiber*

INTRODUCTION

Industrial hemp (*Cannabis sativa* L.) is an annual herbaceous plant, native to the temperate regions of Central Asia [7]. Industrial hemp (*Cannabis sativa* L., Cannabaceae) is a crop plant with a long history as a cultivated plant, valued since ancient times for its fibers, as a food resource and medicinal uses, with a complex functional role in all types of agricultural systems of over time, and even more so for the future [15, 16].

As a result of the similarities and some associations between industrial hemp (fibers, seeds) and the narcotic (medicinal) type of cannabis, the cultivation and production of industrial hemp was prohibited in most countries for quite a long period of time, which led to the loss of knowledge accumulated over centuries of learning, as well as to the loss of some valuable genetic resources [16]. The current position, adopted about two decades ago, makes most countries legalize the production of industrial hemp, and industrial hemp is seen as a multifunctional plant for the global food chain [16].

Industrial hemp is a plant that is based on the concept of "circular economy", in that it has multiple functionalities: ecological crop, friendly to the environment; contributes to CO_2 fixation; contributes to soil protection; provides resources for different industries – textile products, food, construction, furniture, pulp and paper, cosmetics, composite materials, biofuels, bioplastics, biopesticides, etc.) [15].

Hemp is increasingly used in food, as food, functional foods, or food ingredients. For food safety and consumer health, related to THC, it is necessary to comply with the regulations in force (<0.3% Tetrahydrocannabinol – THC), when using hemp in food for the safety of the food product [1].

As a result of the high economic profitability potential of industrial hemp in established countries (for seeds and fibers), there is interest in expanding the cultivation of industrial hemp in new areas with tropical climate conditions.

Recent studies have used simulation models to simulate and map the yield potential of hemp in relation to climatic conditions and to map the areas with minimum feasible productions (fibers, seeds) in order to expand the cultivation of hemp in new areas, such as some tropical countries, e.g. Malaysia and other Asian countries with tropical conditions [17].

As a result of the importance of industrial hemp, various studies have evaluated the opportunity of building and developing an industry based on industrial hemp, from a food perspective (seeds, flour, protein, hemp seed oil). As a result, the directions of agronomic approach, farm management, product valorisation (farm, and post-farm strategies), but also improvement programs and selection of valuable genotypes were outlined, all associated with opportunities led by the market [3].

Due to the directions of alternative use of hemp, which are of increasing interest compared to traditional use, recent studies have concatenated classical knowledge regarding industrial hemp with current knowledge, in order to outline new research paths, and advanced applications of industrial hemp [13].

Under the conditions of the "Farm Bill" standards, in the USA, in the State of Arkansas, it was found, based on restricted linear programming models, the increase of the area cultivated with industrial hemp by 2.8 - 4.4% and the increase of profit at the state level by 0.3 - 18.2% [14]. The results communicated based on the study [14], confirmed the profitability of the industrial hemp crop, and support the consideration of this crop in the conditions of the sustainable economy. In the state of Florida (USA), after the Legislative Session of 2019, there were various scientific analyzes and presentations in the media, in order to inform about policies and the economic potential for the production of industrial hemp [12].

Starting from compliance with "Farm Bill 2018" (<0.3% THC) Barnes et al. (2023) [2] studied the possibility and profitability of cultivating industrial hemp (fiber production) interspersed with a plantation of loblolly pine (*Pinus taeda*). Based on the simulation of some information and data, and some growth models, the authors of the study recorded that the interspersed culture of pine and hemp, under the conditions of the study, can generate higher profits by about 25% compared to the pure culture (monoculture) of pine loblolly. The results communicated by the authors show high interest for agricultural and agro-forestry systems, in order to increase productivity and economic benefits.

Recent studies carried out in the USA [11] have highlighted the importance of industrial hemp and its potential as a sustainable crop in the context of climate change, by the fact that it meets the conditions of the "pillar of sustainability" (the "economy-environment-society" triangle).

At the EU level, from statistical data [5], it was found that the area cultivated with industrial hemp has increased, from 20,540 ha (year 2015) to 33,020 ha (year 2022), which represents an increase of approx. 60%.

Hemp production registered an increase from 97,130 t to 179,020 t, in the same period 2015 - 2022, which represents an increase of about 84.3%. Within the EU countries, France occupies the first place (> 60% of the EU production), followed by Germany (approx. 17% of the EU production) and the Netherlands (approx. 5% of the EU production).

The present study evaluated elements of productivity and quality of the fiber in relation to physiological indices and biometric parameters of the plants in three industrial hemp genotypes, *Cannabis sativa* L. in order to describe through mathematical and graphical models the variation of the elements of fiber productivity, with importance in breeding programs for industrial hemp and for crop technologies.

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MATERIALS AND METHODS

The study evaluated fiber productivity elements in relation to biometric parameters and plant physiological indices in industrial hemp, *Cannabis sativa* L. The study took place in the experimental conditions of ARDS Lovrin, Romania. Three varieties of industrial hemp were analyzed, Silvana (as control), Teodora, and Lv-300. The experiment took place under the conditions of a chernozem type soil, non-irrigated system, period 2021 - 2022. The general aspect of the comparative crop of industrial hemp, which included the three analyzed varieties, is presented in Photo 1. The climatic conditions, in terms of the pluviometric and thermal regime during the study period, are presented in Fig. 1.

Photo. 1. Experimental field, industrial hemp (*Cannabis sativa* L.), ARDS Lovrin
Source: Original photo taken by the authors.

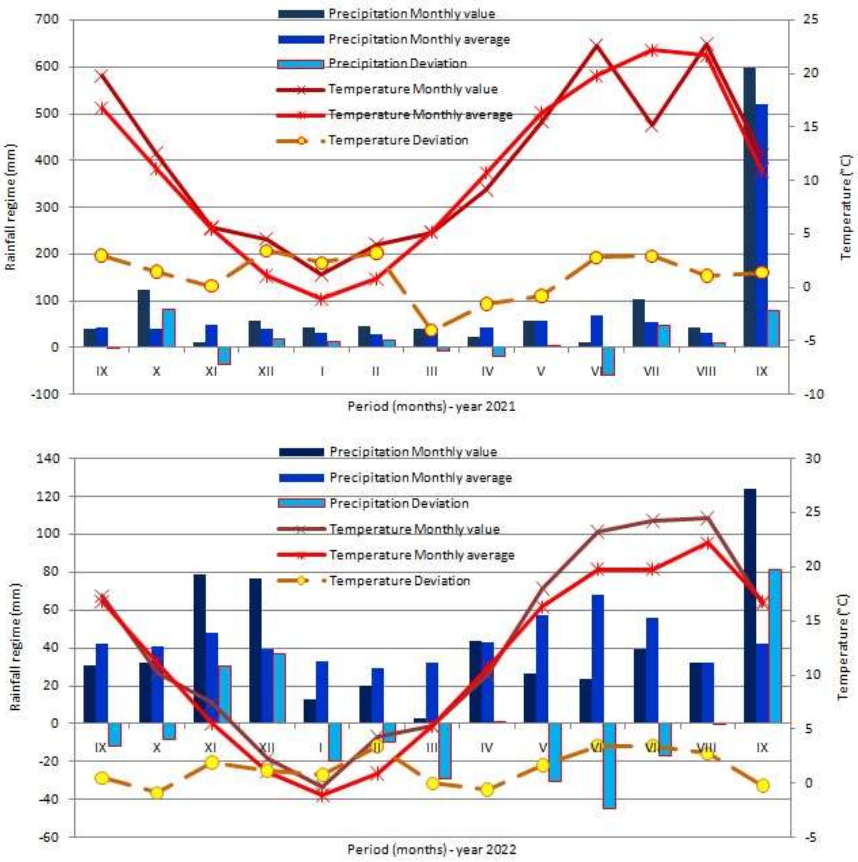


Fig. 1. Climatic conditions during the study period, ARDS Lovrin
Source: Original figure, generated by the authors

The experimental variants were cultivated in three repetitions. In order to determine the biometric parameters and productivity elements, according to the study protocol, elite plants were extracted from each variant and repetition. Within the biometric and physiological parameters of the elite plants and the elements of fiber productivity were determined: total plant weight (TPW), stem length (SL), inflorescence length (IL), technical length (TL), middle stem diameter (MSD), dry sample weight (DSW), dry fiber content (DFC), pure fiber weight (PFW), and technical fiber (TF).

The recorded results were analyzed for a general statistical description. The Anova test was applied for specific statistical evaluation (Alpha=0.001). The correlation analysis was used to identify the interdependence between the parameters and indices of the elite plants, considered in the study. The regression analysis was applied to find equations and models describing the variation of some fiber indices in relation to biometric parameters. The comparative analysis between the studied genotypes, Teodora, Lv-300 and Silvana (considered as control) was made with regard to technical fiber (TF), as a representative fiber productivity index (t-test, Mann-Whitney non-parametric test). In relation to the purpose of the study, appropriate mathematical and statistical analysis tools were used [8, 9, 18].

RESULTS AND DISCUSSIONS

From the analysis of the elite plants of the three varieties of industrial hemp (Silvana, Teodora, Lv-300) the values of the biometric and fiber parameters were obtained. The descriptive statistical analysis led to the data in Table 1. The total weight of the elite plants (TPW) varied between 78.00 – 226.00±8.866 g. The stem length of the elite plants (SL) varied between 221.00 – 311.00±6.442 cm, and the technical length (TL) varied between 120.00 – 227.00±6.557 cm. The diameter at the middle of the elite plants (MSD) varied between 9.12 – 14.79±0.335 mm. The dry weight of the samples (DSW) varied between 17.55 – 46.72±1.812 g. Dry fiber content (DFC) varied between 4.29 – 8.11±0.288 g. Pure fiber weight (PFW) varied between 17.18 – 27.18±0.672 %. Technical fiber (TF) varied between 22.34 – 35.33± 0.874 %. The Anova test confirmed the statistical reliability of the data and the presence of variance, Table 2.

Table 1. Descriptive statistics

Statistical parameters	TPW	SL	IL	TL	MSD	ST/TL	DSW	DFC	PFW	TF
Valid	18	18	18	18	18	18	18	18	18	18
Missing	0	0	0	0	0	0	0	0	0	0
Median	110.50	252.50	93.00	157.50	11.91	1.58	25.25	6.08	22.71	29.52
Mean	120.00	257.61	93.50	164.11	11.68	1.59	26.87	6.00	22.85	29.70
Std. Error of Mean	8.866	6.442	3.912	6.557	0.335	0.042	1.812	0.288	0.672	0.874
Std. Deviation	37.614	27.333	16.596	27.819	1.42	0.176	7.69	1.223	2.853	3.708
Minimum	78.00	221.00	73.00	120.00	9.12	1.32	17.55	4.29	17.18	22.34
Maximum	226.00	311.00	135.00	227.00	14.79	2.13	46.72	8.11	27.18	35.33
25th percentile	94.50	234.25	81.00	147.25	10.69	1.48	20.63	4.96	21.08	27.41
50th percentile	110.50	252.50	93.00	157.50	11.91	1.58	25.25	6.08	22.71	29.52
75th percentile	141.50	278.75	104.75	174.75	12.60	1.64	30.46	6.82	24.87	32.33

Source: Original data resulting from the calculation.

Table 2. Anova test

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	1155365	9	128373.8	274.8338	2.14E-96	3.293745
Within Groups	79406.37	170	467.0963			
Total	1234771	179				

Source: Original data resulting from the calculation.

Correlation analysis (Kendall's Tau B) led to the values in Table 3. Correlations were recorded between the biometric parameters of the elite plants and the analyzed productivity indices, under statistical safety conditions. For the DFC index, positive, moderate correlations were recorded with SL (r=0.708***), with MSD (r=0.712***) and with DSW (r=0.739***), and weak correlations with TPW (r =0.546**), and with TL (r=0.399*). For the PFW index, negative correlations of weak intensity were recorded with TPW (r=-0.493**) and with DSW (r=-0.373*). Technical fiber (TF) is the index of high importance in the assessment of fiber production and valuable genotypes, and in the case of this index, very strong, positive correlations were recorded with PFW (r=0.999***) and negative correlations with the other parameters, and with statistical assurance in the case of TPW (r=-0.493**) and with DSW (r=-0.373*). Other correlations were also recorded between the parameters analyzed in the elite plants, some of which were correlated with statistical assurance.

Table 3. Correlation matrix table, Kendall's Tau B

Variable	Correlation parameters	TPW	SL	IL	TL	MSD	ST/TL	DSW	DFC	PFW	TF
TPW	Kendall's Tau B	—									
	p-value	—									
SL	Kendall's Tau B	0.594***	—								
	p-value	< .001	—								
IL	Kendall's Tau B	0.332	0.192	—							
	p-value	0.057	0.27	—							
TL	Kendall's Tau B	0.270	0.616***	-0.198	—						
	p-value	0.12	< .001	0.255	—						
MSD	Kendall's Tau B	0.678***	0.603***	0.317	0.320	—					
	p-value	< .001	< .001	0.068	0.068	—					
ST/TL	Kendall's Tau B	0.060	-0.185	0.638***	-0.572***	0.007	—				
	p-value	0.732	0.288	< .001	< .001	0.97	—				
DSW	Kendall's Tau B	0.704***	0.630***	0.343*	0.320	0.765***	0.007	—			
	p-value	< .001	< .001	0.048	0.068	< .001	0.97	—			
DFC	Kendall's Tau B	0.546**	0.708***	0.277	0.399*	0.712***	-0.020	0.739***	—		
	p-value	0.002	< .001	0.111	0.021	< .001	0.909	< .001	—		
PFW	Kendall's Tau B	-0.493**	-0.157	-0.224	-0.007	-0.320	-0.112	-0.373*	-0.111	—	
	p-value	0.004	0.363	0.197	1.000	0.068	0.519	0.032	0.550	—	
TF	Kendall's Tau B	-0.493**	-0.157	-0.224	-0.007	-0.320	-0.112	-0.373*	-0.111	0.999***	—
	p-value	0.004	0.363	0.197	1.000	0.068	0.519	0.032	0.550	< .001	—
* p < .05, ** p < .01, *** p < .001											

Source: Original data resulting from the calculation.

The variation of the productivity indices was analyzed in relation to the biometric parameters of the plants. The DFC variation depending on the biometric parameters of the elite plants was described by equation (1), under conditions of R^2=0.826, F=15.4676, p<0.001, RMSEP=0.49516.

$$\begin{aligned} DFC &= -4.42002 + 0.00102 \cdot TPW + 0.02188 \cdot SL \\ &- 0.00072 \cdot TL + 0.4086 \cdot MSD \end{aligned} \tag{1}$$

The PFW variation depending on the biometric parameters of the elite plants was described by equation (2), under conditions of R^2=0.611, F=5.1370, p=0.010, RMSEP= 1.72566.

$$\begin{aligned} PFW &= 17.7130 - 0.0886 \cdot TPW + 0.04726 \cdot SL \\ &- 0.00385 \cdot TL + 0.36216 \cdot MSD \end{aligned} \tag{2}$$

The TF variation depending on the biometric parameters of the elite plants was described by equation (3), under conditions of R^2=0.613, F=5.13885, p=0.010, RMSEP= 2.24290.

$$TF = 23.0305 - 0.11527 \cdot TPW + 0.06142 \cdot SL - 0.00499 \cdot TL + 0.47066 \cdot MSD \quad (3)$$

As the technical fiber (TF) represents the most expressive productivity index, the variation of this index was analyzed in relation to the biometric parameters of the plants, as a direct influence and interaction. The multiple regression analysis led to obtaining a general equation, equation (4). The values of the coefficients of this equation, and the values of the statistical parameters are presented in Table 4. From the analysis of the data presented in table 4, statistical safety ($p<0.05$) was recorded in the case of three combinations of parameters, respectively TPW with MSD, TL with DSW, and MSD with DSW respectively. For these cases, the 3D graphic models and in isoquants format is presented in Figures 2, 3 and 4.

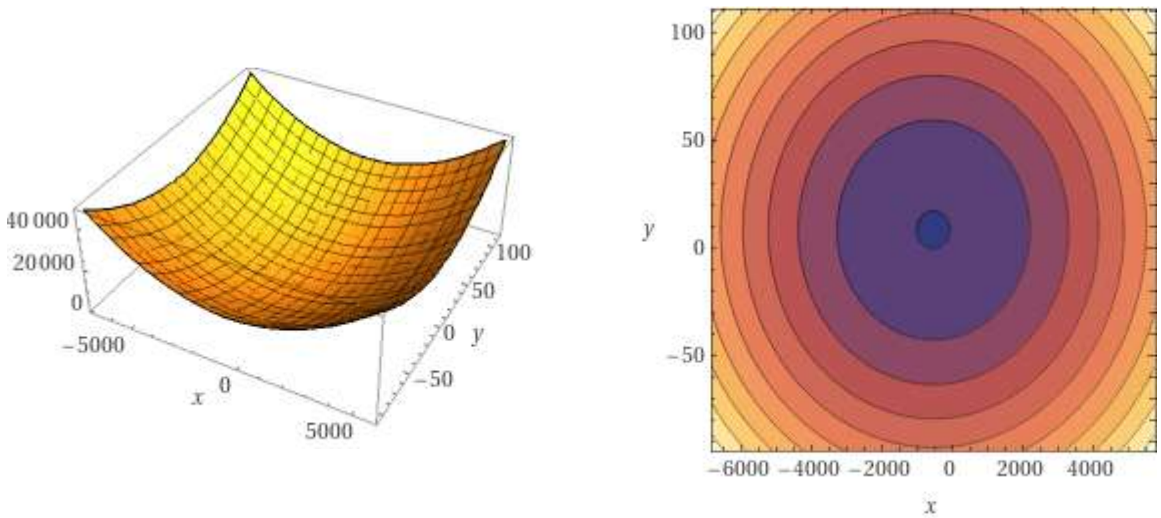
$$TF = ax^2 + by^2 + cx + dy + exy + f \quad (4)$$

where: TF – Technical fiber (%); x, y – biometric parameters of elite plants considered in the study (Table 4); a, b, c, d, e, f – the coefficients of the equation (4); all values are presented in Table 4.

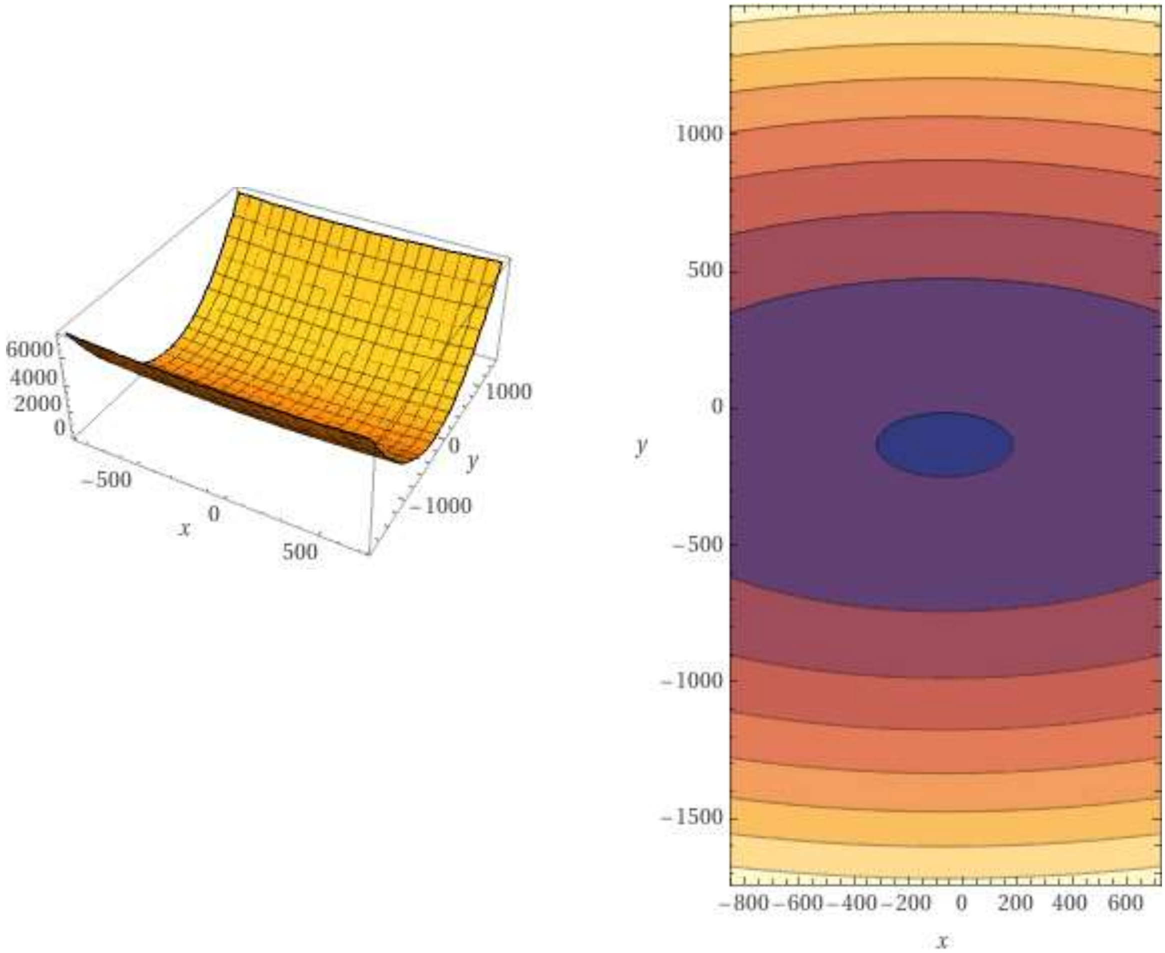
Table 4. Values of the equation (4) coefficients for the description of the TF index variation in industrial hemp

Biometric parameters	The coefficients of the Eq. (4)						Statistical safety parameters		
	a	b	c	D	e	f	R^2	p	RMSEP
x=TPW y=MSD	0.000687	1.960412	0.721412	-33.725505	-0.085277	178.396379	0.636	0.019*	2.1733
x=SL y=TL	-0.002685	-0.000479	0.829316	-0.530436	0.002876	-26.805030	0.189	0.728	3.2444
x=TL y=MSD	-0.000208	-0.161210	0.445861	6.635047	-0.028764	-37.346792	0.370	0.288	2.8593
x=TPW y=DSW	0.006221	0.077195	-0.263348	1.597033	-0.048093	28.255546	0.550	0.058	2.3169
x=TL y=DSW	0.000613	0.002797	0.080341	0.750581	-0.008263	14.387326	0.595	0.034*	2.2925
x=MSD y=DSW	3.483541	0.076379	-51.517695	8.283841	-1.087770	219.070596	0.644	0.017*	2.1509
x=SL y=DFC	-0.002720	-2.591058	0.333292	-15.603287	0.179304	34.946019	0.199	0.703	3.2247
x=TL y=DFC	-0.001376	-1.215268	-0.202063	-2.166022	0.101856	57.147587	0.240	0.596	3.1413

* $p < 0.05$
Source: Original data resulted by calculations.



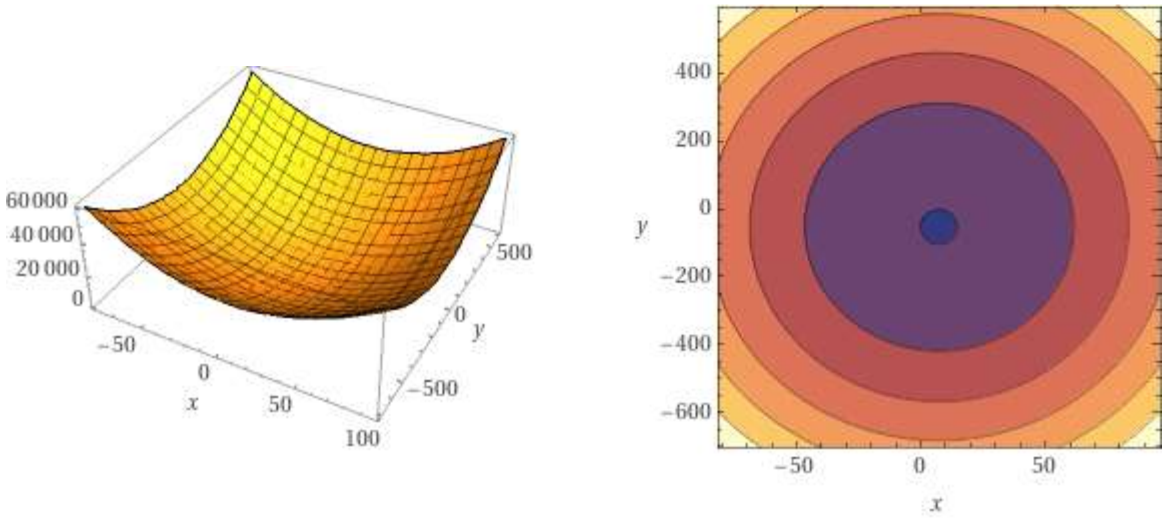
(a) (b)
Fig. 2. Graphic distribution of TF in relation to TPW (x-axis), and MSD (y-axis), industrial hemp
Source: Original graphs.



(a) (b)

Fig. 3. Graphic distribution of TF in relation to TL (x-axis), and DSW (y-axis), industrial hemp

Source: Original graphs.



(a) (b)

Fig. 4. Graphic distribution of TF in relation to MSD (x-axis), and DSW (y-axis), industrial hemp

Source: Original graphs.

In order to evaluate the differences regarding the technical fiber (TF), the comparative analysis was applied to the three genotypes, respectively Teodora and Lv-300 in relation to Silvana, considered as the control variant. From the comparative analysis of the Teodora genotype in relation to Silvana (control variant), average values of TF_S=28.388

(Silvana) and TF_T=31.355 (Teodora) resulted. According to the t-test, the result was t=2.5948, with p=0.013 ($p<0.05$). The recorded results (t, p values) rejected the null hypothesis; therefore there are significant differences, with statistical assurance, between the two genotypes (Teodora compared to Silvana, as a control variant). Additional verification of the differences between the two genotypes was done based on the non-parametric Mann-Whitney test. The value U=72 (p=0.0045), also indicated significant differences between the data series for the TF productivity index in the two genotypes, Teodora in relation to Silvana.

The Lv-300 genotype was also analyzed compared to the Silvana genotype (as control variant). From the comparative analysis of the Lv-300 genotype in relation to Silvana (control), average values of TF_S=28.388 (Silvana) and $TF_{Lv\text{-}300}$=29.357 (Lv-300) resulted. According to the t-test, the result was t=0.763, with p=0.451 ($p>0.05$). The recorded results (t, p values) showed that there are differences between the two genotypes, but without statistical assurance ($p>0.05$) (Lv-300 compared to Silvana, as the control variant). Additional verification of the differences between the two genotypes was done based on the non-parametric Mann-Whitney test. The value U=117 (p=0.158), also indicated differences between the two genotypes, but without statistical certainty ($p>0.05$).

Industrial hemp has a high agronomic and economic importance, and reaches the time of harvest in optimal crop conditions, after a period of 90-120 days [4].

Due to the biological specificity of the plants and the high biomass productions achieved, industrial hemp has high soil requirements; it requires soils with a neutral pH (weakly acid, weakly alkaline, pH=6.0 - 7.5), well-drained soils, with a good water regime, moist, soils with a well-represented profile [10].

The industrial hemp crop is a crop of interest for the objectives of the European Green Pact, with a number of benefits for the environment. Thus, hemp crop contributes during the vegetation period (approx. 5 months) to carbon fixation (9-15 t CO_2 ha^{-1}), a similar amount of carbon fixed by a young forest, but the hemp crop in a much shorter period of time. From an agronomic point of view, the hemp crop contributes to interrupting the cycle of some pathogens (diseases) with benefits in crop rotation, and also contributes to reducing the degree of soil pollution (great shading capacity). It contributes to the reduction of soil erosion, to the regulation of the water regime in the soil. It also has an important role in biodiversity, through the flowering period (July - September) and the large amount of pollen it produces, a period that is otherwise scarce for pollinating species and bees. It provides shelter for some species of birds (large habitat of the crops and plants, height of 2.5 - 4.5 m), as well as the source of food through seeds. It can also be considered an "environmentally friendly" plant, due to the reduced need for pesticides in the crop technology [5]. The products (fiber, seeds) and by-products (leaves, stems, roots, ingot-cellulose) resulting from the culture of industrial hemp, show high potential, with a wide spectrum of valorisation in the textile industry (fiber production), the food industry and animal husbandry (hemp seeds), constructions industry (hemp fiber, ingot-cellulosic mass), pulp and paper industry (fiber, ingot-cellulosic mass), other directions and industry of use (cosmetics, bioenergy production, composite material, etc.).

Industrial hemp (*Cannabis sativa* L.) is grown for industrial use, and the EU catalog includes 75 varieties. According to international legislation and EU Regulation 1308/2013 (Art. 189) [6], industrial hemp must fall under NC code 5302 10 (THC<0.3%), as well as other legal provisions regarding the cultivation of this plant for industrial purposes [5].

Farmers growing industrial hemp, according to EU rules, are eligible for direct payments on the area cultivated with industrial hemp under the CAP, and also, under certain conditions, they can benefit from voluntary coupled support (VCS) (support currently implemented in three countries, France, Poland, and Romania) [5].

The present study contributes through the results presented to the database and information regarding industrial hemp, with the comparative presentation of the three varieties analyzed, and the results regarding the fiber productivity elements in relation to the physiological parameters and indices of the elite plants.

CONCLUSIONS

The study facilitated the comparative evaluation of the three genotypes of industrial hemp, under the aspect of fiber productivity elements in relation to biometric and physiological plant parameters and indices.

Various levels of correlations were recorded between fiber productivity elements (dry fiber content – DFC, pure fiber weight – PFW), and technical fiber – TF), and plant physiological parameters and indices, an important aspect for hemp breeding programs industrial, but also for cultural technologies.

Models in the form of equations, as well as graphical models, described the variation of the fiber productivity elements (DFC, PFW, TF) in relation to parameters and physiological indices of the elite plants, under statistical safety conditions in the case of some parameters and combinations (DSW, MSD, NSD, TL, and TPW).

The comparative analysis of the varieties Teodora and Lv-300 with Silvana (as control genotype) highlighted differences in the technical fiber (TF), in the study conditions, with statistical assurance in the case of Teodora, which represents a perspective genotype.

The recorded results are important for industrial hemp breeding programs, but also for crop technologies, with the aim of yields of quality fiber productivity.

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FRUIT CONSUMPTION IN ROMANIA (2017-2019)

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Abstract

Fruits can be an important component of food consumption, due to their beneficial properties, related to the content in nutritional principles. The study tries to present the situation of consumers in Romania, based on fruit consumption in the context of existing realities worldwide and at European Union level, for the period 2017-2019. The total recorded fruit consumption is characterized by an average of 3,255.33 thousand t, and the consumption per inhabitant was, on average, 102.12 kg. Worldwide, Romania accounted for an average of 0.45% of total fruit consumption, with about 4.70% of the Community consumption. Regarding the consumption per capita, compared to the situation for world and community, Romania exceeded the level for total consumption of fruit by +15.0 and 31.61%, respectively. There is a preponderance of consumption of grapes, other fruits and apples (about 86%). It can be appreciated that it is necessary to revive the fruit sector and the processing industry, as prerequisites for increasing fruit consumption in Romania.

Key words: *consumption, dynamics, fruits, inhabitant, structure*

INTRODUCTION

Fruits, along with cereals and vegetables, are essential components of the human diet, having valences related to a healthy diet due to the high and varied content in bio-active substances [13].

Fruits are products with a variable degree of perishability, the period of time influencing the storage capacity and quality of products at the time of completion of storage and availability of consignments of goods for consumption [5]. If fruit storage is not carried out properly, it is estimated that losses can reach up to 45-55% of total production [6].

Fruits obtained on the basis of traditional technologies, have a higher quality than intensive or super-intensive production, as such they can be preferred in consumption [3].

The proper capitalization of fruits may be related to their proper processing (an aspect that also influences consumption), but this is not obvious at present in Romania, where fruit and vegetable processing represents only about 3% of the added value generated by the food industry [1].

Fruit consumption is under the influence of current socio-economic changes, which have consequences on the structures of food and non-food consumption of the population [14].

Fruit consumption is linked to their quality, the aspect being directly related to the efficiency of their valorization [4].

Although Romania is a country with tradition in the cultivation of fruit species, at present, due to the exploitation of plantations and their aging, the import of fruits clearly exceeds export operations (given the decrease in production), an aspect with various effects on consumption [8,15].

After 2015, for consumers in Romania, there is a change in the structure of the food ration, through the wider use of fruits [12].

Lately, there has been an increase in fruit consumption because the average consumer is more concerned with ensuring the daily need for useful nutritional principles, as a result of the campaigns carried out in the information media concerning the properties of fruits [7].

Changes in the structure of food consumption have good effects at producer level, leading to increased fruit production due to consumer demand [2].

The purpose of this study is to present the situation of consumers in Romania, based on fruit consumption in the context of existing realities worldwide and at European Union level, for the period 2017-2019.

MATERIALS AND METHODS

In order to carry out the work, it was operated with indicators called total consumption (availability) (thousand t) and average annual consumption per inhabitant (kg). It represents the total quantity of products available at the level of an area(s), i.e. the quantity of a product or group of agri-food products (primary or processed) consumed by an inhabitant, during the reference period, regardless of the source of supply (wholesale, retail, restaurants, canteens, own production, etc.) and the place where they are consumed (individual households, restaurants, canteens, confectioneries, institutional households, etc.) [10, 11]. The analyzed period is 2017-2019, to which by adding the average of the period, a dynamic series of four terms was achieved.
The two indicators shall be presented at the general level of the product group, as well as for its components: pineapple and derived products; Bananas; oranges and mandarins; lemons and limes; grapefruit and products thereof; other citrus fruits; apples and products thereof; grape; other fruits (FAO classification) [9]. The elaboration of this study called for the method of comparison in time and space. The dynamic series consists of four terms (to the three years analyzed being added the average of the period). The work uses only indices with a fixed base. Structural indices, calculated for total and per capita consumption, were determined by the formula:

$$IS_C = \frac{Qi}{Qt} x100\ (\%) \qquad (1)$$

where: IS_C – structure index (%);Qi = consumption by product type (thousand t, kg);Qt = total consumption (thousand t, kg).
Establishing the positioning, for the consumption per inhabitant, beside the reference levels (the world level in the case of the European Union, respectively the world and community level for Romania) was achieved by using the following formula:

$$P = \frac{Ni}{Nt} x100\ (\%) \qquad (2)$$

where: P– positioning relative to baseline (%); Ni = sequential level of the indicator (national consumption - thousand t, kg);Nt = indicator reference level (world or Community consumption - thousand t, kg).

RESULTS AND DISCUSSIONS

Table 1 shows the level of total fruit consumption, at national level, for this product group and its components.

Table 1. Total fruit consumption in Romania – thousand t (2017-2019)

Specification	Year						Period average**		
	2017		2018		2019				
	Effective*	Ibf** (%)	Effective*	Ibf** (%)	Effective*	Ibf** (%)	Effective	Ibf %	Structure %
Pineapple and products thereof	15	100	15	100.0	14	93.33	14.67	97.80	0.45
Banans	204	100	217	106.37	209	102.45	210.00	102.94	6.46
Oranges and tangerines	153	100	160	104.58	155	101.31	156.00	101.96	4.79
Lemons and limes	61	100	62	101.64	62	101.64	61.67	101.10	1.89
Grapefruit and products thereof	10	100	3	30.0	6	60.0	6.33	63.30	0.19
Other citrus fruits	1	100	1	100.0	1	100.0	1.00	100.0	0.03
Apples and products thereof	530	100	583	110.0	603	113.77	572.00	107.92	17.57
Grape	1,126	100	1,192	105.86	1,013	89.96	1,110,33	98.61	34.11
Other fruits	863	100	1,373	159.10	1,134	131.40	1,123.33	130.17	34.51
Total	2,963	100	3,606	121.70	3,197	107.90	3,255.33	109.87	100

Source: *https://www.fao.org/faostat/fr/#data/FBS (20.02.2023) [9].
**own calculations.

For pineapples and derived products, consumption levels from 14 thousand t (2019) to 15 thousand t (2017 and 2018) are found, and the average indicator was 14.67 thousand t. The dynamics of the indicator is uniformly downward, – equinity level of incidence in 2018 and decreases compared to the comparison term by 6.67% in 2019 and 2.20% at the level of the average of the period.

Banana consumption is characterized by an average of 210 thousand t (+2.94% compared to the reporting base – 2017), a level based on annual situations of: 204 thousand t in 2017, 217 thousand t in 2018 and 209 thousand t for 2019. The dynamics shows an upward-fluctuating evolution, the indices were strictly supra-unitary: 106.37% for 2018, 102.45% for 2019.

For the consumption of orange and mandarin, annual levels of 153 thousand t were recorded for year 2017, 160 thousand t in 2018 and 155 thousand t in 2019. As a result, the average of the period recorded a level of 156 thousand t. Under these circumstances, the evolution of the indicator is ascending-uneven – increases by 1.31, 1.96 and 4.58% for the average of the period and respectively at the level of 2019 and 2018.

If we refer to the specific situation of lemon and lime consumption, there are limits of variation of 61 (2017) and 62 thousand t (2018 and 2019, respectively), levels that led to an average of 61.67 thousand t. In these circumstances, there is a uniform upward-trend of the indicator, the comparison base being exceeded as follows: +1.64% for 2018 and 2019, +1.10% for the average period.

For grapefruit and derived products, consumption levels from 3 thousand t (2018) to 10 thousand t (2017) are found, and the average indicator was 6.33 thousand t. The dynamics of the indicator contains strictly subunit values - decreases compared to the comparison term by 36.70% at the level of the average of the period, by 40% in 2019 (6 thousand t) and by 70% in the case of 2018.

The quantities consumed from other citrus fruits were characterized by a uniform evolution – level of 1 thousand tons for all components of the dynamic series. In the case of consumption of apples and derived products, annual sequential levels of 530 thousand t were recorded for 2017, 583 thousand t for 2018 and 603 thousand t for 2019, respectively. Thus, the average of the period had a level of 572 thousand t. Under these circumstances, we observe an upward evolution of the indicator – annual increases of 1.10 and 1.13 times at the level of 2018 and 2019, respectively. The average period, exceeded the reporting level by 7.92%.

If we refer to the specific situation of grape consumption, there are limits of variation of 1,013 and 1,192 thousand t for 2019 and 2018, respectively, levels that, corroborated with the specific situation of 2017 (1,126 thousand t) led to an average of 1,110.33 thousand t. In these circumstances, there is an uneven trend of the indicator, compared to the comparison base being recorded exceedances and decreases, as follows: +5.86% for 2018, -10.04% for 2019, -1.39% for the average period.

For other fruits, consumption levels are found from 863 thousand t (2017) to 1,373 thousand t (2018), and the average indicator was 1,123.33 thousand t. The dynamics of the indicator contains only supra-unitary values - exceedances of the comparison term by 59.10% in 2018, 31.40% for 2019 and 30.17% at the level of the average of the period. As a result, it can be said that the evolution was an upward-fluctuating one.

The total recorded fruit consumption is characterized by an average of 3,255.33 thousand t (+9.87% compared to the reporting base - 2017), level based on annual situations of: 2936 thousand t in 2017, 3606 thousand t in 2018 and 3197 thousand t for 2019. The dynamics shows an upward-uneven evolution - the indices were strictly supra-unitary: 121.70% for 2018, 107.90% for 2019.

If we analyze the structure of total fruit consumption, at national level (average of the period), we find variable weights of different products, as follows (Fig. 1): 34.51% other fruits; 34.11% grapes; 17.57% apples and products thereof; 6.46% bananas; 4.79% oranges and mandarins; 1.89% lemons and limes; 0.45% pineapple and products thereof; 0.19% grapefruit and products thereof; 0.03% other citrus fruits.

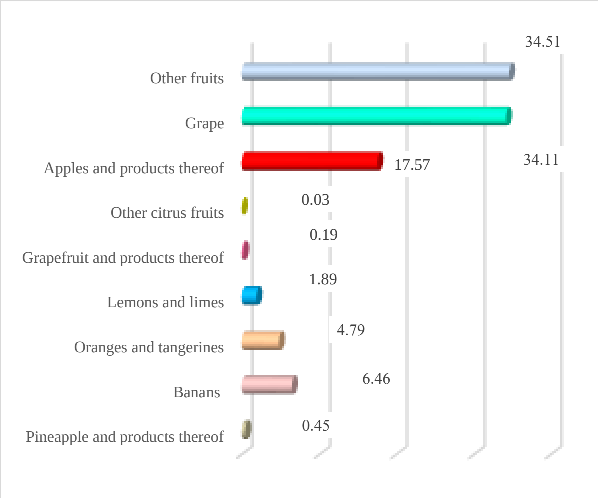

Fig. 1. Structure of total fruit consumption in Romania – average period (%)
Source: own calculations.

Table 2, shows the consumption of fruits and fruit products per inhabitant, at national level. In the case of consumption of pineapple and derived products, annual sequential levels of 0.75 kg were recorded for 2017, 0.77 kg for 2018 and 0.70 for 2019, respectively. So, the period average period reached a level of 0.74 kg. Under this conditions, the evolution of the indicator is fluctuating – annual increase of 1.02 times at the level of 2018 and decreases respectively for 2019 and the average of the period by 6.67 and 1.33%. If we refer to the specific situation of banana consumption, there are limits of variation of 10.03 and 10.73 kg for 2017 and 2018, respectively, levels that corroborated with the specific situation of 2019 (10.36 kg) led to an average of 10.37 kg. Under these circumstances, there is an upward-uneven trend of the indicator – effective values of 106.98, 103.29 and 103.39% for 2018, 2019 and respectively for the average of the period. For oranges and mandarins, consumption levels range from 6.95 kg (2017) to 7.32 kg (2018), and the average indicator was 7.15 kg. The dynamics of the indicator contains only supra-unitary values of the component indices (compared to the reporting deadline 2017): 105.32% in 2018, 103.31% in 2019 (7.18 kg) and 102.88% at the average level of the period.

Table 2. Fruit consumption per inhabitant in Romania – kg (2017-2019)

Specification	Year						Period average**		
	2017		2018		2019				
	Effective*	Ibf** (%)	Effective*	Ibf** (%)	Effective*	Ibf** (%)	Effective	Ibf %	Structure %
Pineapple and products thereof	0.75	100	0.77	102.67	0.70	93.33	0.74	98.67	0.72
Banans	10.03	100	10.73	106.98	10.36	103.29	10.37	103.39	10.15
Oranges and tangerines	6.95	100	7.32	105.32	7.18	103.31	7.15	102.88	7.01
Lemons and limes	2.95	100	3.01	102.03	3.06	103.73	3.01	102.03	2.95
Grapefruit and products thereof	0.48	100	0.44	91.67	0.32	66.67	0.41	85.42	0.40
Other citrus fruits	0.05	100	0.04	80.0	0,05	100.0	0.05	100.0	0.05
Apples and products thereof	24.39	100	26.23	107.54	27.46	112.59	26.03	106.72	25.49
Grape	13.54	100	14.37	106.13	17.90	132.20	15.27	112.78	14.95
Other fruits	32.59	100	44.67	137.07	40.01	122.77	39.09	119.94	38.28
Total	91.73	100	107.58	117.28	107.04	116.69	102.12	111.33	100

Source: *https://www.fao.org/faostat/fr/#data/FBS(20.02.2023) [9].
**own calculations.

The consumption of lemons and limes recorded is characterized by an average of 3.01 kg (+2.03% compared to the reporting base – 2017), a level based on annual situations of: 2.95 kg for 2017, 3.01 kg for 2018 and 3.06 kg for 2019. The dynamics shows an upward trend, the indices were supra-unitary for 2018 and 2019: 102.03 and 103.73%.

In the case of grapefruit consumption and derived products, annual sequential levels of 0.48 kg were recorded for 2017, 0.44 kg in 2018 and 0.32 kg in 2019, respectively. As a result, the average of the period recorded a level of 0.41 kg (-14.58% when compared to the reference term – 2017). Under this conditions, the evolution of the indicator is a decreasing one, highlighted by the level of dynamics indices: 91.67% in 2018, 66.67% in 2019.

If we refer to the specific situation of consumption of other citrus fruits, there are limits of variation of 0.04 and 0.05 kg for 2018 and 2017 and 2019, respectively, levels that led to an average of 0.05 kg. In these circumstances, there is a downward-uniform trend of the indicator, compared to the comparison base, with decreases of 20.0% for 2018 and equal levels for the rest of the terms of the dynamic series.

For apples and derived products, consumption levels range from 24.39 kg (2017) to 27.46 kg (2019) and the average indicator was 26.03 kg. The dynamics of the indicator contains only supra-unitary values (evolution is ascending) - exceedances of the comparison term by 7.54% in 2018 (26.23 kg), 12.59% in the case of 2019 and 6.72% at the level of the average of the period.

The recorded grape consumption is characterized by an average of 15.27 kg (+12.78% compared to the reporting base – 2017), level based on annual situations of: 13.54 kg in 2017, 14.37 kg in 2018 and 17.90 kg respectively in 2019. The dynamics shows an upward evolution, the reporting base being surpassed by 1.06, 1.32 and 1.12 times in 2018, 2019 and respectively by the average of the period.

If we refer to other fruits - consumption -, we observe sequential annual levels of 32.59 kg that were recorded for 2017, 44.67 kg in 2018 and 40.01 kg in 2019, respectively. As a result, the average period recorded a level of 39.09 kg. Under these circumstances, the evolution of the indicator is ascending-uneven – differences compared to the reference term, as follows: +37.07% in 2018, +22.77% in 2019, +19.94% for the average of the period.

If we refer to the specific situation of total fruit consumption, there are limits of variation of 91.73 and 107.58 kg for 2017 and 2018, respectively, levels that corroborated with the specific situation of 2019 (107.04 kg) led to an average of 102.12 kg. In these circumstances, the upward-uneven trend of the indicator is observed, the comparison base being exceeded as follows: +17.28% for 2018, +16.69% for 2019, +11.33% for the average period.

At national level, the structure of fruit consumption per inhabitant (average of the period) was (Fig. 2): 0.05% other citrus fruits; 0.40% grapefruit and derived products; 0.72% pineapple and products thereof; 2.95% lemons and limes; 7.01% oranges and mandarins; 10.15% bananas; 14.95% grapes; 25.49% apples and products thereof; 38.28% other fruits.

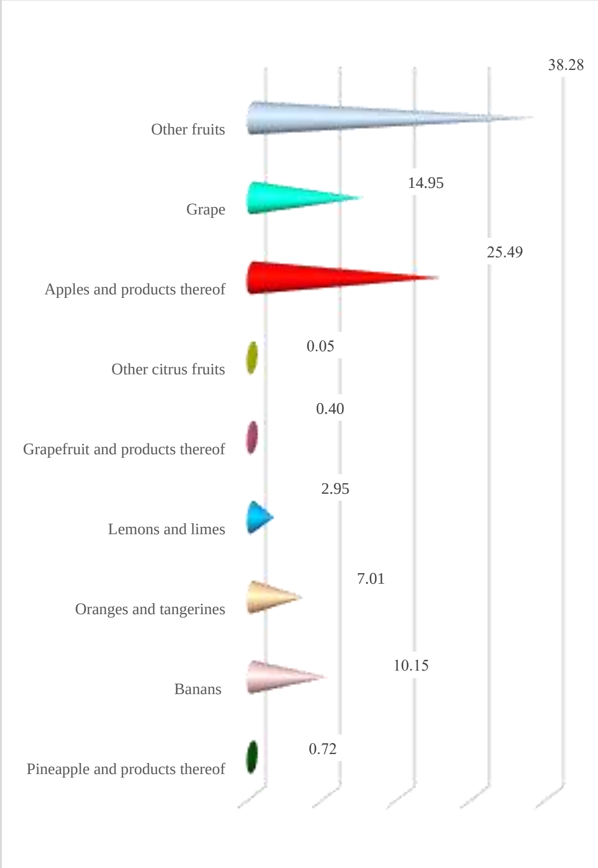

Fig. 2. Structure of fruit consumption per inhabitant in Romania – average period (%)
Source: own calculations.

Table 3 shows Romania's positioning at international level, in terms of fruit consumption.

Worldwide, Romania accounted for an average of 0.45% of total fruit consumption, and for the rest of the products the threshold of 1% is exceeded only for grapes (1.46%). Romania, regardless of consumption for other citrus fruits, has very low shares for pineapple and derived products, grapefruit and derived products, bananas, oranges and mandarins (0.06, 0.07, 0.14 and 0.15%, respectively) and higher shares for lemons and limes, other fruits as well as for apples and derived products (0.34, 0.48 and 0.67%, respectively - Fig. 3). In the Community context, Romania held shares of about 4.70% for total fruit consumption.At the level of the component products of the group, there are situations exceeding the aforementioned level (5.77% for apples and derived products; 8.33% for other fruits), but also situations placed below this level (1.24% - pineapple and derived products; 3.85% - bananas; 1.45% - oranges and mandarins; 3.52% - lemons and limes; 1.51% grapefruit and derived products; 0.69% - other citrus fruits; 4.30% - grapes). These aspects are shown in Figure 3.

If we refer, strictly, to Romania's positioning in the global and community context, in terms of consumption per capita, the following aspects are noteworthy: compared to the world situation, Romania has exceeded the specific level for total consumption of fruits (+15.0%) and those for other fruits (+41.58%), lemons and limes (+48.28%), apples and derived products (+193.46%), grapes (+224.04%).

Table 3. Romania's share in international fruit consumption – average period (%)*

No.	Specification	Total consumption		Consumption per capita	
		% from the world level	% from the community level	% compared to the world level	% compared to the community level
1	Pineapple and products thereof	0.06	1.24	25.69	30.58
2	Banans	0.14	3.85	62.92	98.48
3	Oranges and tangerines	0.15	1.45	58.04	34.76
4	Lemons and limes	0.34	3.52	148.28	87.25
5	Grapefruit and products thereof	0.07	1.51	39.05	47.13
6	Other citrus fruits	-	0.69	3.03	15.15
7	Apples and products thereof	0.67	5.77	293.46	175.76
8	Grape	1.46	4.30	334.04	159.73
9	Other fruits	0.48	8.33	141.58	148.86
10	Total	0.45	4.73	115.0	131.61

Source: *own calculations.

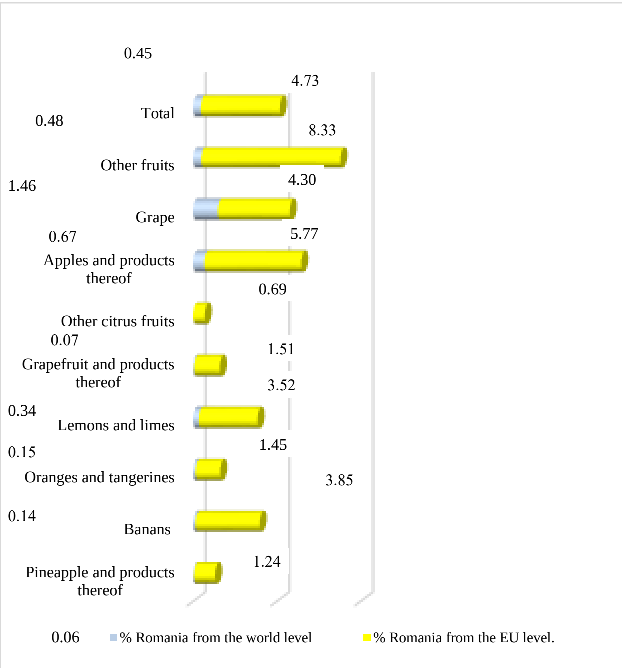

Fig. 3. Romania's share in the international context of total fruit consumption – average of the period (%)
Source: own calculations.

Romania ranks below the world level with: 37.08% for bananas, 41.96% for oranges and mandarins, 60.95% for grapefruit and derived products, 74.31% for pineapple and derived products, 96.97% for other citrus fruits (Fig. 4).

Compared to the Community situation, Romania exceeded the level of the indicator for apples and derived products, grapes, other fruits and at general level (175.76, 159.73, 148.86 and 131.61%, respectively).

In the rest of the situations, we are below the Community level, as follows: 98.48% for bananas, 87.25% for lemons and limes, 47.13% for grapefruit and derived products, 34.76% for oranges and mandarins, 30.58% for pineapples and derived products, 15.15% for other citrus fruits (Fig. 4).

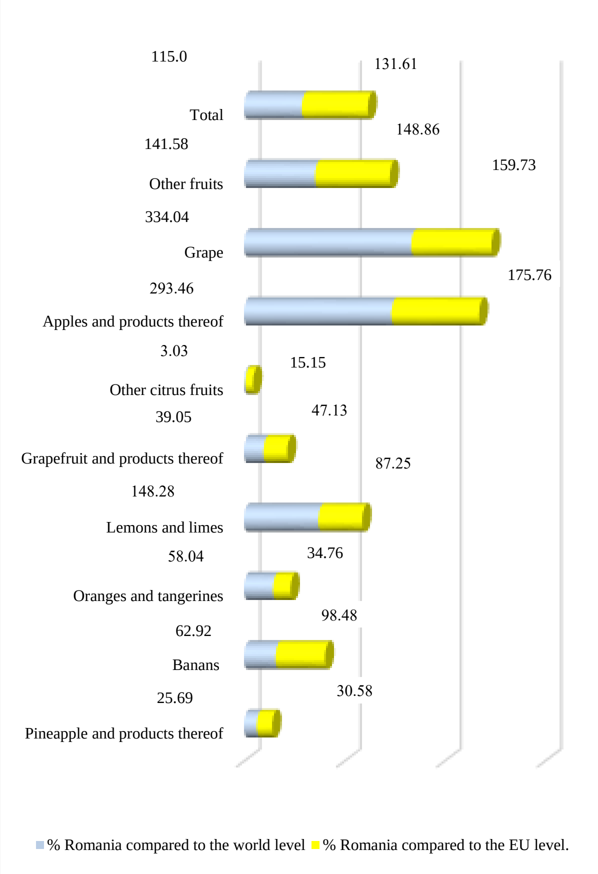

Fig. 4. Romania's positioning in the international context of fruit consumption per capita – average of the period (%)
Source: own calculations.

CONCLUSIONS

Total consumption evolved upward-uneven, except for apples (upward trend), lemons and limes (upward-uniform trend), other citrus fruits (uniform evolution), pineapple (uniform-downward trend), grapes (fluctuating trend), grapefruit (downward-uneven trend).

The consumption of grapes, other fruits and apples (about 86%) is predominant. This aspect must also be assessed in accordance with the zoning of species, depending on the favorability of the cultivation areas, but also according to the consumption habits of the population.

The consumption per capita registered an upward-uneven trend, situation from which grapes deviate, namely lemons and limes (upward trend), pineapple (fluctuating trend), other citrus fruits (downward-uniform evolution) and grapefruit (downward trend). There are pronounced amplitudes for other fruits, grapes and apples (12.08, 4.46 and 3.07 kg respectively), but for other citrus fruits and pineapples the amplitude of variation is reduced (0.01 and 0.07 kg).

Currently, for Romania, it is necessary to revive both fruit plantations and the processing industry, given that most of the consumption is ensured by imports of specific products. To these must be added an adequate involvement of the state at the level of intermediaries. In conjunction with this, measures must be taken to influence the purchasing and implicitly consumption behavior of the population, in order to improve the share of fruits and fruit products in the structure of total food consumption. These aspects can be improved by food, industrial, commercial and agricultural policy regulations.

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THE IMPACT OF CLIMATE CHANGES ON THE DEVELOPMENT OF AGRICULTURE AND FOOD SECURITY (CASE OF UKRAINE AND SLOVAKIA)

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Abstract

The purpose of the paper was to assess the impact of climate changes on agricultural development and food security in Ukraine and Slovakia using statistical data from Statistical Office of the Slovak Republic, State Statistics Service of Ukraine, Eurostat, Food and Agriculture Organization and other sources. The comparison method was used to evaluate changes in agricultural development indicators, as well as climate changes in 1998-2021 in Ukraine and Slovakia. The main indicators of agricultural development used in the research were agricultural raw materials exports(%), agricultural raw materials imports (%), agriculture value added (% of GDP), agriculture value added (annual % growth), agriculture value added (current US$), cereal production (metric tons), cereal yield (kg per hectare), crop production index, food production index. Correlation and regression equations were used to establish the relationship between climatic factors and agricultural development indicators. The multiple correlations between air temperature and indicators of agricultural development was r=0.75 for Ukraine, r=0.69 for Slovakia. Using neuromodeling tools, the indicators of cereal production volumes and cereals yields in Ukraine and Slovakia in 2024-2033 were predicted. Tables were used to summarize the results. In conclusion, it should be noted that climatic conditions should be analyzed in each sector of crop production, and measures should be taken to adapt technologies for the gradual expansion of obligations for the production and export of agricultural products to world markets.

Key words**:** *agriculture, climate change, food security, agricultural development indicators, Ukraine, Slovakia.*

INTRODUCTION

The relevance of the issue of the impact on the development of agriculture and food security of global climate changes lies in the fact that the last decades in many countries of the world have been characterized by noticeable climate changes, which are manifested in the increase in the average annual temperature, in the rise in the level of the oceans, in the increase in the number of natural disasters, in such phenomena, such as desertification, landslides, hurricanes, floods, floods, heavy downpours, hail, droughts, etc. Therefore, climate change affects food production, the food environment and socio-economic conditions, affects the quality of food and the degree of malnutrition, that is, global food security. The global system of food production is forced to adapt to the growth of the planet's population and climate change. Due to unpredictable changes in the weather, agriculture, namely food production, which is an important feature for the normal functioning of mankind, is at risk.

Sun et al. emphasize that in the coming decades, due to global warming, the productivity of agriculture will decrease by 17%. Instead, the need for agricultural production will increase by 70% by 2050 to meet the food shortage due to the increase in the number of the global population [22].

Birgani et al. examine in detail the issue of providing food to the population and note that climate change is a key problem for the development of agriculture in the world. In the case of climate change, the yield of certain agricultural crops may decrease in certain regions, which is the reason for the increase in food prices, and, in turn, affects the diet and level of consumption, and, accordingly, food security. The increase in average temperature and uneven distribution of precipitation caused by global climate changes can lead to the transformation of climatic and agricultural zones [4]. Demyanjuk claims that the climate changes taking place can affect the redistribution of natural resources among different states and cause a conflict of their interests [8]. Fuglie summarizes that today one of the main areas of the economy is agriculture, which guarantees food security and the production of quality food products. Climate change has a significant negative impact on agriculture, primarily on crop yields, quantity and quality of food products [14]. Seppelt et al. emphasize that extremely high temperatures, droughts, excessive intense precipitation, or their absence, disruption of the rhythm and duration of seasonal weather changes have a significant impact not only on production, but also on the use of food [19].

Chandio et al. explain that in connection with the fact that agriculture is one of the main branches of the economy of many countries of the world, the share of GDP of which is a significant specific weight, there is a need to improve existing models of agricultural production and optimize methods of managing agricultural systems in accordance with climate changes [6]. Climate change is a global and long-term phenomenon that requires global coordination and a forward-looking approach according to Kompas et al. [17].

Abbade defines that food products are the main and indispensable in the full functioning of a person. Based on this, the development of the food industry and agricultural products, which are the basis of nutrition, act as a demographic factor, that is, they are key to the realization of basic human needs. Food security is characterized as a state of the economy and belongs to one of the factors of national security, which contributes to the sustainable development of society. That is, it is considered as the state of food production in the state, which has the opportunity to fully realize the needs for quality food products of every citizen, provided that it is balanced and available to the extent necessary for maintaining human health and working capacity [1].

Allen & Prosperi conclude that solving the country's food security problem is impossible without ensuring the quality and safety of food products. The main directions of achieving food safety are clear compliance and control of sanitary and hygienic requirements, technological instructions, recipes, modes of processing, storage, transportation, sale of raw materials and finished products [3]. Climate change has an impact on crop yields, micronutrient deficiencies, rising food prices, shortages of quality food products, and a decrease in food security (according to research by Burke et al.) [5]. Affoh et al. point out that already 821 million people on the planet suffer from hunger, and more than 2 billion people suffer from micronutrient deficiencies, including iron and zinc, which are a major cause of death and disease. And this situation tends to worsen. Low- and middle-income countries are already on the brink of nutrient deficiencies. Deficiency of trace elements has negative consequences for the health of the population [2].

Stoicea et al. say in their research that climate change will cause drought in more than 60% of the areas where wheat, an important source of food and energy, is grown. The growing of leguminous crops is becoming more difficult due to increased drought. Such climate changes threaten the loss of such foods as durum wheat pasta, coffee, cocoa beans, nuts, and some vegetables and fruits [21].

Adaptation to climate change is a key challenge for managing the impacts of climate change on food security, the food environment and human health. Preventive actions are very important in this direction, as climate change reduces the opportunities for successful adaptation and increases the associated costs.

Strategies aimed at minimizing the impact of the results of climate change are focused on stable production of necessary food products, healthy nutrition and reduction of food waste (according to the research of Radin Firdaus and others) [11]. The trends observed in agrarian business require constant monitoring, evaluation and management decisions to prevent a food crisis. In the long run, food security depends on how successfully it will be possible to adapt agricultural systems to climatic phenomena, taking into account a comprehensive understanding of production systems, logistics, food consumption and social and economic characteristics of the countries of the world [11].

However, the impact of rising average temperatures, changing precipitation regimes, and the growth of extreme weather events affecting the world's crop production and livestock production in the world is uneven. In the southern countries, the changes will be very negative, which will affect them in reducing the yield of agricultural crops. However, warming will have a positive effect on agriculture in countries located in northern latitudes [9]. Forecasts indicate that the negative consequences of climate change will have the most negative impact on agriculture in India, sub-Saharan Africa and South Asia [12]. However, global warming will have a beneficial effect on North America, some areas of South America (for example, Chile), Eastern Europe and Central Asia [13]. That is, the international export of agricultural products will change. There will be a concentration of international agricultural markets, that is, the main volume of exports will fall on a smaller number of countries. In this connection, the comparative advantages and the level of competitiveness of agriculture in different countries will change. Some countries will benefit from climate change, and some will lose. The problem of global warming is one of the most important problems of the world economy. Damages to the world economy are estimated at hundreds of billions of dollars per year, and in the future, by 2100, they may reach 20% of the global gross product [18]. The economic consequences of global warming affect both the growth and the quality of agricultural products with high economic value. The negative impact on the agricultural sector will increase the level of poverty in rural areas [7].

Among the main indicators used by scientists when analysing the impact of climate change on the development of agriculture are the trend of temperature changes and changes in the amount of precipitation. At the same time, each of the models has its own characteristics. The temperature level affects the growth rate of per capita production only temporarily [15]. Macroeconomic climate-economics models almost always assume that temperature is a level effect [16].

Therefore, the strategy of adaptation to climate change is aimed at strengthening the ability to continue agribusiness in the conditions of climate change, responding to natural challenges at the micro and macro levels. The purpose of the research is to assess the impact of temperature changes and the amount of precipitation on the economic indicators of agricultural development, namely the level of export and import of agricultural raw materials, the increase in the added value of agriculture, the production and yield of grain crops, the index of crop production and the index of food production, as well as determination of the nature of fluctuations of these indicators in Ukraine and Slovakia under the influence of changes in climatic conditions and forecasting future trends in the economic development of agriculture in the countries.

MATERIALS AND METHODS

The research work is based on a large amount of information, including empirical data from the State Statistics Service of Ukraine, the Office of Statistics of the Slovak Republic, Eurostat and other sources [23, 20, 10, 24]. The main indicators used in this study were indicators for Ukraine and Slovakia, namely Agricultural raw materials exports (% of merchandise exports) (Var1), Agricultural raw materials imports (% of merchandise imports) (Var2), Agriculture, value added (% of GDP) (Var3), Agriculture, value added (annual % growth) (Var4), Agriculture, value added (current US$) (Var5), Cereal production (metric tons) (Var6), Cereal yield (kg per hectare) (Var7), Crop production index (Var8), Food production index (Var9), Average precipitation, Average annual temperature. The study period is 24 years (from 1998 to 2021). Correlation coefficients were calculated between economic indicators of agricultural development and temperature, as well as precipitation. Regression equations were used to assess the dependence of economic indicators of agricultural development on the level of temperatures and precipitation. Using neuromodeling tools, the indicators of cereal production volumes and cereal yields in Ukraine and Slovakia in 2024-2033 were predicted. Tables were used to summarize the results. The conclusions present the main ideas drawn from this research.

RESULTS AND DISCUSSIONS

Consider the impact of climate change on the development of agriculture using the examples of Slovakia and Ukraine. Annual data for 1998-2021 are used for calculations. Table 1 presents dynamics of indicators of the development of agriculture in Ukraine, as well as average temperature and average precipitation in 1998-2021.

The data in Table 1 show that for 24 years, agriculture accounted for 7-13% of the GDP of Ukraine, starting from 2002 (except for 2008).

Also, the export of agricultural products exceeded the import, the grain yield increased more than 2 times from 1998 to 2021.

Table 1. Dynamics of agricultural development indicators in Ukraine, as well as average temperature and average precipitation in 1998-2021

Year	Agricultural raw materials exports (% of merchandise exports)	Agricultural raw materials imports (% of merchandise imports)	Agriculture, value added (% of GDP)	Agriculture, value added (annual growth%)	Agriculture, value added (current US$)	Cereal production (metric tons)	Cereal yield (kg per hectare)	Crop production index	Food production index	Average precipitation (in mm)	Average annual temperature (°C)
1998	1.09	1.95	12.07	-11.18	5054414941.57	25699039.30	2,109.40	44.3	59.6	599.88	8.62
1999	1.61	1.67	11.88	-3.95	3750204275.98	23960468.59	2,002.90	40.7	56.5	546.34	9.63
2000	1.69	1.50	13.95	12.10	4516901848.57	23814123.87	1,950.80	49.2	61.8	520.39	9.48
2001	1.49	1.53	13.98	10.02	5493940916.96	38886120.16	2,729.50	55.4	66.2	629.94	9.01
2002	1.81	1.32	12.60	1.91	5539905662.59	37984706.45	2,752.20	55.5	68	543.15	9.45
2003	1.85	1.33	10.50	-11.12	5460847921.30	27493983.59	2,278.40	52.8	66	519.64	8.36
2004	1.55	1.35	10.44	19.71	7015792442.19	40996700.00	2,845.20	63.1	72.7	642.54	8.92
2005	1.47	1.32	8.88	0.28	7920223684.02	37258000.00	2,623.00	63.1	72.6	598.85	9.06
2006	1.36	1.17	7.24	1.66	8099405940.59	33518621.59	2,427.70	62.6	72.8	555.95	8.68
2007	1.29	1.02	6.28	-6.17	9344950495.05	28945257.88	2,206.70	56.5	67.6	532.89	10.22
2008	0.87	0.89	6.54	16.87	12293768360.51	52747334.16	3,486.90	79.6	84.2	549.99	9.72
2009	1.18	1.09	6.91	-2.00	8393657133.15	45413410.45	3,003.80	74.2	80.1	565.94	9.67
2010	1.15	1.08	7.40	0.21	10452591863.71	38685986.74	2,726.60	70.2	77.6	665.72	9.46
2011	1.07	0.99	8.15	19.57	13801083505.73	56263263.02	3,753.70	91.9	94	456.03	9.08
2012	0.99	0.96	7.76	-4.00	14171515993.27	45750171.09	3,156.80	83.7	88.1	563.63	9.53
2013	1.27	0.99	8.69	12.64	16558738896.53	62687581.61	4,030.80	99.6	101.2	574	9.76
2014	1.77	1.09	10.15	-0.68	13556794583.86	63388560.00	4,400.20	100.1	101.1	521.01	9.75
2015	2.15	1.14	12.06	-4.38	10977766896.18	59627180.00	4,140.90	96.1	96.8	492.5	10.36
2016	2.11	1.24	11.73	6.33	10946629977.24	65217850.00	4,651.60	103.8	102.1	639.33	9.71
2017	1.74	1.18	10.18	-2.52	11408184810.41	60689783.33	4,311.30	100.8	100.1	526.29	9.84
2018	2.02	1.06	10.14	8.18	13271745069.03	69112267.78	4,847.30	111.1	107.3	549.6	9.88
2019	1.74	0.97	8.97	1.00	13795893581.74	74443852.37	4,975.80	112.8	108.9	462.25	10.67
2020	1,71	1,05	9,31	-10,7	14581346358.46	64343120.16	4,293.40	100.9	99.3	497.11	10.86
2021	1.57	1.02	10.89	15.13	21746055913.64	85338631.18	5,453.10	96.50	92.10	623.82	9.38

Source: Statistical information of Ukraine [23].

The index crop production increased more than twice from 1998 to 2019, the downward trend of this indicator can be traced in 2020-2021, the same situation with the food production index. Regarding climatic conditions, the average annual temperature has increased by 2 degrees Celsius over 24 years and there is no direct trend in the average amount of precipitation.

In order to compare the trends of the indicators, similar initial data for the Slovak Republic were formed. Table 2 presents dynamics of agricultural development indicators in Slovakia, as well as temperature and precipitation in 1998-2021.

Table 2. Dynamics of agricultural development in Slovakia, as well as temperature and precipitation in 1998-2021

Year	Agricultural raw materials exports (%)	Agricultural raw materials imports (%)	Agriculture, value added (% of GDP)	Agriculture, value added (annual growth%)	Agriculture, value added (current US$)	Cereal production (metric tons)	Cereal yield (kg per hectare)	Crop production index	Food production index	Average annual temperature (°C)	Average precipitation (in mm)
1998	2.32	1.74	2.12	-0.39	634341648.95	3485707.64	4,054.90	96.7	127.7	8.35	822
1999	2.49	1.75	1.64	-23.84	500855247.02	2829922.00	3,857.40	89.7	121.5	8.65	765
2000	2.18	1.85	1.71	14.65	500137118.91	2202543.00	2,709.90	72.9	102.5	9.46	845
2001	2.07	1.63	2.12	32.50	652577168.89	3212188.00	3,889.70	88.4	110.6	8.35	841
2002	1.90	1.61	2.04	5.75	721098305.35	3197881.00	3,899.70	87.7	113.7	9.12	573
2003	1.57	1.51	1.81	4.69	849431322.57	2490571.00	3,136.00	74.3	104.3	8.51	851
2004	1.53	1.38	1.67	1.01	957758759.40	3797352.00	4,641.80	98.1	116.3	8.26	938
2005	1.78	1.27	1.62	6.11	1016738995.55	3585251.00	4,511.80	92.7	113.2	7.95	776
2006	1.31	1.15	1.85	22.49	1307989940.04	2928803.00	3,996.30	82.7	105.1	8.42	894
2007	1.07	1.19	2.30	26.35	1987506996.33	2793485.00	3,561.20	76.3	100.5	9.44	873
2008	0.95	1.03	2.53	20.01	2555490574.15	4137019.00	5,175.30	100.9	114.3	9.45	890
2009	1.25	1.14	2.09	-3.19	1864094626.84	3332824.00	4,331.50	87.2	101.2	9.12	1,255
2010	1.29	1.41	1.57	-22.59	1429781447.85	2554376.00	3,737.30	69.1	87.2	8.10	656
2011	1.06	1.49	1.88	17.81	1879983116.32	3714041.00	5,009.00	89.6	99,00	8.84	747
2012	1.06	1.44	1.90	-1.45	1799615055.79	3035809.80	3,829.10	70.2	85.4	9.01	864
2013	0.99	1.41	2.22	22.63	2198643632.96	3411961.00	4,490.40	82.1	93.5	8.94	934
2014	0.96	1.10	2.75	32.96	2788252132.11	4707654.80	6,038.70	105.00	104.7	10.07	719
2015	0.92	1.02	2.20	-16.15	1952156864.69	3805712.00	5,079.60	86.7	89.6	9.82	924
2016	0.87	0.97	2.24	8.74	2017081869.95	4847544.00	6,430.40	108.3	105.7	9.2	827
2017	0.84	1.07	2.09	-6.02	1999441918.82	3484061.00	4,856.00	87.5	91.9	9.08	674
2018	0.87	1.05	2.15	13.59	2276713780.32	4020160.00	5,409.70	96.8	97.9	10.05	848
2019	0.81	1.08	1.67	-18.34	1764047782.01	4104050.00	5,336.00	93.5	97.9	10.14	886
2020	0.83	1.06	1.73	5.55	1847134419.08	4580900.00	6,129.80	101.1	101.3	9.93	761
2021	0.99	1.21	1.78	-1.34	2108828338.35	4289470.00	5,976.80	99.8	97.4	8.78	822

Source: Statistical Office of the Slovak Republic [20] and Eurostat [10].

From 1998 to 2006, as well as in 2008-2009, there was an excess of export of agricultural products over import in Slovakia, during the last decade, import of agricultural products was greater than export. The specific weight of GDP from agriculture fluctuates for 24 years at the level of 2%. The grain yield is constantly fluctuating, but in general there is an almost 2-fold increase. There are no clear trends for crop production and food production indices, the values have approximately the same dynamics. There is no significant change in climatic indicators.

The assessment of the impact of changes in average temperature and average precipitation on economic indicators in the agriculture of the countries under consideration, namely Ukraine and Slovakia, is carried out with the help of correlation-regression analysis tools, using the STATISTICA 13.5.

Table 3 presents results of the regression analysis of the dependence of the agricultural development indicators of Ukraine on changes in climatic conditions.

Table 3. Results of the regression analysis of the dependence of the agricultural development indicators of Ukraine on climate change

	b* coefficient	**Std. Err. - of b* Standard error**	**t statistics**	**p-value**
Intercept	12.91766	3.732659	3.46071	0.003822
Var1	-0.01638	0.428632	-0.03821	0.970059
Var2	-0.53130	0.533450	-0.99596	0.336173
Var3	0.36755	0.446027	0.82405	0.423729
Var4	-0.43999	0.238892	-1.84178	0.086789
Var5	-0.47869	0.589395	-0.81217	0.430286
Var6	1.86204	2.488206	0.74835	0.466637
Var7	-2.25903	2.777485	-0.81334	0.429642
Var8	4.38580	4.316815	1.01598	0.326876
Var9	-3.21244	3.612327	-0.88930	0.388867

Source: Own calculation on the basis of data from Statistical information of Ukraine [23].

The results of multiple regression show the impact of changes in temperature and precipitation on indicators of the efficiency of agriculture in Ukraine. The most significant is the dependence on climate change of the indicators of cereal production, their productivity and indexes of crop production and food production.

The multiple correlation coefficient (Multiple R = 0.74627918) testifies to the high closeness of the connection between the change in temperature and indicators of the efficiency of agricultural development in Ukraine. The coefficient of determination (R^2= 0.55693262) shows that a significant part of the variability of the variable can be explained with the help of the built model, that is, the value of the coefficient of determination determines the significant share of changes due to the influence of factor characteristics in the overall variability of the resulting characteristic. The coefficients of the multiple regression model are given in column 1. The most statistically significant are highlighted in red.

The results of the regression analysis of the dependence of indicators of the agricultural economy of Ukraine on changes in the amount of precipitation showed a high degree of correlation between indicators of the effectiveness of agricultural development.

The multiple correlation coefficient (Multiple R = 0.74627918) testifies to the high closeness of the connection between the indicators of the development of agribusiness in Ukraine and the change in the average annual temperature. At the same time, the coefficient of determination (R^2= 0.55693262) indicates that a significant part of the variability of the variable can be explained by the constructed multiple regression model.

Table 4 presents the results of a regression analysis of the dependence of the agricultural development indicators of Slovakia on changes in the average annual temperature.

The results of the regression analysis indicate the significant dependence of Slovakia's agriculture on climate change. The values of the coefficients indicate the dependence between such indicators as grain yield, grain production volume, crop production index, food index and increase in average annual temperature. The same trends are taking place in the agricultural market of Ukraine.

Table 4. Results of the regression analysis of the dependence of the agricultural development indicators of Slovakia on climate change

	b* coefficient	Std.Err. - of b* Standard error	t statistics	p-value
Intercept	9.431189	3.057398	3.08471	0.008074
Var1	-0.29521	0.948842	-0.31113	0.760288
Var2	0.10064	0.507005	0.19849	0.845512
Var3	0.26588	0.413372	0.64319	0.530498
Var4	-0.18881	0.259655	-0.72714	0.479123
Var5	0.11514	0.756507	0.15220	0.881199
Var6	0.59929	1.353204	0.44287	0.664628
Var7	-1.76363	1.773285	-0.99456	0.336832
Var8	1.51799	1.576221	0.96306	0.351860
Var9	-0.96213	0.809968	-1.18787	0.254648

Source: Own calculation on the basis of data from Statistical Office of the Slovak Republic [20] and Eurostat [10].

The multiple correlation coefficient (Multiple R = 0.68744870) testifies to the high closeness of the connection between the indicators of the development of agrarian business in Slovakia and the increase in temperature in this country. At the same time, the coefficient of determination (R^2= 0.47258572), which is less than the similar one in Ukraine, means that the variability of the variable can be explained with the help of the constructed regression model.

The results of the dependence of indicators of the agricultural economy of Slovakia on changes in the amount of precipitation showed a low degree of correlation with indicators of the effectiveness of agricultural development, but a significant one in general.

The multiple correlation coefficient (Multiple R = 0.46845539) indicates a moderate closeness of the relationship between the change in the amount of precipitation and indicators of the efficiency of agricultural development in Slovakia. The coefficient of determination (R^2= 0.21945045) shows that a small part of the variability of the variable can be explained by the constructed multiple regression model. According to the obtained values and interdependencies, using neuromodeling tools in STATISTICA 13.5, it is possible to forecast such indicators as Cereal production (metric tons) and Cereal yield (kg per hectare) for 2024-2033 for Ukraine and Slovakia. The dynamics of economic indicators within the framework of the researched process act as input information for the neural network, that is, the data on which it learns. In the process of applying the neuromodeling toolkit, typical regularities of the dynamics of changes in agribusiness development indicators are formed in order to assess the development of the time series, which will be recognized by the Kohonen layer. These images are the examples for neural network training. In this case, the studied image is the dynamics of agricultural development indicators over a certain period of time, and the task of the neural network is to recognize this image and establish the class to which it corresponds. To predict the dynamics of indicators of agricultural development, a neural network of counterpropagation is built based on the combination of layers of Kohonen and Grossberg neurons. Model parameters are calculated during network setup.

Tables 5 and 6 present the results of forecasting indicators of the development of agriculture in Ukraine and Slovakia.

Table 5. Predictions for cereal production (metric tons) and cereal yield (kg per hectare) in Ukraine

Year	Cereal production (metric tons)			Cereal yield (kg per hectare)		
	Pessimistic prediction	Most probable prediction	Optimistic prediction	Pessimistic prediction	Most probable prediction	Optimistic prediction
2024	25699039	46950800	46933312	2,109.400	3,331.660	3,427.934
2025	23960469	46676412	46872449	2,002.900	3,311.817	3,427.089
2026	23814124	46464254	46863456	1,950.800	3,307.404	3,424.084
2027	38886120	47230434	46935438	2,729.500	3,335.049	3,432.178
2028	37984706	46629114	46877374	2,752.200	3,312.501	3,426.105
2029	27493984	46328742	46897766	2,278.400	3,316.968	3,419.382
2030	37258000	46998407	46919473	2,623.000	3,327.727	3,429.645
2031	33518622	46629613	46909316	2,427.700	3,321.649	3,424.185
2032	52747334	46715795	46870978	3,486.900	3,311.941	3,427.764
2033	38685987	47574065	46935122	2,726.600	3,339.797	3,436.967

Source: Own calculation on the basis of data from Statistical information of Ukraine [23]

Table 6. Predictions for cereal production (metric tons) and cereal yield (kg per hectare) in Slovakia

Year	Cereal production (metric tons)			Cereal yield (kg per hectare)		
	Pessimistic prediction	Most probable prediction	Optimistic prediction	Pessimistic prediction	Most probable prediction	Optimistic prediction
2024	3485708	3479775	3509363	4,054.900	4,516.091	4,554.566
2025	2829922	3477262	3509526	3,857.400	4,513.660	4,554.569
2026	2202543	3476316	3509967	2,709.900	4,515.767	4,554.732
2027	3212188	3477528	3509363	3,889.700	4,512.722	4,554.504
2028	3197881	3471986	3509781	3,899.700	4,507.811	4,554.536
2029	2490571	3501067	3509454	3,136.000	4,548.714	4,555.178
2030	3585251	3472396	3509143	4,511.800	4,503.213	4,554.264
2031	2928803	3483196	3509402	3,996.300	4,521.535	4,554.676
2032	4137019	3466677	3509960	5,175.300	4,501.275	4,554.466
2033	2554376	3443531	3509219	4,054.900	4,516.091	4,554.566

Source: Own calculation on the basis of data from Statistical Office of the Slovak Republic [20] and Eurostat [10].

Forecast indicators of cereal production (metric tons) and cereal yield (kg per hectare) in Slovakia and Ukraine in 2024-2033 indicate that the increase in temperature and changes in the amount of precipitation will not lead to a decrease in the volume of cereal production and their yield, there will be a tendency to the growth of relevant indicators, which will allow to increase exports.

CONCLUSIONS

Thus, the results of regression analysis and neuroforecasting regarding the development of agribusiness in Ukraine and Slovakia indicate that climate change affects the performance indicators in the agriculture of these countries. Forecasting the effectiveness of some indicators of agricultural development in Ukraine and Slovakia shows that climate change in these countries will have a positive impact on the development of the agricultural sector. Therefore, in the future, Slovakia and Ukraine can gradually increase the volume of production and export of agricultural products to world markets.

As a result of climate change, Ukraine and Slovakia are likely to be among those who will benefit from global warming. Accordingly, the agricultural export of these countries will become a means of supplying food to regions affected by global warming, and this will be a solution to the problems of the decline in agricultural production in these countries.

Therefore, in order to increase the production of agricultural crops and agricultural exports, the main task for the near future is to prepare not to lose the chance provided by global climate change, and to carry out reforms in the agricultural sector in order to be able to increase production volumes, reduce costs, stimulating development of agribusiness, family farms, to implement the latest innovative methods.

Food shortages associated with warming, with a growing population and rising food prices, will increase the number of players and supply of agricultural products in global agribusiness. One of the priority directions of the agrarian business development strategy of Ukraine and Slovakia should be the creation of conditions for investments in innovation in agriculture, as well as tax benefits to stimulate investments of agrarian companies.

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IMPACT OF MARINE PROTECTED AREAS ON FISHERS' CATCH PRODUCTIVITY AND INCOME: A PROPENSITY SCORE MATCHING ANALYSIS

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Abstract

Marine Protected Areas or MPAs have been established to protect coastal and marine habitat. This study aims to examine the efficiency of MPAs in the province of Leyte, Philippines. Mann-Whitney U test, a nonparametric analysis, was used to compare fishers both from MPA and non-MPA sites using selected fishing variables. Multiple regression analysis was applied to identify variable/s that significantly influences fish catch and fishing income. Propensity score matching or PSM quantifies the impact of MPAs. Based on the results, in terms of catch, revenue, costs, and travel time to fishing areas MPA sites are significantly higher than non-MPA sites. By regression analysis, only motorized boats showed to significantly increase the catch as well as the income. By PSM, MPA fishing grounds lead to higher fish catch of small-scale fishers which is considered a positive impact of MPA. MPA increases fish catch by 0.3470 kg and income by MPA sites increases their monthly income by PHP 95.44

Key words*: *propensity score matching, impact assessment, marine protected areas

INTRODUCTION

The Philippines is one of the world's centers of marine biodiversity [4]. The Philippine Archipelago consists of around 7,107 islands with a total coastline length of approximately 36,289 kilometers. The territorial sea of the country is more than twice the total land area estimated at about 679,000 km^2 and more than a third of this comprise coastal waters (226,000 km^2).

A marine protected area is a region of land or water that is regulated by law or other practical methods with the goal of preserving biological diversity, the environment, and related cultural resources [6]. It contributes to the restoration and replenishment of resources for social, economic, and cultural enrichment [12]. MPA is essentially a space in the ocean where human activity is more severely monitored than in the surrounding waters. These places are given special protections for natural or historic marine resources by local, state, territorial, native, regional, or national authorities [8].

The marine resources of the Philippines are experiencing the highest level of anthropogenic and climatic threats [10]. A strategy for developing sustainable fisheries is the establishment of "no-take" marine reserves, which totally exclude fishing pressure from important locations such spawning, nursery, feeding, and sheltering habitats. Under these management conditions, targeted fish stocks and the larger communities of which they are a part of are given the opportunity to rebound [3].

Marine Protected Areas (MPAs) have been established to safeguard marine and coastal environments. It is considered as one of the solutions to address the threats afflicting marine life [4]. MPAs can result in fisheries advantages in nearby areas through "spill over" and conservation benefits to fish assemblages within no-take zones. They are a mainstream management tool for conserving biodiversity assisting resource management in all the world's oceans and seas. They are increasingly used to protect threatened habitats [1].

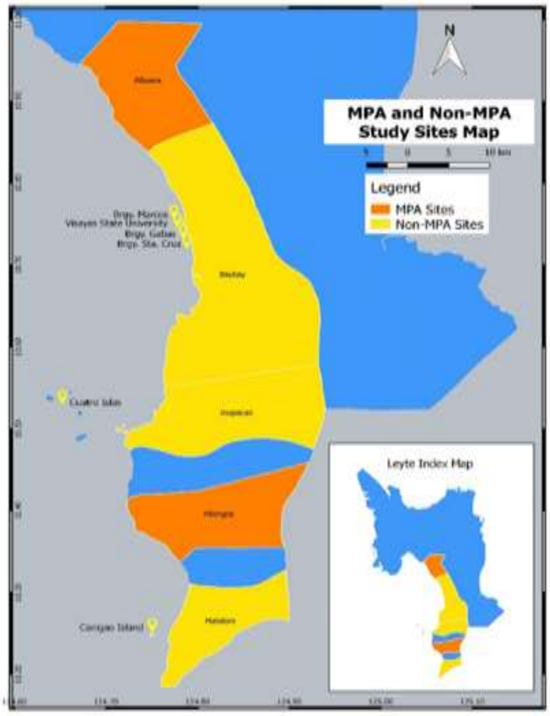
The first marine protected areas were proclaimed early in the 20th century. [9] listed 430 marine protected areas created in 1985 but mostly covering relatively small coastal areas. Many more MPAs were proclaimed in the last two decades of the 20th century. By 1995, there were at least 1,306 sub-tidal MPAs with a median size of 1,584 hectares globally [5]. There have been several MPAs that were created, and the government spent resources in creation of these MPAs. In fact, there are over 1,800 MPAs in the Philippines and they can be categorized into two governance levels, namely: national and local established MPAs [2]. The government invested a significant number of resources in the creation of MPAs thus it is appropriate to subject this to an impact assessment to determine the actual impacts to its beneficiaries, the fishers, whether the project has achieved its desired effects. It plays a key role in ensuring accountability in resource allocation among projects and offering concrete evidence of positive benefits. In assessing the impact of marine protected areas in the province of Leyte, this paper uses PSM or propensity score matching. PSM is a quasi-experimental method in which an artificial control group were constructed through matching each treated unit (MPA) with a non-treated unit (non-MPA) of similar characteristics. Using these matches, the impact of MPAs was estimated.

MATERIALS AND METHODS

Study sites

Leyte Gulf is among the major fishing grounds in the Philippines with a shelf area of 13,147 km^2 covering the islands of Samar and Leyte [11].

This study included fishing grounds that are close to and those that are far from Marine Protected Areas. The localities with fishing grounds near to the Marine Protected Areas (MPAs) include the municipalities of Hilongos and Albuera. On the other hand, the localities with fishing grounds that are far from MPAs include the municipalities of Matalom, Inopacan, and Baybay. The map with the studied sites, MPA and non-MPA is shown on the next column (Map 1).



Map 1. Study sites, MPA and non-MPA
Source: [7].

Data Collection

Structured face-to-face interviews were conducted by trained enumerators in collecting the cross-sectional data. Fisher respondents were selected randomly from each fishing site. The necessary data for the study was obtained using a pre-tested survey questionnaire. The survey instrument consisted of two sections: respondent socio-demographic profile, and selected fishing characteristics. The instrument was translated from English to Cebuano to ensure comprehension of the context of the survey.

Sample Size Determination

The study makes use of a 95% confidence interval, which implies that 95% of the time the sample is certain. Due to the limited information, it was presumed that the proportion is 0.5. A conservative assumption of 6% was applied to the margin of error. The sample size decreases with increasing margin of error and increases with decreasing margin of error. Using the equation below, the estimated sample size for the study areas is computed:

$$n_0 = \frac{Z^2_{\alpha/2}(p)*(1-p)}{e^2}$$

$$n_o = \frac{1.96^2(0.5)*(1-0.5)}{0.06^2} = 266$$

where:
n_o = sample size to be determined
$Z_{\alpha/2}$ = confidence interval (95%)
p = proportion (0.5)
e = margin of error (6%)

Data Analysis

Nonparametric analysis: Mann-Whitney U test compares fishing areas that are close to and far from MPAs. This nonparametric option for the independent samples means comparison test replaces the t-test. The following theories were investigated in order to ascertain the impact of MPA creation utilizing the selected fishing variables:

Ho: No significant difference between fishing grounds distant and nearby of MPAs.

Ha: Fishing grounds that are distant from and near to MPAs vary significantly.

Multiple regression: In identifying the variables that significantly influence catch and fishing income, the multiple regression analysis was applied. The dependent variables were fish catch in kg and fishing revenue in Philippine pesos while the independent variables were fishing variables and selected socio-economic characteristics.

The following model was estimated:

$$Y_i = \beta_0 + \beta_1\, high\_educ_i + \beta_2\, motor\_boat_i + \beta_3\, boat\_own_i + \beta_4 org\_member_i + \beta_5\, fishing\_days_i + \beta_6 MPA_i + u_i$$

where:
β0 = y-intercept
u_i = error term
Y_i = dependent variable/s which captures the average fish catch in kilograms and fishing income in Philippine peso;
$high\_educ_i$ = dummy variable representing the highest educational attainment of fisher respondents (1=at least high school education, 0=otherwise);
$motor\_boat_i$ = dummy variable which representing type of boat being used (0= non-motorized boat, 1= motorized boat);
$boat\_own_i$ = dummy variable representing ownership of fishing boat (0=not owned, 1=owned);
org_member_i = dummy variable that captures the membership in a fisher's organization (0=not member, 1=member);
$fishing\_days_i$ = a continuous variable representing the number of fishing days in a week;
MPAi = dummy variable representing fishing grounds nearby marine protected area (1=MPA, 0=non-MPA).

Impact estimation: To estimate the impact, propensity score matching (PSM) was employed to quantify the effect of the marine protected areas since there is no available baseline data, and the assignment of fishers is not randomly taken. Through PSM, the selection bias was reduced by matching similar individuals from the treatment (MPA) and the control group (non-MPA). To match the treated and control group, propensity scores were computed using the respondents' socio-demographic indicators and other fishing variables. These variables were considered to have important relationships and assumed as significant factors in the outcome variables based on the related studies. The propensity score is the probability of a fisher being a part of MPA group, given a similar pre-condition of socio-economic characteristics. Propensity scores were estimated through the probit model:

$$Pi = E(T_i=1|X) = \beta_0 + \beta_1 high\_educi + \beta_2\, motor\_boat_i + \beta_0 boat\_own_i + \beta_0 org\_member_i + \beta_0\, fishing\_days_i + u_i$$

where:
P_i = probability of a fisher being in the treatment group (MPA)
E = the expected value of being part of the treatment group given the indicators
T = 1 if fisher is in the treatment group (MPA) and 0 for control group (non-MPA)
X = is a set of explanatory variables
β_0 = is the intercept
β_1 = the regression coefficients

The explanatory variables include the following:
$high\_educ_i$ = a dummy variable representing at least high school education (1=at least high school, 0=otherwise)

$motor\_boat_i$ = dummy variable which representing type of boat being used (0= non-motorized boat, 1= motorized boat);
$boat\_own_i$ = dummy variable representing ownership of fishing boat (0=not owned, 1=owned);
org_member_i = dummy variable that captures the membership in a fisher's organization (0=not member, 1=member);
fishing_days = number of days fishing in a week
ui = error term

RESULTS AND DISCUSSIONS

For MPA fishers, most of them (61%) owned the boats they use for fishing while more than half (63.8%) of the non-MPA fishers did not own the boats they use. Majority of the fisher-respondents from non-MPA went fishing with other fishers.

Sixty percent of MPA fishers do fishing in the morning. Approximately 50% of fisher-respondents from both sites were not members in any organization for fishers.

The membership of some of the fishers in this kind of organization encourages them to participate in open forums on fisheries management planning in small-scale fishing communities.

Also, those fishers who were members will be oriented on MPA establishment in their community (Table 1).

Table 1. Comparison of MPA and non-MPA

Variables	Categories	Non MPA		MPA	
		Count	%	Count	%
Boat ownership	Owned	83	61.0	53	39.0
	Not owned	47	36.2	83	63.8
Presence of companion	Without	36	40.0	54	60.0
	With	94	53.4	82	46.6
Time in fishing	Morning	25	39.7	38	60.3
	Evening	102	52.6	92	47.4
	Both	4	36.4	7	63.6
Membership in organization	Not member	81	48.5	86	51.5
	Member	49	50	49	50

Source: Author's calculation and analysis (2024).

Non-parametric Analysis: Mann Whitney U Test

The Mann Whitney U Test was used to compare MPA and non-MPA fishing sites based on specific fishing factors. This test employs a non-parametric approach to compare two groups subsequent to the normality assumption test's failure. Based on the results, no statistically significant evidence was found to support the claim that non-MPA fishers fished for longer hours than MPA fishers. Although non-MPA fishers have more fishing companions than MPA fishers (non-MPA= 9, MPA=7), the difference was not significant. This outcome presents itself due to varied fishing methods utilized by fishers.

Some fishing techniques, like *sinsoro*, which was mostly employed in non-MPA areas, called for the participation of multiple fishers. Techniques like *undak*, which were common in MPA fishing areas, only need a small number of people, if any. Consequently, there was no statistical proof that the net revenue of MPA and non-MPA fishers differed from one another. (non-MPA=214.04, MPA=179.13).

The fisher's income was dependent on the type of fish caught and this make sense because different species have their varying prices which in turn, resulted to no significant difference across groups. Furthermore, MPA fishers took longer hours of travel from the shoreline to fishing area but still the number of hours spent depends on the type of fishing method employed (non-MPA=1.11 MPA=1.72) and the disparity was statistically significant.

This implies that MPA fishers will go fishing in distant sites since restricted fishing grounds exist in the surrounding waters in no-take MPAs which cause them to travel longer hours. Furthermore, non-MPA sites awee not constrained with regard to fishing areas so they will not go to far-off fishing grounds just to catch fish. At a closer look, non-MPA fishers spent more days fishing than MPA fishers (non-MPA=6, MPA=5).

Talking about fishing costs, fishers near MPA spent more than non-MPA fishers (MPA=341.90, non-MPA=214.84). This is to confirm that majority of MPA fishers were using fishing methods specifically *undak* that were more costly than using *sinsoro,* which was commonly used method in MPA.

Fishing grounds close to MPAs exhibited statistically higher daily catch than fishing grounds farther from MPAs (MPA= 3.02, non-MPA= 2.69). This situation arose as a result of the fish spillover effect, which increased the productivity of fish catch to nearby fishing grounds and validated the effectiveness of MPA development (Table 2).

Table 2. Mean values between MPA and non-MPA

Variables	Non MPA	MPA	Difference
Average daily catch (kg)	2.69	3.02	0.33***
Average revenue (pesos)	428.8	521.03	92.23***
Average daily fishing cost (pesos)	214.84	341.90	127.06***
Average travel time from shoreline to fishing area (hours)	1.11	1.72	0.61***
Average fishing days in a week	6	5	1**
Average fishing effort (hours)	7	6	1
Number of companions in fishing	9	7	2
Net income	214.04	179.13	34.91

Source: Author's calculation and analysis (2024).
*, **, *** indicates significance at the 90%, 95%, and 99% levels, respectively

Multiple Regression Analysis

The model postulates that the following explanatory variables will affect the dependent variables: education level, number of fishing days, ownership of a boat, involvement in a fishing organization, use of motorized boats, and fishing grounds nearby MPAs. Only the use of motorized boats has the greatest impact on the quantity of fish caught out of all the factors thought to be highly significant.

The use of motorized boats requires the operator to possess skills specific to the type of boats they are using, either motorized or non- motorized boats. When operating a powered boat, either a motorized or non-motorized boat, the operator needs to have skills unique to that kind of boat. The analysis showed that fisher's use of motorized boats had a beneficial effect on the amount of fish caught. Because motorized boats can go beyond the reef and may allow taking catch in comparison to boats not driven by engines, fishers using motorized boats had a 55% greater catch rate than those using non-motorized boats. Conversely, fishers using non-motorized boats may find it more difficult to fish offshore, especially during inclement weather. However, the estimate for other variables such as membership in a fisher's organization, high level of education, fishing days, boat ownership, membership in a fishing group, and fishing grounds close to MPAs didn't affect significantly. This means that there were no actual evidence based on the data gathered showing that the estimate was significantly different from zero (Table 3).

Table 3. Results of multiple regression analysis with fish catch as dependent variable

Variables	Coefficient	Standard Error
MPA	.2677827	.2090137
High education	.1134599	.1337008
Motorized boat	.5452587**	.2424547
Boat ownership	-.3409084	.2388907
Org membership	.1048119	.2120023
Fishing days	.0655962	.055708
Constant	2.139156	.4172719

Source: Author's calculation and analysis (2024).
** indicates significance at the 95% levels

The same is true with the second model having fishing income as dependent variable, the usage of motorized boats appeared to be statistically significant at 10% level (Table 4).

Table 4. Results of multiple regression analysis with fishing income as dependent variable

Variables	Coefficient	Standard Error
MPA	77.94312	37.59263
High education	31.169	24.04705
Motorized boat	83.07398*	43.60723
Boat ownership	-28.06779	42.96622
Org membership	26.424	38.13015
Fishing days	26.424	10.01949
cons	294.5264	75.04937

Source: Author's calculation and analysis (2024)
* indicates significance at the 90 significance levels

Impact on Fish Catch

The impact of marine protected areas on fish catch was estimated through the average treatment effect of the treated (ATT) using the three matching algorithms namely nearest neighbour, radius matching and kernel matching. A comparison of these algorithms checks the robustness of the result.

Table 5 shows that only radius matching, and kernel matching are exhibiting significant impact estimates where the ATT is around 0.35 kg however nearest neighbour matching appeared to be have no significant impact on estimates.

Table 5. Impact estimate of fish catch (kg) using the average treatment effect of the treated (ATT) of three matching algorithms

Fish catch (in kg)	Nearest neighbour	Radius matching	Kernel matching
MPA	3.0406	3.0406	3.0406
Control group (non-MPA)	2.8708	2.6937	2.6938
ATT	0.1698	0.3470*	0.3468*
Bootstrapped SE (100 reps)	0.2745	0.1865	0.2027
Standard error	0.2953	.1425	.2399
Test statistic	0.58	2.43	1.45
Z	0.62	1.86	1.71
P>|z|	0.536	0.063	0.087
Sample size of MPA	130	130	130
Sample size of non-MPA	131	131	131

Source: Author's calculation and analysis (2024).

In this study, the radius matching technique was used to estimate the average treatment effect of the treated. It shows that the ATT is 0.3470 kg which means that MPA has increased the fish catch of fishers from MPA sites, significant at a 1% level.

Thus, the MPA leads to higher fish catch of small-scale fishers which is considered a positive impact of MPA.

Impact on fishing income

For impact estimation of fishing income, the same techniques were applied to check the robustness of the results.

Only the two algorithms exhibit a significant average treatment effect of the treated (ATT) for the income of small-scale fishers. The ATT ranges ranging from PHP 57.62 to PHP 99.85 using different sample sizes of the matched respondents (Table 6).

Using the radius matching technique, the estimated ATT on the monthly income is PHP 95.44 from the matched 261 respondents.

This suggests that the MPA brought a positive impact on the small-scale fishers in terms of income.

There is enough evidence that the monthly income of fishers from MPA sites increases their monthly income by PHP 95.44, significant at 1% level.

Table 6. Impact estimate of income in fishing (in Philippine peso) using the average treatment effect of the treated (ATT) of three matching algorithms

Revenue	Nearest neighbor	Radius matching	Kernel matching
MPA	524.3187	524.3187	524.31870
Control group (non-MPA)	466.6972	428.8808	424.4681
ATT	57.6215	95.4379	99.8506
Bootstrapped SE (100 reps)	49.3097	36.5247	38.9022
Standard error	50.4264	26.8657	42.0313
Test statistic	1.14	3.55	2.38
P>|z|	0.243	0.009	0.010
Sample size of MPA	131	131	131
Sample size of non-MPA	130	130	130

Source: Author’s calculation and analysis (2024).

CONCLUSIONS

The study's findings showed that the use of motorized boats increased fisher's income and productivity in catching fish. This outcome suggests assistance from local governments of the municipalities in providing fishers with motorized boats that would help them increase their earnings. Additionally, the promotion of livelihood options for the fishers to augment their income should also be considered since fishers are earning less and are economically poor. Income-generating activities and access to micro-enterprise development track that may provide participants with access to funds and training to set up their own microenterprise. Based on the impact estimates using propensity score matching, marine protected areas showed a positive impact to fishers’ catch and income. Hence, according to this study, LGU and other organizations should adopt regulations and provide support for the creation of new MPA sites to increase overall fisheries productivity and enhance the living conditions of fishers. Management policies to preserve and protect new MPA sites should also be implemented for sustainability. There must be institutional coordination in support to MPA establishment since the design, implementation, and monitoring of MPAs require effective institutional structures at local levels of management. Sufficient regulatory funding for monitoring, research, and enforcement must be made available in order to carry out management plans and preserve public support for protected areas.

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REVIVAL OF TOURISM DEMAND IN THE POST COVID-19 PANDEMIC PERIOD - A STATISTICAL OVERVIEW IN ROMANIA

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Abstract

The goal of this study is the analysis of the dynamics of tourist flow (domestic and inbound) in terms of tourist arrivals and overnight stays in Romania after the Covid-19 pandemic, using the statistical data provided by National Institute of Statistics. The methodology involved the calculation of the fixed and variable basis indices and the comparison of the level of each indicator from a year to another. Dynamics of the tourist arrivals and overnight stays involved to establish the trend using polynomial regression functions and determination coefficient. The results showed that the recovery of the tourist flow from its lowest level registered in 2020, the worst year of tourism during the pandemic, needed three years to attain a higher performance than in 2019, a year which was considered the peak in Romania's tourism. In 2023, the number of domestic and foreign tourist arrivals accounted for 13,647.30 thousands, being 2.13 times higher than in 2020, and by 2.03% higher than in 2019. Also, the number of overnight stays reached 29,171.1 thousands, being 2 times higher than in 2020, by 7.8%higher than in 2022, but by 3.05% smaller than in 2019. The experience learnt in the travel and hospitality industry has generated a new resilience strategy to sustain the development of tourism and its contribution to GDP and better satisfy tourists demand.

***Key words**: : tourism revival, tourist domestic and inbound flow, arrivals, overnight stays, Romania*

INTRODUCTION

Tourism demand is defined as "the total number of persons who travel or desire to travel and use tourist facilities and services at destinations away from their places of residence or work" [5].
Travels are generated by many reasons like: the need for leisure, recreation and spending holidays, visiting relatives and friends, solving various health problems, pilgrimage to well known religious places, business interests and taking part to various scientific, sport and/or cultural events and other purposes.
The incentive to travel is determined by many factors, but essential is the disposable income that a tourist has to spend for a trip. The stronger the economy of a country, the more income people has to spend on travels!
The price of a tourism product is also important in connection to disposable income, as the higher the price, the lower is the amount of money spent, the travel length and leisure time. The exchange rate is another financial factor taken into consideration by tourists in connection to the choice of travel destination.
Tourists' age, gender, education and cultural level, and also their reasons, purposes, experience in traveling, preferences, personality are other factors which determine their travels.
The technological progress achieved in IT tools like computers, internet access, smart

phones, mobile apps, TV travel channels is more and more utilized in making travel arrangements.

The distance to the desired destination, natural attractions and hazards, climate and season are among the geographical and environmental factors which influence tourist demand. In addition, the historical and cultural importance of a destination, its image compared to other destinations, quality of the tourist product, travel facilities and formalities, local policy and security degree should not be ignored in making the decision where to travel [2, 3].

Travel advice and advisories regarding safety and security offered by Ministry of Tourism, Ministry of Foreign Affairs are also important in making the final decision regarding the choice of a tourist destination [4].

The decision to travel needs also to be based on the security status offered by a chosen destination regarding the health risks during outbreaks and natural disasters and also it has to take into account the information about the actions taken by authorities to prevent infection and avoid the spread of the disease.

The recent Covid-19 pandemic proved how important is tourist's perception of the health risk factor during a travel and also on travel behavior.

In case of lack of security and danger to get a disease, tourists should choose a different and safe destination [9].

The Covid-19 pandemic that emerged in the year 2020 produced not only a crisis in the health system, but also in the economic and social life worldwide. The travel restrictions taken to avoid the spread of the virus determined the tourists to stay in their country of origin or in safety places than to travel abroad, which caused drastic changes in tourism demand and offer in travel and hospitality sector almost in all the countries [10].

After the record performance in tourism industry in the year 2019, the pandemic outbreak in 2020 paralyzed tourist flow and revenue because tourists' behavior changed.

After lifting travel bans in the year 2020 and mainly in 2021, the domestic tourism started to recover and in a fewer measure inbound tourism, but variations were noticed from a country to another and even from a region to another. In general, during the pandemic, the highest losses in tourism industry were carried out in the urban destinations and in inbound tourism [7], and a new orientation has appeared to smaller and rural localities and ecotourism [12, 18, 20, 29, 30].

To develop a resilient development of tourism ecosystems, the authorities have started to apply a new strategic approach, adapted to the local specific conditions [1, 11, 15].

Despite that Romania is not ranked on the top positions as a tourist destination in Europe, it is recognized as a country with a high tourism potential grace to its varied relief from the Black Sea [19] and the Danube river to the peaks of the Carpathians [21], different tourist destinations represented by spa [22], mountain [24] and sea shore resorts [17, 19], the Danube Delta biosphere reservation, historical and cultural heritage places (fortresses, palaces, castles, churches and monasteries) [6], gastronomy and wines to which hospitality and high quality of services offered at convenient prices, all these recommend Romania as a charming and attractive tourism destination [33].

The main accommodation units preferred by tourist are hotels and guest houses (rural and agro-tourist pensions) [23, 28].

Romania's tourism suffered a negative impact in 2020 [32], as the restrictions imposed reduced the tourist flow and income [16, 17]. In that year, tourism contribution to GDP was only 1.88%, compared to 5.74% in 2020 [8].

The recover needs about three years as statistical data showed in 2023. Since 2021, tourist flow and income is increasing slowly, the situation being better and better from a year to another [25, 26, 27, 31].

Tourism contribution to GDP increased to 2.65% in 2021, 3.42% in 2022, and in 2023 attained 4.19% [8].

In this context, the goal of this study is to analyze and quantify two essential indicators of tourist flow: number of arrivals and overnight stays (for domestic and inbound tourism) in the period 2019-2023 and to point out the differences which reflects the recovery of tourism in the last years versus 2020, the year of the Covid-19 pandemic the worst year for tourism and also compared to 2019 tourism highest performance in Romania.

MATERIALS AND METHODS

After studying the literature in the field regarding the impact of the pandemic in 2020, the present analysis needed to be based on the collection of statistical data offered by National Institute of Statistics for the period 2019-2023, to enable the authors to make comparisons on how tourist flow (domestic and inbound) in terms of tourist arrivals and overnight stays have evolved from a year to another as a reflection of the recovery in travel and hospitality sector.

The analysis regards both the arrivals and stays as a whole, but also by tourist category: Romanians and foreigners. More than this, the dynamics of these two flow indicators were studied by destination category: spa resorts, seashore resorts without Constanta City, mountain resorts, Bucharest and other main cities, the Danube Delta and Tulcea City and other localities and tourism routes.

Suggestive graphics were designed to help the readers to better understand the evolution of the two indicators in the period 2019-2023.

The year 2020 when the pandemic emerged was considered the reference year to which the data recorded in the next years were compared. Also, the analysis explains the records compared to the top performance in Romania's tourism in the year 2019, and also in 2023 versus each year in the period 2019 till present. The fixed and variable basis indices were calculated to show in what measure the level of each indicator changed from a year to another. Also, the structural index was useful to determine the weight of tourist arrivals and, respectively, the weight of overnight stays in their total number by destination. The trend lines were analyzed using illustrative graphics where the polynomial equations were displayed as well as the R square. the data processing was achieved using the Excel facilities.

The results were accompanied by suitable comments and at the end of the study, the conclusions highlighted the main ideas resulting from this research.

RESULTS AND DISCUSSIONS

Tourist arrivals (domestic and inbound)

The year 2020, when the Covid-19 pandemic emerged, has deeply affected Romania's tourism. Tourist arrivals accounted for 6,398,642 being by 52.16% smaller than in 2019, which was the best year in tourism in Romania and in many other EU countries and even at the world level in terms of international arrivals and revenues.

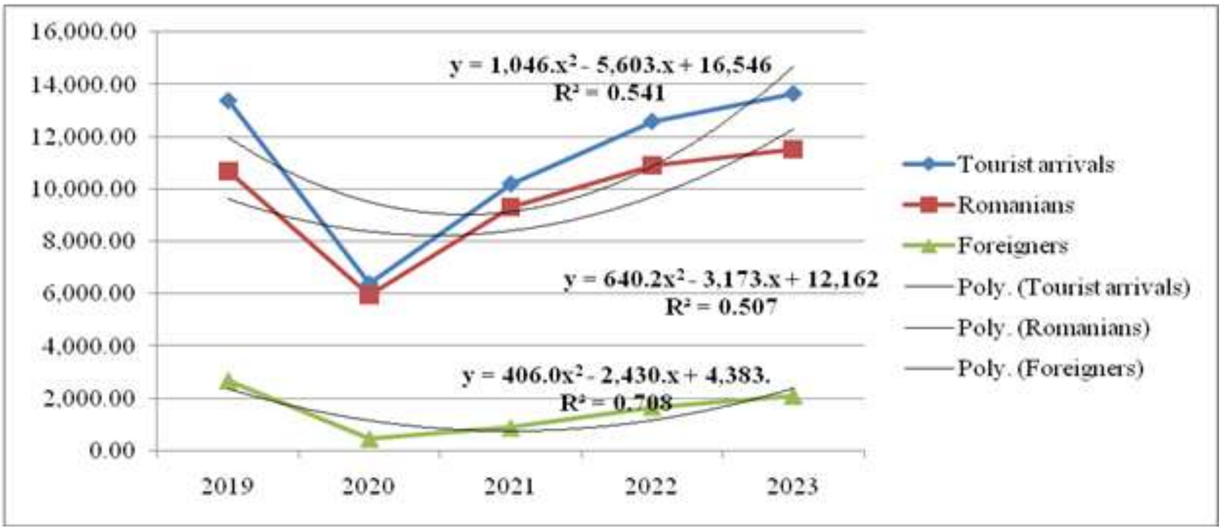


Fig.1. Tourist arrivals, Romania, 2019-2023 (Thousand)
Source: Own design and calculation based on the data from NIS, 2023 [13].

After 2020, when the restrictions imposed by authorities have been more relaxed and then disappeared, the number of tourist arrivals restarted to grow in Romania and, in 2023, it reached 13,647.30 thousands, being 2.13 times higher than in 2020 and 2.03% higher than in 2019.

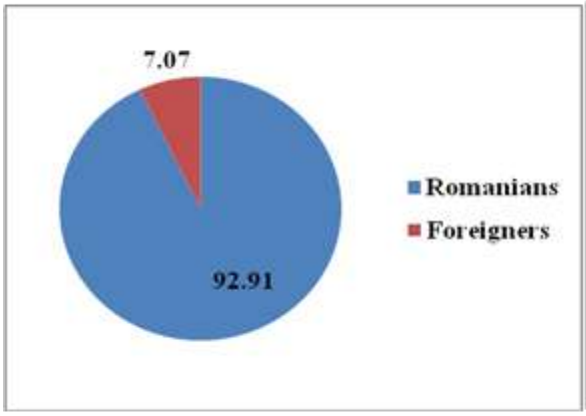
The number of the Romanians' arrivals accounted for 11,546 thousands in 2023, being by 8% higher than in 2019 and by 94.22% higher than in 2020 (Fig. 1).

The R square value equal to 0.541 reflected that only 54.1% of the variation in tourist arrivals depended on time, and the difference by other factors closely related to the dynamics of restrictions imposed by the health security.

In case of foreign tourists' arrivals, R square showed that 70.8% of the changes of this tourism indicator was determined by time, being linked to a smaller number of tourists.

The share of the Romanians in total tourist arrivals is dominant ranging between 92.91% in the year 2020, 79.94% in 2019 and 84.6% in 2023.

The foreign tourists have still a small weight. In 2020, they represented just 7.09% in total arrivals, compared to 20.06% in 2019. In 2023, foreign tourists accounted only for 15.4% (Fig. 2).



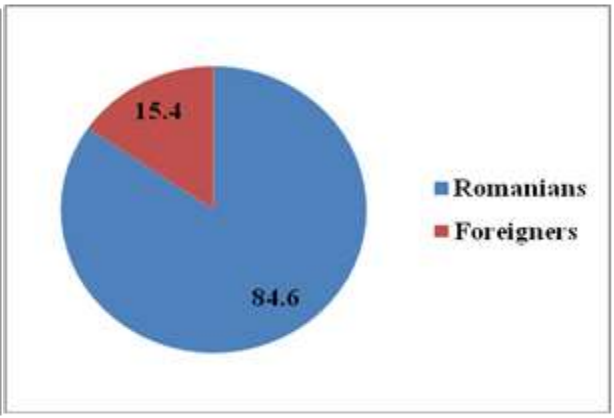


Fig.2. The share of Romanian and foreign tourists in tourist arrivals in 2020 (Left) and 2023 (Right)
Source: Own design and calculation based on NIS data 2023 [13].

Tourism demand in terms of tourist arrivals in 2023 versus all the previous years before and after the pandemic

Total tourist arrivals in 2023 exceeded the tourist arrivals in all the analyzed years in various percentages. In case of the Romanian tourists, the arrivals in 2023 also were higher than in any other previous year of the studied interval. But, in case of the foreign tourists, in 2023, their arrivals were higher than in 2020, 2021 and 2022, but by 21.73% smaller versus 2019. The slight growth in the number of foreigners visiting Romania could be explained by increased travel costs which oblige people to select more carefully their holiday destination (Table 1).

Table 1. Comparison regarding the tourist arrivals by tourist category in the period 2019-2023

	Tourist arrivals (Thousands)	Romanians (Thousands)	Foreigners (Thousands)
2023	13,647	11,546	2,101
2022	12,588	10,914	1,674
2021	10,205	9,326	879
2020	6,399	5,945	454
2019	13,375	10,691	2,684
2023/2022 %	108.41	105.79	125.5
2023/2021 %	133.72	123.80	239.02
2023/2020 %	213,26	194.18	462.77
2023/2019 %	102.03	107.99	78.27

Source: Own conception and calculation based on the data provided by NIS Press releases [14].

Tourist arrivals by destination

After the peak of tourism performance in 2019, and the year 2020 when all the tourist destinations were affected more or less, starting from 2021, it was noticed a recovery, the number of tourist arrivals restarting to raise.

Versus 2020 level, in 2023 the arrivals reached 1,168.9 thousands (+94.38%) in balneary resorts, 1,564.29 thousands (+72.80%) in seashore resorts, 2,586.17 thousands (+99.6%) in mountain resorts, 6,077.14 (+157.6%) in Bucharest and the main cities, 2,298.78 thousands, being 2.06 times higher in other localities and, finally, the Danube Delta which was visited in 2023 by 334.39 thousands tourists, representing 2.82 times more than in 2020 (Fig. 3).

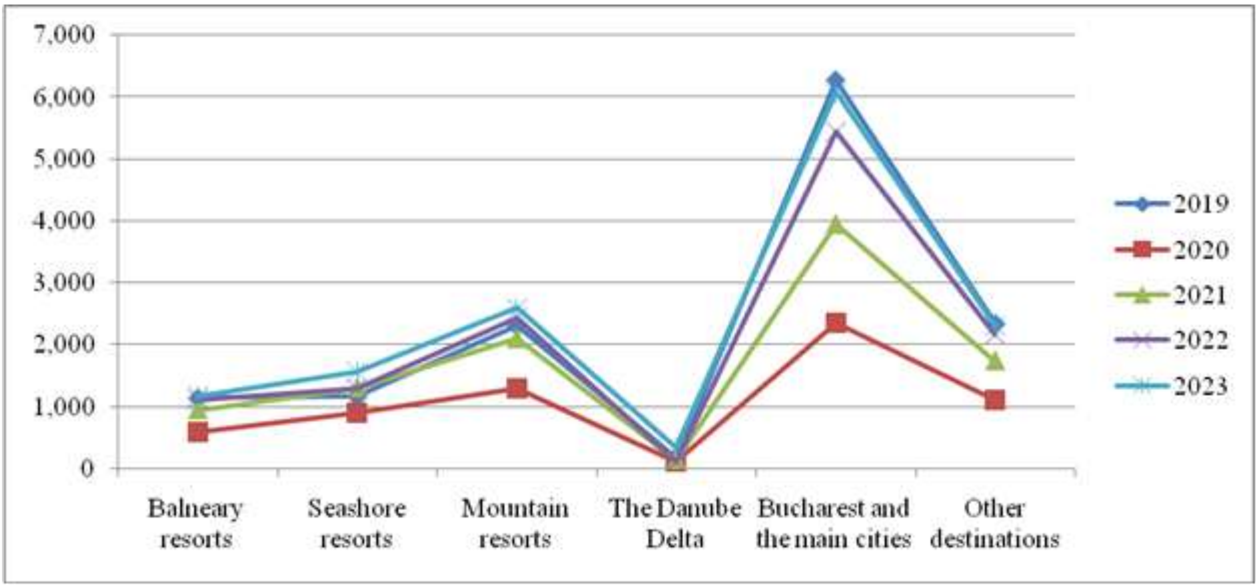


Fig. 3. Tourist arrivals by destination, Romania, 2019-2022 (Thousand)
Source: Own design and calculation based on the data from NIS, 2023 [13].

This graph shows that the capital and the main cities of Romania like Constanta, Brasov, Cluj-Napoca, Sibiu, Iasi, Timisoara etc, attract each year the most numerous visitors. It is normal to be so as any tourist who intend to visit a country go first to the capital where always it could be found a large range of attractions. Then, other destinations could be chosen depending on the preference of each tourist.

On the second position there are the mountain resorts, because Romania's mountains offer a diverse range of landscapes, forests, grasslands, wild flora, caves, volcanic and glacial lakes, many beautiful sparkling river valleys etc. Tourists could enjoy climbing the peaks, hiking, skiing, bungee jumping, visiting the caves or salt mines, gorges, practicing horse riding, biking, bird and wild flora watching, relaxing in the mountain villages and resorts, having a close contact with the local cultural and gastronomic traditions.

The sea shore resorts came on the third position as preference, as the Black Sea coast offers a large variety of beautiful beaches, a warm sea water compared to other seas, opportunities to practice water sports. Also, hotels have tariffs for each one's pocket, in the resorts there are clubs and other places for entertainment, delicious food based on sea fruit and also Romanian traditional dishes, and cultural and historical objectives in the surroundings.

The Danube Delta is visited by the smallest number of tourists, but it is obviously normal as long as it is a trans-boundary biosphere reserve belonging to the UNESCO patrimony. It offers the opportunity to see a wide variety of wildlife, including numerous bird and fish species, and for having an idea about the small villages where traditional fish dishes are served or experiencing a boat cruise on the channels and lagoons.

Balneary resorts offer natural factors which are beneficial for preventing illness and treating various diseases. The balneary complexes have a large range of modern and indispensable facilities for a wide range of purposes.

The share of the destinations in tourist arrivals reflects tourist preferences. In 2023, Bucharest and the main cities accounts for 44%, followed by mountain resorts with 18%, other destinations 176%, the seashore resorts with 11%, balneary resorts with 8% and finally the Danube Delta with 2%.

The differences in percentage points between the weight of each destination in the year 2023 versus 2020 was the following one: Bucharest and the main cities +7.14 pp, seashore resorts -3.14 pp, the Danube Delta +0.16 pp, other destinations -0.53 pp, balneary resorts -1.39 pp. mountain resorts -2.24 pp. The negative difference reflects the importance of the cities among tourist attractions for the lovers of the attractions in ten urban area and also in the Danube Delta for the explorers of biodiversity.

The distribution of tourist arrivals by the preferred destination is illustrated in Fig. 4.

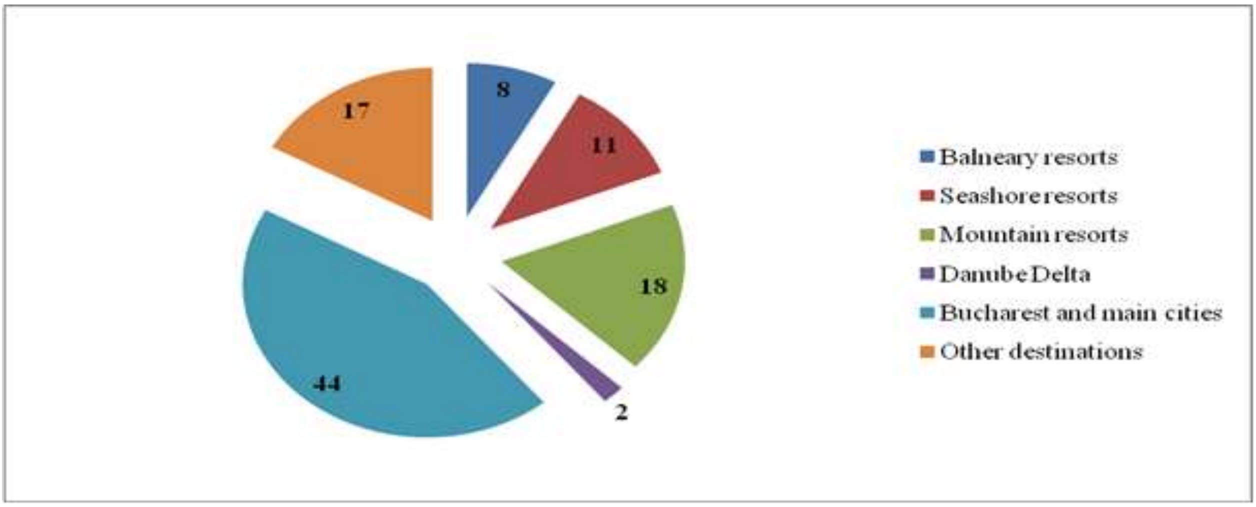


Fig. 4. The distribution of tourist arrivals by the preferred destination in the year 2023 (%)
Source: Own design based on own calculations.

The share of tourist arrivals by destination

The share of tourists by destination is presented in Table 2. As mentioned before, the order of preference of the destinations in Romania is, in the decreasing order: the capital and the main cities, then the mountain resorts, other destinations, seashore resorts, balneary resorts and the Danube Delta.

In the last five years, a slight decline was observed in case on the balneary resorts, but the share of all the other destinations increased a little. Slight variations have happened from a year to another.

During the pandemic in the year 2020, tourist were more oriented to mountain resorts and seashore resorts, the Danube Delta and balneary resorts, only the urban areas registered a smaller share, as tourists applied for safe and healthier destinations.

Table 2. The share of tourist arrivals by destination in the period 2019-2023 (%)

	Balneary resorts	Seashore resorts	Mountain resorts	The Danube Delta	Bucharest and other cities	Other destinations
2019	8.47	8.62	17.23	1.24	46.92	17.52
2020	9.39	14.14	20.24	1.84	36.86	17.53
2021	9.32	12.84	20.60	1.40	38.72	17.12
2022	8.88	10.27	19.88	0.92	43.29	16.76
2023	8.00	11.00	18.00	2.00	44.00	17.00

Source: Own calculation based on the data from NIS [13].

Overnight stays (domestic and inbound)

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The number of overnight stays registered the lowest level which accounted for 14,579.14 thousand stays in the year 2020.
Since 2021, it started to recover, reaching 27,044.37 thousand stay in 2022, of which 86.45% belonged to the Romanians and 13.55% to the foreign tourists. In 2023, compared to 2019, the stays were by -3.31% less, but compared to 2020, in 2023 there were achieved 2 times more stays (Fig. 5).

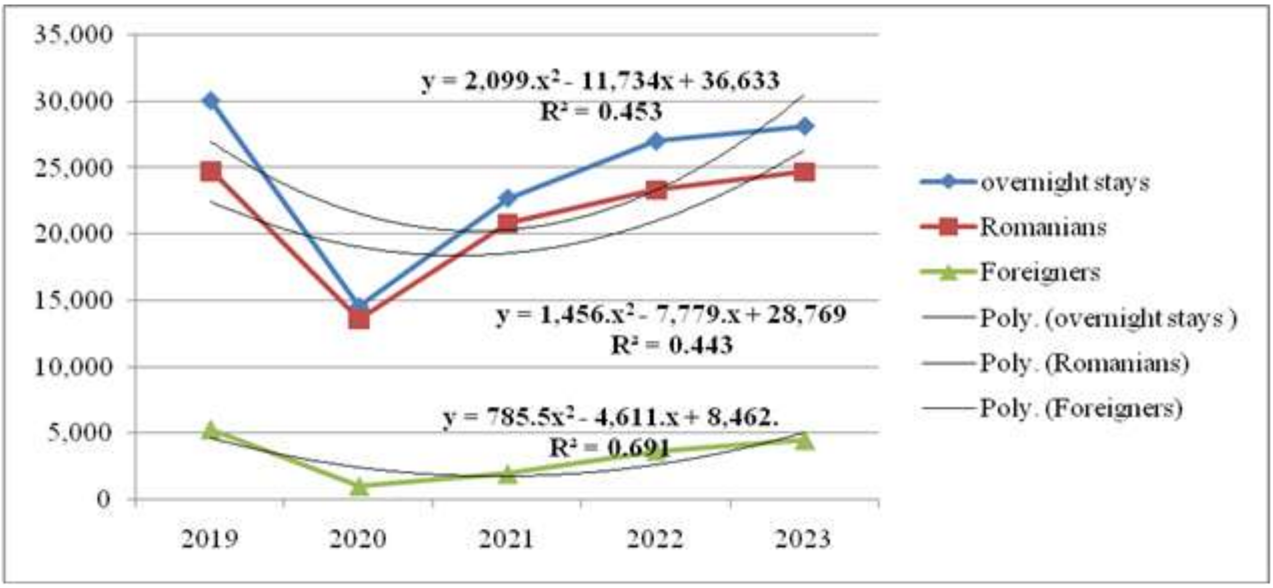

Fig. 5. Number of overnight stays in Romania, 2019-2022 (Thousand)
Source: Own design and calculation based on the data from NIS, 2023 [13].

Analyzing the dynamics of all overnight stays, it could be affirmed that in 2023 the number of stays was higher than in 2020, 2021 and 2022 in various proportions, but by 3.05% lower compared to the year 2019. A similar situation was noticed in case of the overnights stays belonging to the Romanian tourists. In case of the foreign tourists, the number of stays in 2023 were higher than in 2021 and 2020, but lower than in 2022 and 2019 (Table 3).

Table 3. Comparison regarding the tourist overnight stays by tourist category in the period 2019-2023

	Tourist overnight stays (Thousands)	Romanians (Thousands)	Foreigners (Thousands)
2023	29,171.1	24,706.9	3,364.2
2022	27,044	23,378	3,666
2021	22,748	20,823	1,925
2020	14,579	13,582	997.3
2019	30,086	24,795	5,291
2023/2022 %	107.86	105.68	91.76
2023/2021 %	128.23	118.65	174.76
2023/2020 %	200.00	181.90	337.33
2023/2019 %	96.95	99.64	63.58

Source: Own conception and calculation based on the data provided by NIS Press releases [14].

Therefore, as the number of arrivals was higher and higher but with a higher growth rate than the number of overnight stays in the year 2023 versus 2019 for Romanians and in 2019 and 2022 for the foreign tourists.
The value of the determination coefficient showed that 44.3% of the variation in overnight stays depended on the time change, therefore, the difference of 55.7% was influenced by other factors, especially by the higher tariffs for the services practiced by accommodation units.

The share of the resident and foreign tourists in total arrivals and total overnight stays is shown in by year in Table 4.

Table 4. Tourist arrivals and overnight stays distribution by Romanian and foreign tourist in the period 2019-2023 (%)

	Tourist arrivals		Overnights stays	
	Romanians	Foreigners	Romanians	Foreigners
2019	79.94	20.06	82.42	17.58
2020	92.91	7.09	93.16	6.84
2021	91.39	8.61	91.54	8.46
2022	86.70	13.30	86.45	13.55
2023	84.60	15.40	94.69	5.31

Source: Own calculation based on NIS data [14].

The results reflect a decline in the share of the Romanians in the total arrivals, but an increase in the arrivals of the foreigners.

Regarding the overnight stays, in 2023 the Romanians reached the highest share accounting for 94.69% in the studied interval, while the share of foreign tourists became very small, only 5.31%, even thou their number of arrivals increased.

This aspect reflects that the length of stay has grown in case of the Romanians, while the duration of stay declined in case of the foreign tourists.

CONCLUSIONS

Before the Covid-19 pandemic, more exactly in 2019, Romania registered the top performance in travel and hospitality industry, when the number of tourist arrivals and overnight stays reached the highest level, accounting for 13.37 million arrivals and over 30.08 million overnight stays.

The year 2020 was an unexpected bad year, the worst for tourism industry as many units were obliged to close or to work at a reduced capacity, resulting either a fail or low revenue. In that year, during the period of relaxed measures taken by the authorities, Romanians saved tourism, being the dominant category of visitors. They decided to discover their own country, with its beautiful landscapes in the mountains or on the seashore, or going to treatment in balneary resorts and in the rural areas, or in the Danube Delta for avoiding the cities.

However, the number of tourist arrivals was by 52.16% lower in 2020 compared to 2019, and in terms of overnight stays it was by 48.45% smaller.

In 2021, it was noticed a recover in tourism due to the relaxed restrictions starting from March compared to June in 2020. The number of arrivals accounted for over 9.37 million and the number of overnight stays for over 20.83 million.

Tourism entrepreneurs had time to apply an adequate strategy to offer diverse services to satisfy tourists desires and sustain their business.

Year by year the number of Romanians interested to spend their vacations in the country increased their arrivals and of much help have been the "holiday vouchers" offered by the Government which encouraged and sustained both the residents and travel and hospitality industry.

The facilities offered by modern digital communication tools have reduced the time for making the travel arrangements in many cases.

The empirical evidence proved that in the year 2023, the number of tourist arrivals has surpassed the peak level registered in the year 2019 and was more than 2 times higher than the arrivals in 2020, the year of the pandemic.

Also, the number of overnight stays increased but with a smaller growth rate than the arrivals, so that the stays have not yet exceeded the peak registered in 2019.

The final conclusion is that tourism strategy in Romania adapted to the new circumstances has led to good results based on diversification of services and high quality as a priority and also based on large variety of resources offered by many destinations which could attract more and more tourists.

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LAND USE - AT THE GLOBAL AND EUROPEAN UNION LEVEL IN THE PERIOD 2000-2021

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Abstract

The aim of this study is to analyze the land use at the global level and in the European Union in the period, 2000-2021, in order to identify the changes and trend pointing out the status of agricultural land and by category of use. Fixed and structural indices and suggestive illustration were used to show the variations and trends for agricultural land, arable land, crop land and permanent meadows and pastures at the global level, for the top countries with the largest agricultural area and in the EU-27 by member states. The global agricultural land decreased, in 2021, being 4,787.5 Million ha, by 1.8% smaller. The world crop land increased to 1,579.8 Million ha in 2021, being by 5.7% larger. Of the global agricultural land, 33% is cropland and 67% permanent grasslands. The larger cropland is in Asia, Americas and Europe. The largest countries in cropland represent 39.3%, while the largest countries in grasslands 23.2%. About 40% of the EU's territory is represented by agricultural land and belongs to France, Spain, Sweden, Germany, Poland, Finland, Italy, and Romania. The EU agricultural land decreased to 162,905.8 thousand ha, being by 10.83% smaller. Cropland declined by 9.4%, and permanent grasslands declined by 13.71%. Cropland accounts for 68%, while permanent grasslands for 32% in the EU. The EU keeps 3.4% of the global agricultural land, 7.01% of crop land and 1.62% of grasslands. In the most EU countries agricultural land declined. In the EU, it is a high concentration of agricultural land, but no concentration in arable land, cropland and permanent grasslands. The world agricultural land per capita declined from 0.24 ha in 2000 to 0.20 ha in 2021. The highest cropland per capita is in Oceania 0.77 ha, Europe 0.39 ha, Americas 0.37 ha, Africa 0.21 ha and Asia with only 0.13 ha. In the EU-27, the average is 36.56 ha agricultural land per capita. The expand of the agricultural land has to be stopped, as it is enough food to nourish the global population. New agro-eco technologies are called to increase crop yield and productivity to protect environment and biodiversity. The reduction in meat production and consumption will protect forests and cropland, and stopping deforestation will orient the people to a healthier and green diet.

Key words: *land use, agricultural land, arable land, crop land, pastures and meadows, world, European Union*

INTRODUCTION

The Earth is our home which offers us conditions to live! It was nick named the Blue Planet as seen from the satellite it has a blue color, grace to large surface covered by water (oceans, seas, lakes, rivers etc) accounting for 361,132,000 km^2, representing 70.8% of the total Terra area of 510,072,000 km^2 [12].

Only 148,940,000 km^2, that is 29.2% represents land cover which belongs to the five continents and millions of islands [28, 29].

Therefore, land is our "golden treasure" representing the main resource which sustains the development of agriculture destined to provide food to humans and feed for farm animals.

The countries with the largest land area in the world, in the decreasing order are Russia, China, Canada, USA, Brazil, Australia, India, Argentina, Kazakhstan and Algeria, which together keep 70,837,771 km^2 , representing 47.5% of the land cover.

In the total area of these countries, land represents: 99.9% in Algeria, 99.8% in Australia, 99% in Kazakhstan, 98.4% in Argentina, 98.1% in Brazil, 97.5% in USA, 96.7% in China, 95.7% in Russia, 91% in Canada, and 90.4% in India. The share of these ten countries having the largest area in the global land is shown in Fig. 1.

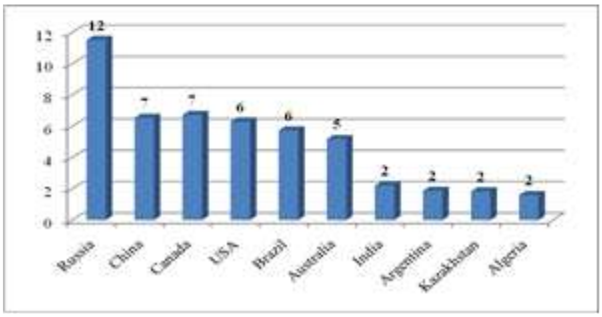

Fig.1. Share of top 10 countries with the largest area in the world land surface (%)
Source: Own design based on the data from [31].

However, only 38.17% of land cover is suitable for agriculture, that is 56.59 million km^2, calculated for 193 countries in the year 2021 for the period 1961-2021. The highest weight is 81.89% in Burundi and the lowest percent is 0.5% in Suriname [24].

Only this surface could offer good conditions in terms of topography, soil features and quality, climate (temperatures and precipitations), vegetation type and composition.

According to FAO (2020) and Anderson (2023), agricultural land is used for two purposes: 33% as crop land and 67% for grazing livestock (Fig. 2) [1, 4].

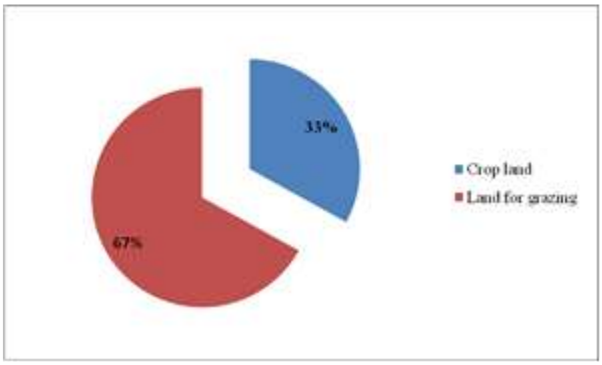

Fig. 2. Agricultural land destinations (%)
Source: Own design based on the data from [1, 4].

FAO (2020) divides agricultural land into two groups:

-*Arable land,* where both annual and perennial crops are cultivated to grow production providing products for human consumption and also a part of arable land for producing forages needed by animals;

-*Permanent grasslands*, which are used for grazing livestock.

Therefore, agricultural land is shared between crops for human consumption 23% and 77% for animal feed (Fig. 3) [1, 6].

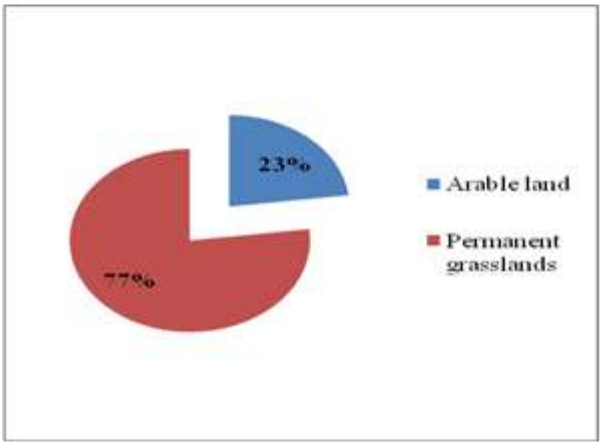

Fig. 3. The distribution of agricultural land by arable land and permanent grasslands
Source: Own design based on the data from [1, 6].

Ritchie and Moser (2019) affirmed that the agricultural land is divided into 28% arable land, 3% for permanent crops and 69% for grasslands [21].

In this context, the purpose of this paper is to analyze the distribution of agricultural land at the global level and in the European Union for showing the importance of land use in connection to the population growth and food security.

MATERIALS AND METHODS

The study is based on a short literature review selected on the topic.

Land use is analyzed at the global level, by continents and in the European Union, using FAOSTAT and World Bank data and also from other information sources and regard the last two decades in the interval 2000-2021 for which the data are available.

The data was studied using fixed basis indices whose well known formula is $I_{FB}= (y_i/y_0)*100$, where y_i is the value of the variable taken into consideration in the year i, where i = 1, 2, 3,...n, and y_0 is the value of the variable y in the first year, expressed in percentages.

Also, in certain cases, it was determined the absolute deviation, $\Delta y = y_n - y_0$, reflecting the difference between the value of the variable in a specific year and its value in another year, usually considered a term of reference.

The structural index was utilized to calculate and interpret the share of a region or continent or a country in the global value of a variable or in case of the EU, the share of each member state in the total EU level for a certain land indicator.

The concentration of land was determined only in the EU regarding agricultural land and also crop land and the land covered by permanent meadows and pastures.

For this purpose, there were used the specific concentration indices: Herfindhal-Hirschman index (HHI), Gini-Struck index (GSI) and Concentration coefficient (CC_j), whose formulas are shown below.

$$HHI= \sum_{i=1}^{n} g_i^2 \qquad \text{..............................(1)}$$

where:

g is the square of the share of each country in the EU level for the analyzed indicator.

$$GSI = \sqrt{\frac{n\sum_{i=1}^{n} g_i^2 - 1}{n-1}} \qquad \text{.................................. (2)}$$

$$CC_j = [n/(n-1)]* GSI \text{...............................(3)}$$

The results were illustrated in tables and graphics and were correspondingly commented and interpreted.

Finally, the most important conclusions resulting from this research were presented at the end of the paper.

RESULTS AND DISCUSSIONS

Agricultural land surface

Agricultural land is very important for assuring food for the globe population and also its distribution by continent, region and country has also a high impact [20].

Analyzing agricultural land at the global level, it was registered a reduction by 1.8% from 4,873.6 Million ha in the year 2000 to 4,787.5 Million ha in 2021. Africa is the only continent where agricultural land increased by 6.82 % reaching 1,161 Million ha in 2021.

In the Americas, agricultural land decreased to 1,124.6 Million ha in 2021, being by 2.4% smaller than in the year 2000. Asia had 1,664.8 Million ha used for agriculture in 2021, by 1% less than two decades ago. In Europe, the reduction was 5%, so that in 2021, agricultural land accounted for 460.2 Million ha.

The highest declined was registered in Oceania, -20%, so that in 2021, agricultural land accounted for only 376.2 Million ha (Table 1).

Table 1. Agricultural land by continent in 2021 versus 2000 (Million ha)

	2000	2021	2021/2000 %
World	4,873	4,787.5	98.2
Africa	1,987.3	1,161.7	106.8
America	1,151.5	1,124.6	97.6
Asia	1,680.1	1,664.8	99.0
Europe	484.6	460.2	95.0
Oceania	470.0	376.2	80.0

Source: Own calculations based on the data from [5].

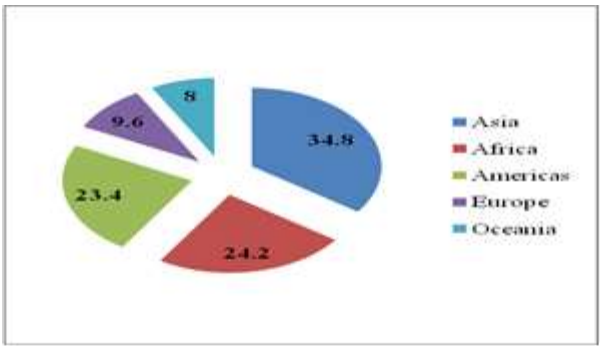

Fig. 4. Distribution of agricultural land by continent in 2021 (%)
Source: Own design based on the data from [5].

As a result, the share of the regions in the global agricultural land in 2021 reflects that the largest surface is, in the decreasing order, in Asia, Africa, Americas, Europe, and Oceania (Fig. 4).

Distribution of agricultural land by permanent grasslands and cropland

Grasslands

*At the global level***,** the permanent grasslands registered a decrease by 5.1% from 3,379.7 Million ha in 2000 to 3,207.6 Million ha in 2021.Crop land increased by 5.7% from 1,493.9 Million ha in 2000 to 1,579.8 Million ha in 2021 (Table 2).

Table 2. Distribution of agricultural land by permanent grasslands and crop land at the global level (Million ha)

Land category	2000	2021	2021/2000%
World	**4,873.6**	**4,787.4**	**98.2**
-Permanent grasslands	3,379.7	3,207.6	94.9
-Cropland	1,493.9	1,579.8	105.7

Source: Own calculation based on the data from [5].

By region, based on the surface with permanent grasslands, Asia comes on the top position with 33.5%, being followed by Africa with 27.1%, Americas with 23.3%, Oceania with 10.7% and finally Europe with 5.4%.

In almost all the regions, the area of grasslands increased, except in Oceania.

Cropland

The largest cropland is in Asia (37.1%), Americas (23.9%), Africa (18.5%), Europe (18.2%) and only 2.2% in Oceania.

The cropland registered a decline in Europe, Americas, and Asia, but an increase in Africa (+3.1%) and Oceania (Table 3).

Table 3. Share of permanent grasslands and crop land in the global agricultural land by continent in 2021 versus 2000 (%)

Region	Permanent grasslands			Crop land		
	2000	2021	Difference pp	2000	2021	Difference pp
Africa	25.4	27.1	+1.7	15.4	18.5	+3.1
Americas	23.1	23.3	+0.2	24.7	23.9	-0.8
Asia	33.0	33.5	+0.5	37.7	37.1	-0.6
Europe	5.3	5.4	+0.1	20.3	18.2	-2.1
Oceania	13.2	10.7	-2.5	1.7	2.2	+0.5

Source: Own calculations based on the data from [5].

Top 10 countries with the largest agricultural land at the global level, in the decreasing order

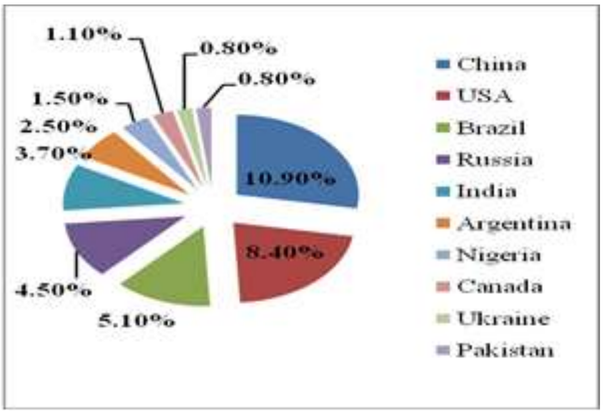

Fig. 5. Top 10 countries in the world based on their share in the global agricultural land (%)
Source: Own calculations based on the data from [5, 9].

Figure 5 shows that the largest agricultural land belongs to the following ten countries, in the decreasing of their market share, which are the following ones: China, USA, Brazil, Russia, India, Argentina, Nigeria, Canada, Ukraine, and Pakistan.

Analyzing the dynamics of the agricultural land in these top 10 countries, it was noticed that in 2021 versus 2000, the agricultural area increased only in Brazil (+4.8%) and Nigeria (+4.7%), while in the other countries declined: Argentina (-8.3%), Canada (-1.8%), USA (-2.1%), India (-1.4%), Pakistan (-1.1%), Russia (-0.8%) China (-0.4%), Ukraine (-0.3%) (Table 4).

All these 10 countries together have a share of 39.3% in the global agricultural land in 2021, which is by 0.3 pp higher than in the year 2000.

The share of each country from the top 10 based on the agricultural land by type: permanent grasslands and cropland is shown in Table 5. From this table, it is easy to identify that China, followed by USA and Brazil have the highest share in the global grasslands in 2021, accounting for 12.2%, 7.6% and, respectively, 5.4%.

Table 4. The top countries with the largest agricultural area at the global level (Million ha)

	2000	2021	2021/2000 %
World	4,873.0	4,787.5	98.2
1.USA	414.4	405.8	97.9
2.India	180.9	178.5	98.6
3.Russia	217.2	215.5	99.2
4.China	523.7	521.5	99.5
5.Brazil	228.3	239.4	104.8
6.Canada	58.0	57.0	98.2
7.Nigeria	65.5	68.6	105.7
8.Ukraine	41.4	41.3	99.7
9.Argentina	128.5	117.9	91.7
10.Pakistan	36.7	36.3	98.9
Total 10	1,894.6	1,881.8	99.32

Source: Own calculation based on the data from [5].

Table 5. Distribution of the agricultural land by type in the top 10 countries with the largest agricultural area (Million ha)

	Permanent grasslands			Crop land		
	2000	2021	2021/2000%	2000	2021	2021/2000%
World	3,379.7	3,207.6	94.9	1,493.9	1,579.8	105.75
1.USA	236.3	245.3	103.6	178.0	160.4	90.1
2.India	10.8	10.4	96.2	170.1	168.1	98.7
3.Russia	90.9	92.0	101.2	126.3	123.4	97.7
4.China	392.8	392.8	100.0	130.8	128.6	98.3
5.Brazil	173.4	173.3	99.9	54.8	66.0	120.4
6.Canada	20.1	18.5	92.0	37.8	38.4	101.5
7.Nigeria	24.7	25.1	101.6	40.8	43.4	106.3
8.Ukraine	7.9	7.5	94.9	33.4	33.7	100.8
9.Argentina	99.8	74.6	74.7	28.6	43.2	151.0
10.Pakistan	5.0	5.0	100.0	31.6	31.3	99.0

Source: Own calculation based on the data from [7].

Table 6. The share on the top 10 countries in the global agricultural land by type (%)

	Permanent grasslands			Crop land		
	2000	2021	Difference 2021-2000 (pps)	2000	2021	Difference 2021-2000 (pps)
1.USA	6.9	7.6	+0.7	11.9	10.1	-1.8
2.India	0.3	0.3	-	11.3	10.6	-0.7
3.Russia	2.6	2.8	+0.2	8.4	7.8	-0.6
4.China	11.6	12.2	+0.6	8.7	8.1	-0.6
5.Brazil	5.1	5.4	+0.3	3.6	4.2	+0.6
6.Canada	0.6	0.6	-	2.5	2.4	-0.1
7.Nigeria	0.7	0.8	+0.1	2.7	2.7	-
8.Ukraine	0.2	0.2	-	2.2	2.1	-0.1
9.Argentina	2.9	0.2	-2.7	1.9	2.7	+0.8
10.Pakistan	0.1	0.1	-	2.1	1.9	-0.2

Source: Own calculation based on the data from [7].

Regarding the share in the global cropland, it was noticed that India has 10.6%, followed by USA 10.1%, China 8.1%, Russia 7.8% and Brazil 4.2%, being on the top five positions.

While the share in the permanent grasslands increased in China, Brazil, Russia, Nigeria, it declined in Argentina, and in the other countries remained at the same level

The share in the global cropland declined in almost all these countries, except Argentina and Brazil when it increased and Nigeria where it remained the same (Table 6).

Top 10 countries in the world ranked by the surface of arable land in 2023

In 2023, the arable land belonging to the top 10 countries with the largest agricultural area is shown in Table 7. USA, India, Russia and China have over 1 million km^2, while Brazil, Canada, Nigeria, Ukraine, Argentina and Pakistan have between over 300,000 km^2 up to 560,000 km^2.

Table 7. Arable land in the top countries with the largest agricultural land in the world (km^2)

Country	Arable land	Rank in the world
1.USA	1,577,368	1
2.India	1,553,690	2
3.Russia	1,216,490	3
4.China	1,188,810	4
5.Brazil	557,620	5
6.Canada	382,340	6
7.Nigeria	350,000	7
8.Ukraine	329,240	8
9.Argentina	326,328	9
10.Pakistan	309,300	10

Source: [30].

Land use in the EU's agriculture

In the EU-27, the largest surface belongs to France, Spain, Sweden, Germany, Poland, Finland, Italy, and Romania and about 40% of the EU's territory is represented by agricultural land. About 75% of agricultural land is used by France, Spain, Germany, Poland, Romania and Italy [13, 15].

Most of the EU member states apply modern technologies assuring high land performance regarding yields and production. About 70% of agricultural output is produced by France, Germany, Italy, Spain, Netherlands, Poland and Romania. A higher agricultural production and value added per unit of utilized agricultural land was achieved in the EU during the last decades [16, 17].

And this is also sustained not only by modern technologies which have started to be environment friendly and to assure a healthy diet, but also by the rural population [14], especially by farmers who are more conscious of their duty to produce more and high quality food [18, 19], diminishing the negative impact of climate change according to Green Deal [2].

In the EU-27, agricultural land has registered a general downward trend from 182,673.3 thousand ha in the year 2000 to 162,905.8 thousand ha in 2021, meaning by 10.83% less. Cropland also declined from 122,279.8 thousand ha in 2000 to 110,785.4 thousand ha in 2021, reflecting a decrease by 9.4%.

Also, the surface covered by permanent grasslands declined by 13.71% from 60,393.5 thousand in 2000 to 52,119.4 thousand ha in 2021.

This tendency is explained by the increased production performance per ha and animal and by the need to diminish the negative impact of agriculture on environment.

Therefore, in the EU-27, cropland accounts for 68%, while permanent grasslands for 32% in total agricultural land, reflecting a slight growth of 1.1 pp in cropland and a reduction by 1.1 pp in grasslands (Fig. 6).

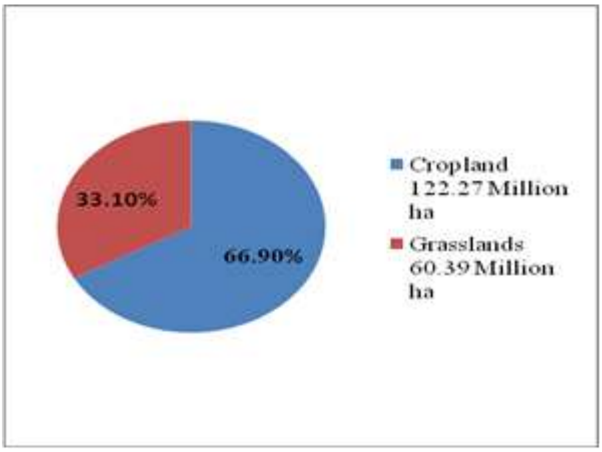

Fig. 6. Distribution of cropland and grasslands in the EU-27 in the year 2021

Source: Own design and calculation based on the data from [7].

In 2021, the weight of the EU-27 agricultural land in the world land was 3.4%.

The cropland represented 7.01% and the land with pastures and meadows accounted for 1.62% in the global level of these categories of land.

The EU-27 countries with the largest agricultural area

Figure 7 shows the EU countries with the largest agricultural area in the descending order based on their surface and share in the year 2021: France, Spain, Germany, Poland, Romania, Italy, Greece, Hungary, Bulgaria, and Ireland, all together accounting for 90.81%.

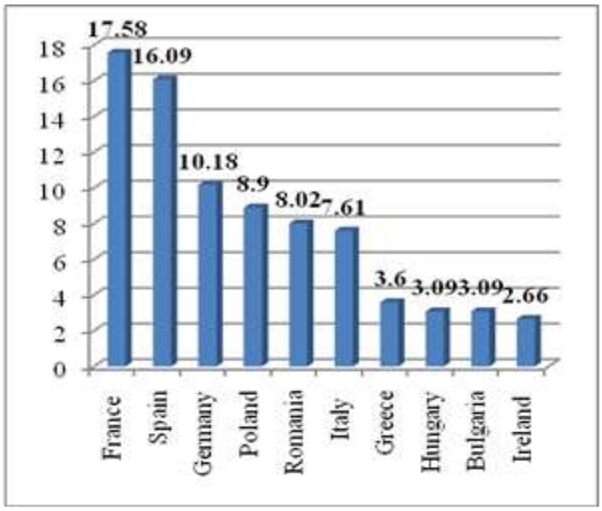

Fig. 7. Top 10 member states in EU-27 agricultural land in the year 2021
Source: Own design and calculation based on the data from [27].

Of the total area of the country, the agricultural land has the highest share in Denmark and Ireland 65.5% and, respectively, 63%.

Also, in land area, an important share of over 55% of agricultural land exists in Romania 56.8%, Hungary 55.3%, Netherlands 53.8%, Spain 52.5%, France 52.1% and Luxembourg 51.6%.

A share between 40 and 40% agricultural area in the country land territory have Poland 47.4%, Germany 47.3%, Lithuania 46.9%, Bulgaria 46.5%, Czechia 45.7%, Greece 45.5%, Belgium 45.1%, Portugal 43.3% and Italy 41.9%.

The smallest share of the agricultural land in the total surface of the county exists in Sweden 7.4%, Finland 7.5% and Cyprus 13.3% (Fig. 8).

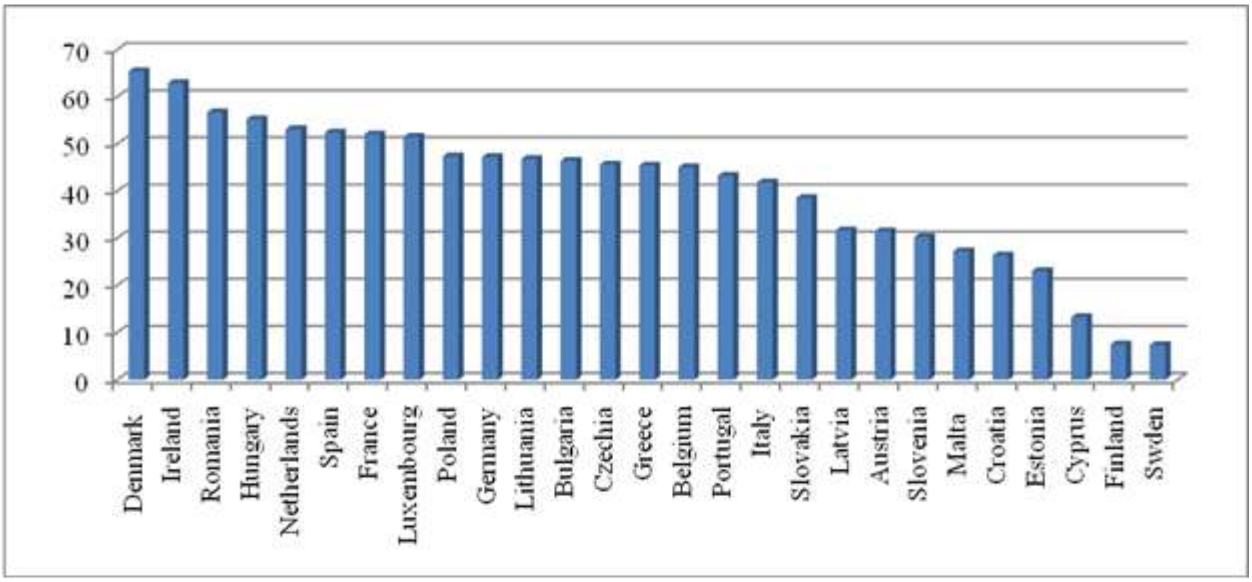

Fig. 8.The hierarchy of the EU countries based on the share of the agricultural land in the total land of the country (%)
Source: Own design and calculation based on the data from [27, 26].

Agricultural land had a general decreasing trend in almost all the EU states, except seven countries where it increased in 2021 compared to the year 2000. It is about: Croatia +26.2%, Latvia +24%, Spain +17.9%, Luxemburg +3.5%, France +2.2%, Sweden + 0.9%, Estonia +0.1% and Portugal +0.1%.

In the other countries, the decline ranged between -31.3% in Greece, the highest loss, and Belgium -1.8%, the smallest loss.

In Table 8 is presented the agricultural area by EU member state in the year 2021 (The year 2000= 100).

Arable land in the EU-27 accounted for 986,528.75 km^2 in the year 2023.

The top 10 EU countries with the largest arable area, in the decreasing order based on their share in the EU arable surface are: France, Germany, Spain, Poland, Romania, Italy, Hungary, Bulgaria, Sweden and Czechia (Fig. 9).

Table 8. Agricultural area by EU member state in the year 2021 - Thousand ha (The year 2000=100)

	2021	2021/2000 %
Austria	2,587.5	88.3
Belgium	1,365.7	98.2
Bulgaria	5,046.6	90.4
Croatia	1,476	126.2
Cyprus	123.1	86.9
Czechia	3,529.8	82.4
Denmark	2,618	98.9
Estonia	987	100.1
Finland	2,268	102.2
France	28,553.7	95.7
Germany	16,590	97.1
Greece	5,867.2	68.7
Hungary	5,047.7	86.1
Ireland	4,338	98.16
Italy	12,403	79.3
Latvia	1,970	124
Lithuania	2,937.8	85.9
Luxemburg	132.5	103.5
Malta	8.8	97.7
Netherlands	1,811	92.3
Poland	14,499.5	78.7
Portugal	3,962.3	100.1
Romania	13,079	88.0
Slovakia	1,856	76.0
Slovenia	611	117.9
Spain	26,228.4	80.1
Sweden	2,002.2	100.9

Source: Own calculations based on the data from [26].

The distribution of arable land by EU country in 2023 is shown in Table 9.

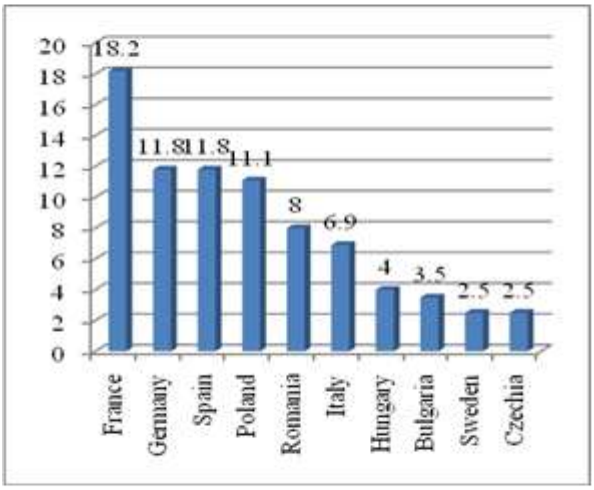

Fig. 9. The EU-27 top 10 countries with the largest arable land (% of the EU arable area)
Source: Own calculation based on the data from [25].

Table 9. Arable land by EU country (km^2) in 2023 and rank in the EU

	2023	Rank
EU-Total arable land	**986,528.75**	**-**
Austria	13,210.8	17
Belgium	8,648.77	21
Bulgaria	34,920	8
Croatia	8,890	20
Cyprus	1,024.02	25
Czechia	24,841.54	10
Denmark	23,709.3	11
Estonia	6,940	22
Finland	22,430	13
France	179,565.6	1
Germany	116,640	2
Greece	21,319.3	14
Hungary	40,120	7
Ireland	4,440	23
Italy	68,310	6
Latvia	13,340	16
Lithuania	22,494	12
Luxemburg	621.3	26
Malta	90.7	27
Netherlands	10,048.3	18
Poland	109,210	4
Portugal	9,515,34	19
Romania	89,150	5
Slovakia	13,460	15
Slovenia	1,810.3	24
Spain	116,393	3
Sweden	25.385.52	9

Source: Own calculations based on the data from [30].

The EU-27 cropland accounted for 110,786.4 thousand ha in 2021, being by 9.4% smaller than 122,279.8 thousand ha in the year 2000.

The countries with the largest cropland, in the decreasing order of their share: France, Spain, Germany, Poland, Italy, Romania, Hungary. Bulgaria, Greece and Sweden, these top 10 countries representing 92% of the EU-27 cropland.

In the interval 2000-2021, cropland in the EU registered a decreasing percentage which varied between -24% in Czechia, the highest level and -1.4% in Germany, the lowest level.

In other five countries, cropland increased as follows: +39.6% in Latvia, +14.4% in Slovenia, +4% in Denmark, +2.5% in Finland, and +1.5% in Luxemburg (Table 10).

Table 10. Crop land by EU country in 2021 (Thousand ha) and changes versus the year 2000=100 (%)

	2021	2021/2000 %
EU-27	**110,786.4**	**90.6**
Austria	1,387.5	94.3
Belgium	889.4	100.7
Bulgaria	3,648.5	95.5
Croatia	936.0	102.7
Cyprus	120.9	86.1
Czechia	2,524.3	76.0
Denmark	2,384.0	104.1
Estonia	705.0	82.4
Finland	2.247.0	102.5
France	18,970.5	97.3
Germany	11,860.0	98.6
Greece	3,220.2	83.5
Hungary	4,289.2	89.3
Ireland	437.0	89.1
Italy	9,861.4	82.9
Latvia	1,371.0	139.6
Lithuania	2,315.2	79.2
Luxemburg	64.0	101.5
Malta	8.8	97.7
Netherlands	1,040.0	98.2
Poland	11,458.8	79.9
Portugal	1,831.8	72.1
Romania	8,989.0	90.7
Slovakia	1,344	85.3
Slovenia	233.4	114.4
Spain	16,609.8	90.7
Sweden	2,538.7	97.5

Source: Own calculations based on the data from [32].

EU-27 permanent meadows and pastures

In the year 2021, the EU-27 surface covered by grasslands accounted for 52,119.4 thousand ha, being by 13.71% smaller than 60,393.5 thousand ha in the year 2000.

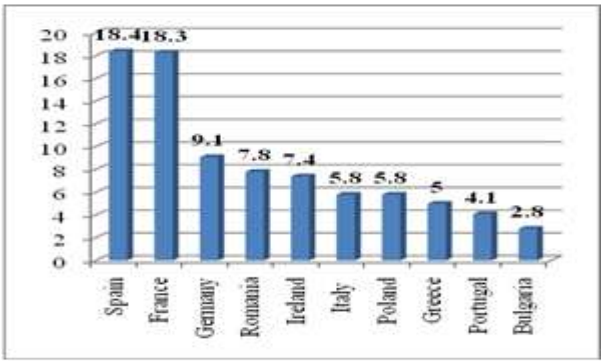

Fig. 10. The EU-27 top 10 countries with the largest area of permanent meadows and pastures in the year 2021 versus 2000 (% of the EU area with grasslands)
Source: Own calculation based on the data from [10].

The countries keeping the largest areas with permanent meadows and pastures and their share in the Total EU-27, in the descending hierarchy are the following ones: Spain, France, Germany, Romania, Ireland, Italy, Poland, Greece, Portugal, and Bulgaria (Fig. 10).

Table 11. EU-27 land with permanent meadows and pastures by member state in 2021 versus 2000 (%) (2000=100)

	2021	2021/2000 %
EU-27	**52,119.4**	**86.29**
Austria	1,210	82.3
Belgium	476.3	93.9
Bulgaria	1,397.1	77.4
Croatia	540.0	209.3
Cyprus	2.2	200.0
Czechia	1,005.5	104.6
Denmark	234	65.3
Estonia	282.0	215.2
Finland	21.0	80.7
France	9,583.2	92.9
Germany	4,730.0	93.7
Greece	2,647.0	56.6
Hungary	754.5	71.7
Ireland	3,901.0	99.8
Italy	3,014.6	69.8
Latvia	599.0	99.8
Lithuania	622.6	125.2
Luxemburg	68.5	105.3
Malta	-	-
Netherlands	771.0	85.4
Poland	3,040.7	74.4
Portugal	2,130.5	150.3
Romania	4,090.0	82.6
Slovakia	512.0	59.1
Slovenia	377.6	120.2
Spain	9,618.6	83.9
Sweden	463.5	124.6

Source: Own calculations based on the data from [10].

In the analyzed interval 2000-2021, the surface covered by permanent meadows and pastures in the EU-27 declined in almost all the EU member states. The highest decrease was noticed in Greece (-43.4%) and Slovakia (-40.9%) and the smallest decline was registered in Ireland (-0.2%0 and Latvia (-1.2%).

In nine EU countries, the surface with permanent grasslands increased as follows; 2.09 times in Croatia, 2 times in Cyprus, by+4.6% in Czechia, 2.15 times in Estonia, by =25.2% in Lithuania, +5.3% in Luxemburg, +50.3% in Portugal, +20.2% in Slovenia and +24.6% in Sweden (Table 11).

The concentration degree of agricultural land, arable land, cropland and the land with permanent meadows and pastures in the EU-27 in the year 2021 is shown in Table 12. The result for Herfindhal-Hirschman index reflected a high concentration of agricultural land in the EU-27. In case of the arable land, we cannot affirm that this category of land is concentrated, on the contrary, we may say that it is a lack of concentration as HHI has a very low value and GSI and CC as well. Also, in case of cropland, there is no concentration as the value of the calculated HHI, GSC and CC are very small. For permanent meadows and pastures, the land use for this purpose is small, close to the limit to a weak concentration degree (HHI < 0.15) as shown in Table 12.

Table 12. Concentration degree of land by category in the EU-27 in the year 2021

Land use	HHI-Herfindhal-Hirschman Index	GSI- Gini-Struck Index	CCj -Coefficient of concentration	Remarks
Agricultural land	0.3192	0.5413	0.5618	High concentration
Arable land	0.0933	0.2418	0.2509	No concentration
Cropland	0.0943	0.2438	0.2530	No concentration
Permanent meadows and pastures	0.1322	0.3143	0.3263	Below the limit of Weak concentration

Source: Own calculations.

Crop land per inhabitant

Crop land per inhabitant is a synthetic indicator which links the agricultural land to the number of the population at the global level, but also by region and country. While the agricultural land is decreasing at the world level, and the number of the population is on an ascending trend, we are worry about food security asking the question: Is it enough food to nourish the globe population? On February 18, 2024, the world population reached 8,118, 835,999 inhabitants and day by day it continuous to grow [33]. Between 1961-2016, as affirmed FAO data, the population of the globe doubled its number and this means higher demand for food. Of course, agricultural production increased due to the modernization of technologies but land is limited and taking into account the population growth, the land per capita declined from 0.45 ha in the year 1961 to 0.21 ha in the year 2016 [6, 8]. In the year 2021, after two decades, the level declined by 0.04 ha reaching the level of 0.20ha/capita. This situation is a reflection of the changes in arable land and also in the surface for permanent crops in various countries and also due to the population trend. The reduction in cropland per capita is an alarm bell regarding food security. The highest cropland per capita is in Oceania 0.77 ha/inhabitant, followed by Europe with 0.39 ha/capita, Americas with 0.37 ha/capita, Africa 0.21 ha and finally with Asia with only 0.13 ha/capita (Fig. 11).

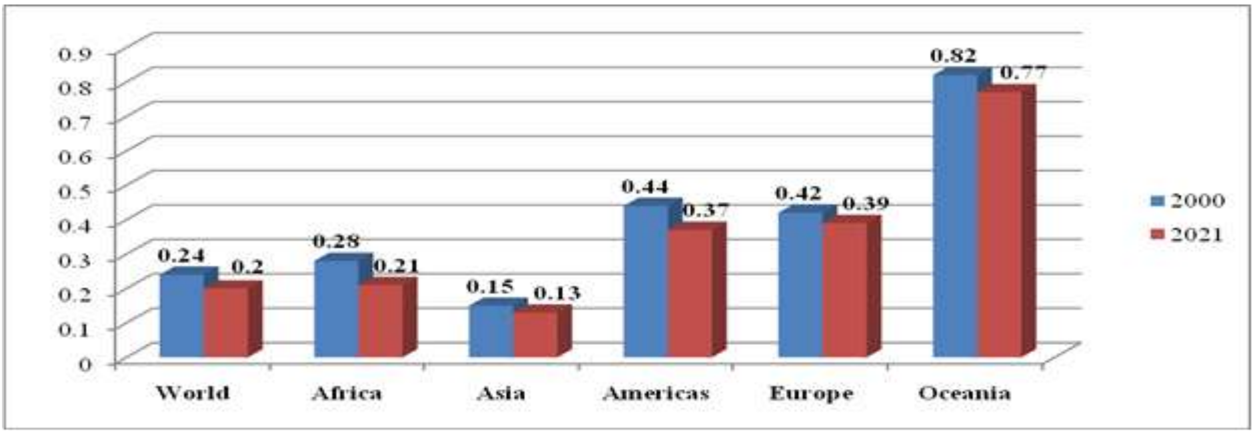

Fig. 11. Crop land (arable land plus permanent crops) per capita by continents in 2021 versus 2009 (ha/capita)
Source: Own design based on the data from [7].

The land per capita in the top 10 countries with the largest arable land registered important reduction in the last two decades, except two countries Ukraine and Argentina, as presented in Table 13.

The data reflect a critical situation in China, India and Pakistan where it is recorded a very low crop land per capita below the world average.

A good situation is in USA, Ukraine and Argentina and a very good situation in Canada.

Table 13. Crop land per capita in the countries with the largest arable land in 2021 versus 2000 (ha)

	2000	2021	2021-2020
World	**0.24**	**0.20**	**-0.04**
1.USA	0.63	0.48	-0.15
2.India	0.16	0.12	-0.04
3.Russia	0.86	0.85	-0.01
4.China	0.10	0.09	-0.01
5.Brazil	0.31	0.31	-
6.Canada	1.34	1.01	-0.33
7.Nigeria	0.33	0.20	-0.13
8.Ukraine	0.69	0.78	+1.13
9.Argentina	0.77	0.96	+0.19
10. Pakistan	0.21	0.14	-0.07

Source: Own processing based on the data from [32].

Crop land per capita in the EU-27 is in average 36.56 ha agricultural land per inhabitant, but the level of this indicator differs from a member state to another.

In 2021, in the decreasing order, the top 10 EU countries with the largest cropland per capita were: Lithuania 0.83, Latvia 0.73, Estonia 0.53, Bulgaria 0.53, Romania 0.47, Denmark 0.41, Finland 0.41, Spain 0.35, Greece 0.31 and Poland 0.30.

In the last two decades, cropland per capita declined in the majority of the EU countries.

The highest decrease was recorded in Spain (-0.10 ha) and the smallest decline was 0.01 ha in Belgium, Finland, Germany and Netherlands.

In Malta there is no change, the crop land per capita remaining stable at 0.02 ha. However, in a few countries, the crop land per capita increased like in Bulgaria (+0.06), Croatia (+0.03), Latvia (+0.32), Lithuania (+0.02), Romania (+0.02), and Slovenia (+0.01) (Table 14).

Table 14. Cropland per capita in the EU-27 by member state in the year 2021 versus 2000 (ha/capita)

	2000	2021	Difference 2021-2000
Austria	0.18	0.16	-0.02
Belgium	0.09	0.08	-0.01
Bulgaria	0.47	0.53	+0.06
Croatia	0.20	0.23	+0/03
Cyprus	0.15	0.10	-0.05
Czechia	0.32	0.24	-0.08
Denmark	0.43	0.41	-0.02
Estonia	0.61	0.53	-0.08
Finland	0.42	0.41	-0.01
France	0.33	0.29	-0.04
Germany	0.15	0.14	-0.01
Greece	0.35	0.31	-0.04
Hungary	0.47	0.44	-0.03
Ireland	0.13	0.09	-0.04
Italy	0.20	0.16	-0.04
Latvia	0.41	0.73	+0.32
Lithuania	0.81	0.83	+0.02
Luxemburg	0.14	0.10	-0.04
Malta	0.02	0.02	-
Netherlands	0.07	0.06	-0.01
Poland	0.37	0.30	-0.07
Portugal	0.25	0.18	-0.07
Romania	0.45	0.47	+0.02
Slovakia	0.29	0.25	-0.04
Slovenia	0.10	0.11	+0.01
Spain	0.45	0.35	-0.10
Sweden	0.29	0.24	-0.05

Source: Own calculation based on the data from [32].

Agricultural land and food production

The result of the agricultural land use is food production, which shows the agriculture technological level and its efficiency to nourish the people and animals.

The success in developing agricultural technologies and agri-food systems has led to a high rate in food production growth which exceeded the expand rate in agricultural land. The new implemented technologies have sustained and continue to increase land productivity in terms of yield and total production, which help us to draw the conclusion that it is not necessary to increase agricultural land in the future [3].

More than this, the last decades proved that the extend of the agricultural land for producing more food and animal feed had a negative impact on the environment and biodiversity. The greenhouse gas emissions increased, the dioxide of carbon reached a high level, deforestration for various purposes reduced an important of oxigen, and all these have led to climate change, loss of biomass, biodiversity and habitats, and to communities loss of access to resources [11].

Therefore, to increase food production it is needed to pass to other alternatives based on a new orientation to a healthier and green diet of the consumers and resulting in beneficial consequences on the environment.

These are the reasons why the experts consider that it is the moment to stop the growth of the agricultural area and even to reduce it to an optimum dimension due to technological performance which enable agriculture to nourish a population of over 8 Billion inhabitants in the future.

The official statistical data proved that after the peak of agricultural land, agricultural production continued to raise strongly.

The only problem is that cropland have not yet reached its peak, but the grasslands have peaked, sustaining the growth of meat production in the last decades, especially coming from cattle which are grown and fattened on pastures but also in sheds where more intensive technologies based on grains produced on croplands are applied. At present, more than 50% of cropland is used to produce foodstuffs for animals and also an important part of cropland is destined to produce more biofuels for diminishing pollution [22, 23].

CONCLUSIONS

The global agricultural land registered a decreasing trend in the period 2000-2021, in the year 2021, accounting for 4,787.5 Million ha, being 1.8% smaller than in the year 2000. The largest surface is in Asia, Africa and Americas.

The world crop land increased and attained 1,579.8 Million ha in 2021, being by 5.7% larger. It accounts for 33% of the global agricultural land, while permanent grasslands represent 67% of 4,787.5 Million ha.

The share of each continent in the world cropland is: Asia (37.1%), Americas (23.9%), Africa (18.5%), Europe (18.2%) and only 2.2% in Oceania. The cropland registered a decline in Europe, Americas, and Asia, but an increase in Africa and Oceania.

China, USA, Brazil, Russia, India, Argentina, Nigeria, Canada, Ukraine, and Pakistan are the largest countries which sum 1,881.8 Million ha agricultural land, representing 39.3% of the global agricultural land.

In 2021, China, USA and Brazil have the highest share in the global grasslands (12.2%, 7.6% and, respectively, 5.4%).

The cropland had a slight decline in USA, Russia, India, China and Pakistan, while in Brazil, Canada and Nigeria increased.

The permanent grasslands increased in USA, Russia, China and Nigeria and declined in Argentina, China, India and Canada.

About 40% of the EU's territory is represented by agricultural land and belongs to France, Spain, Sweden, Germany, Poland, Finland, Italy, and Romania. In the EU-27, agricultural land decreased by 10.83%, accounting for 162,905.8 thousand ha in 2021. This is because, cropland declined by 9.4% from 122,279.8 thousand ha in 2000 to 110,785.4 thousand ha in 2021, while permanent grasslands declined by 13.71% from 60,393.5 thousand in 2000 to 52,119.4 thousand ha. Therefore, cropland accounts for 68%, while permanent grasslands for 32% in the EU-27 agricultural land.

The EU-27 keeps 3.4% of the global agricultural land, 7.01% of the global crop land and 1.62% of the world grasslands.

About 90.81% of the EU agricultural area is in France, Spain, Germany, Poland, Romania, Italy, Greece, Hungary, Bulgaria, and Ireland. In almost EU member states the agricultural area declined, but in a few states it increased

The EU-27 arable land accounted for 986,528.75 km^2 in the year 2023. The largest arable surface is in France, Germany, Spain, Poland, Romania, and Italy, all together summing 67.8 % of the EU arable area.

The EU-27 had 110,786.4 thousand ha cropland in 2021, being by 9.4% smaller than in the year 2000. About 92% of the EU crop area is kept by France, Spain, Germany, Poland, Italy, Romania, Hungary. Bulgaria, Greece and Sweden.

In 2021, the EU-27 surface covered by grasslands was 52,119.4 thousand ha, by

13.71% smaller than in the year 2000. The largest areas with permanent meadows and pastures are in Spain, France, Germany, Romania, Ireland, Italy, Poland, Greece, Portugal, and Bulgaria. The surface covered by permanent meadows and pastures in the EU-27 declined in almost all the EU member states.

In the EU, it is a high concentration of agricultural land, but no concentration regarding arable land, cropland and permanent grasslands.

Because the world population exceeded 8.11 billion inhabitants and will continue to grow, the agricultural land per capita declined from 0.24 ha in the year 2000 to 0.20 ha at the global level in 2021.

The highest cropland per capita is in Oceania 0.77 ha, Europe 0.39 ha, Americas 0.37 ha, Africa 0.21 ha and Asia with only 0.13 ha.

Among the countries with the largest arable land, a critical situation in China, India and Pakistan where the cropland per capita is very small and below the world average. A good situation is in USA, Ukraine and Argentina and a very good situation in Canada.

In the EU-27, the average is 36.56 ha agricultural land per capita, and the countries with the largest cropland per capita are: Lithuania 0.83, Latvia 0.73, Estonia 0.53, Bulgaria 0.53, Romania 0.47, Denmark 0.41, Finland 0.41, Spain 0.35, Greece 0.31 and Poland 0.30.

The fact that agricultural production increased due to the better and better technologies, its growth rate exceeded the rate of expand in agricultural land.

The problem is that the expand of the agricultural land has to be stopped, as enough food could be produced to nourish the global population. This implies important changes to be achieved in adopting new agro-eco technologies called to increase crop yield and productivity but protecting environment and biodiversity. This means a reduction in meat production and consumption to protect forests and cropland, and to stop deforestation, which will encourage and orient the people to a healthier and green diet.

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NEW TRENDS IN THE GLOBAL SILK PRODUCTION IN THE PERIOD 2011-2022

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Abstract

The purpose of this study was to analyze the dynamics of raw silk production in the period 2011-2022 at the global level and in the top six producing countries using the official data and usual methods in such a research: fixed basis and structural indices, descriptive statistics, regression equations, coefficient of determination, correlations, absolute and relative differences, comparisons etc. The results showed that, at the global level, raw silk production accounted for 91,221 Metric tons in the year 2022 being by 30% smaller than in 2011. The top silk producing countries are China, India, Uzbekistan, Vietnam, Thailand and Brazil. While in China, Thailand and Brazil production has substantially declined (- 52%, -33.5%, -23%), in India, Uzbekistan and Vietnam silk production increased by 58.6%, 116.7% and 113.4%. The share of all these six countries in the global production is 99.2%. In 2022, the highest weight belongs to China (54.8%) and India (40.1%). It is expected as silk production to raise taking into account that it is an eco and skin friendly product, and also a biodegradable product, while synthetic fibers are polluting. However, the high production cost, market price fluctuation and other restraining factors could affect small farmers dealing with sericiculture. For the developing countries, silkworm rearing and silk production sector is a profitable business which offer jobs, income, a better living standard, reducing poverty, hungry, gender discrimination, preserving biodiversity and conserving soil quality and contributing to the sustainable development in the rural areas.

Key words**:** *silk, global production, major producing countries, trends*

INTRODUCTION

Silk is "the Queen" of the natural fibers grace to its special qualities: softness, high fineness, pleasant and delicate touch, a higher resistance than a steel wire, brilliant shining, elegant and shimmering appearance [12].
It is also an environmental and skin friendly product. For these reasons it is processed into silk fabric.
The most known silk is that coming from the cocoons produced by silk worms rearing, a subsector of agriculture largely spread mainly in the developing countries [9].
Silk is carried out in more than 60 countries, and about 90% of silk is produced in Asia where also the non-mulberry silk accounts for 100%.
However, silk production represents only about 0.2% of the global production of natural fibers [15].
Silkworm rearing has **an important social-economic and environment importance consisting of:**
- contribution to the development of the rural areas;
- creating jobs for the rural population, especially for women and family members, including old persons; at the global level, millions of people is dealing with sericiculture, mainly in the developing countries;
- limiting migration from the rural area to the cities;
- it needs just a small investments, less machinery and equity [15, 16].

-it is suitable both for small and large farms;
- it requires simple and mainly manual operations to grow silk worms; therefore it needs more labour force than in other activities and has one of the highest employment rate;
-the production cost for producing cocoons for reeling is very small, being considered the lowest cost compared to other deals;
- it could assure income to the farmer and his family developing a profitable business and resulting in a better living standard [11].
- it makes the most profit at the least cost [9].
- For the same volume, silk fabric has a 20 times higher value than a cotton fiber.
-it is considered an eco-friendly activity, because the mulberry tree growing has a beneficial effect on the soil protection against erosion and produces a green cover over the ground; also, it allows the use of the land which is not utilized for crop cultivation.
- silk is a renewable material and silk producing does not pollute the soil and has just a small amount of CO_2 emissions and wastes which are biodegradable;
-silk worms raising depends on the mulberry trees plantations which needs a small amount of fertilizers and pesticides when it is necessary;
- silk worm growing preserves biodiversity in the rural areas;
-silk worm growing and silk industry assure the sustainable development of the countries and mainly of the rural areas, contributing to the reduction of poverty, hungry, gender discrimination, risk of diseases;
-it encourages silk production for international trade, the exporting countries benefiting of an inflow of foreign currency in their trade balance and the importing countries benefiting by the raw silk yarn they need to processing in various silk products [13, 18].

Because demand and consumption increased at the international level, silk worm rearing and silk production are continuously expanding in the developing countries and it is expecting to be in the future as well.

Silk industry is aligned to the "United Nation Organization which established 17 Sustainable Development Goals (SDGs) in the year 2015, focused on: no poverty, zero hungry, gender equality, decent work, economic growth, industry, innovation, infrastructure, reduced inequality, responsible consumption and production, partnership to reach the goals" [21].

According to their origin, **silk types** are classified into two groups: *mulberry silk*, which is the most known silk representing 90% of the global production, and *non-mulberry silk*, which includes various sorts such as:

-*Tasar silk*, produced by a specific variety of silkworms called *Antheraea Mylitta*, which feeds on the leaves of Arjun and Asan trees in the wild [1].

-*Eri Silk*, a protein fiber derived from cocoons made by the *Samia Cynthia Ricini* moth or *Philosamia Ricini* moth; it is mostly used in weaving, knitting, crochet, and embroidery [10].

-*Muga Silk* is a wild silk produced by the larvae of the *Assam silkmoth* in India and has a high durability and a natural yellowish-golden tint [24].

These are the four most known types of silk. But, there are also other sorts like: *Anaphe, Fagara, Coan, Mussel, Spider silk* produced in Africa and Asia.

Silk products are of a large variety and regarding textile and clothing industry, cosmetics industry, medical sector and others [14].

Clothing industry based on silk products is continuously developing due to the higher and higher temperatures connected to climate change and because the increased demand of a large range of silk clothes, most of them being luxury garments produced especially from the mulberry silk type. These clothes are efficiently protective against warmth and also against cold.

The main products achieved from silk are: blouses for women, sarees-traditional dresses for Indian women, scarves for women, collars for men, shirts, suits, luxury dresses, wedding dresses, evening gowns, jerssey dresses, kimonos, silk ties, socks for men, lengerie, pijamas, swimming suits, etc.

Eri silk is utilized for shawls and sophisticated clothes created by fashion designers [4, 6, 20].

Textile Industry is also expanding based on Tasar materials, spider silk for bed covers, tasar holstery and cushions, bed sheets, pillows, draperies, curtains, table cloths, carpets etc.

Cosmetics Industry is fast developing due to the existence of the silk protein which consists of important amino acids, a reason to use silk in producing: liquid soap, shower gel, shampoo, cleansing foam, cremes, lotions, conditioners, nail enamel etc. [4, 6, 20].

Medical sector benefits of the special features of the silk: bio-compatibility and environment friendly. It is successfully utilized in producing smart textiles. As silk has a poor conductivity, metal particles, graphene and other materials are added resulting a useful combination which is used in carrying out specific products and apparel for monitoring hospitals and patients demand.

"Smart textiles have multiple applications in health care, protective clothing, firefighting clothing, smart clothing, sport clothing, military clothing, electronic apparel etc." [23].

Modern measuring instruments include smart fabric and sensors which could detect: temperature, make a cardiogram, myography, could listen to the heart beats, lungs breathing, digest track. They could measure blood flow and pressure, breathing and could help the diagnosis process and the detection of microbes. Among this type of smart fabric it could be cited: clothing and vest for patients, every day apparel for health self-monitoring and treatment without any help from the doctor; caps to treat disorders at the level of the nervous system, therapeutic gloves, devices to sustain heart and correct beats and blood circulation, oximeters for self-monitoring of breathing quality, T-shirts for sportsmen for detecting the effort risk and preventing heart attack, temperature and pressure sensors for self monitoring, smart gloves with electrical stimulation to diminish and eliminate pain for the patients with arthritis etc. [6].

Other utilizations of silk includes: parachutes and bicycle tires etc.

Under the competition of the synthetic fibers which are very cheap, but have a negative impact on health and pollute the environment, a special attention has been paid to natural fibers which are healthy and bio-degradable [12]. This has stimulated production of natural fibers, among which silk is the most precious raw material for luxury products of high quality and which have a high return to producers, manufacturers and traders.

In 2022, silk market size reached USD 24.83 Billion and it is expected to grow to USD 39.12 Billion in 2028.

About 202,000 Metric Tons of silk are produced every year representing about 0.2% of the total fiber use. Taking into account a price of USD 15 per kg of silk, this means a production value of USD 3.03 Billion per year [19].

In 2023, in India, one kg of raw mulberry silk accounted for Rupees 4,590, which means USD 56 per kg, at an average exchange rate of 1 USD = 81.94 Rupees.

In this context, the goal of this study was to analyze the dynamics of raw silk production at the global level and in the main producing countries in order to identify the changes that have appeared in the period 2011-2022 and also in the period 2017-2022 versus 2011-2016. It also aimed to emphasize the changes in the hierarchy of the top producing countries: China, India, Uzbekistan, Vietnam, Thailand and Brazil. This is a continuation of the study which was carried out in the year 2018.

MATERIALS AND METHODS

For this research, the data were collected from various official information sources such as: International Sericicultural Commission, 2024, Statistics, Production, Silk Market Reports, United Nations Development Programme.

Raw silk production was analyzed for the period of reference 2011-2022 for which the data are available at present.

To make a comparison about the dynamics trend, the period was divided into two equal sub intervals: 2011-2016 and 2017-2022, calculating the absolute and relative differences between the period 2017-2022 versus 2011-2017.

The analysis was extended from the global level to the main silk producing countries: China, India, Uzbekistan, Vietnam, Thailand and Brazil, the data being studied applying the same procedure like in case of global production.

Descriptive statistics was used to characterize the main statistical features of silk cocoon production and raw silk production at the global level and by selected country.

Polynomial regression equations displayed the main trends and the changes produced across the time have been judged interpreting the R square values. Fixed basis and Structural index were also calculated to quantify the differences at the end of the period in comparison with the level at the beginning of the interval. Graphical illustrations and the tables showed the data and results being accompanied by suitable comments.

Finally, the main conclusions have been drawn and the author's opinion on the future development of raw silk production was expressed.

RESULTS AND DISCUSSIONS

Silkworm cocoon production

The global production of silk cocoons decreased in the interval 2011-2017 from 501,772 MT in the year 2011 to 414,788 MT in 2022, meaning a reduction by 17.4% (Fig. 1).

Figure 1 has a bell shape as while in the first sub-period, the silkworm cocoons production had an upward trend, reaching the maximum level in the year 2015 (750,309 MT), in the second period, the production has continuously decreased reaching the lowest level of 414,788 MT in 2022.

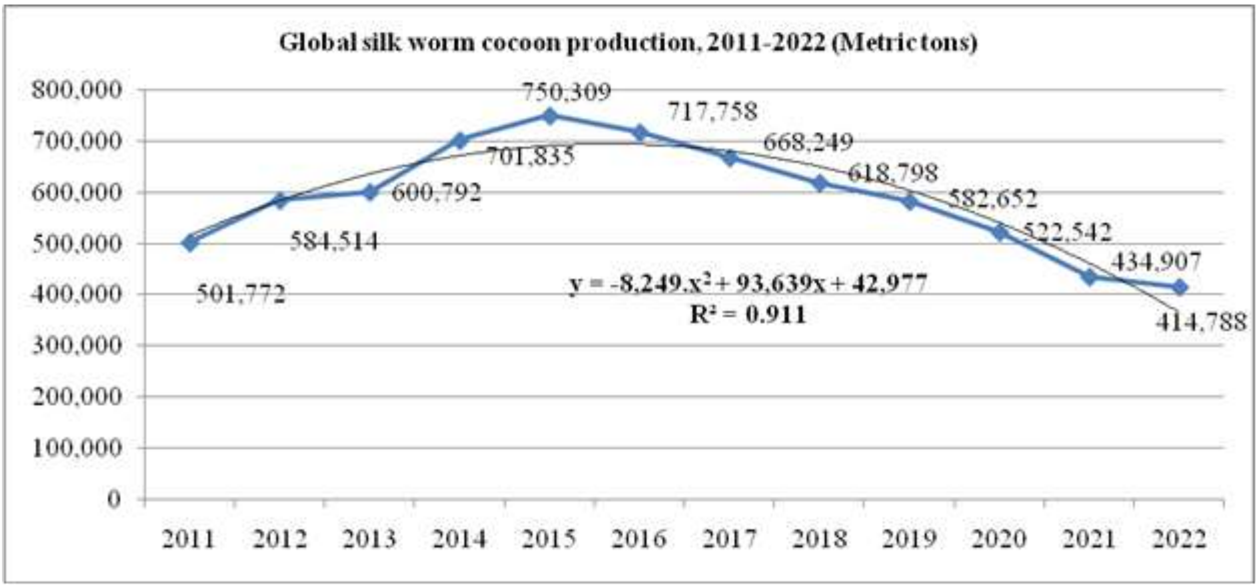

Fig. 1. Global silkworm cocoons production, 2011-2022 (Metric Tons)
Source: Own design based on the data from FAOSTAT, 2024 [2].

This reflects that we could expect to a downward tendency in raw silk production as well.

If we compare the raw silkworm cocoon production in the two subintervals, we may easily observe that in the last period of six years 2017-2022, silk production accounted for 3,241,936 MT being by 16% smaller than 3,856,980 MT in the sub period 2011-2016 (Table 1).

Table 1. Differences in global silkworm cocoons production between the period 2017-2002 versus 2011-2016

2017-2022	2011-2016	Absolute differences 2017-2022 versus 2011-2016 (MT)	Relative differences 2017-2022 versus 2011-2016 (%)
3,241,936	3,856,980	-615,044	-16 %

Source: Own calculation.

World raw silk production

In the period 2011-2022, the global raw silk production registered an ascending trend from 2011 to 2015, and, in this last year, it accounted for 202,073 MT, the maximum level recorded in the whole analyzed period. Since 2015, raw silk production declined reaching the minimum level of 86,311 MT in the year 2021 and, in 2022, it increased a little to 91,221 MT. In 2022, raw silk production was by 30% smaller than in 2011 and by 55% smaller than the peak registered in 2015 (Fig. 2).

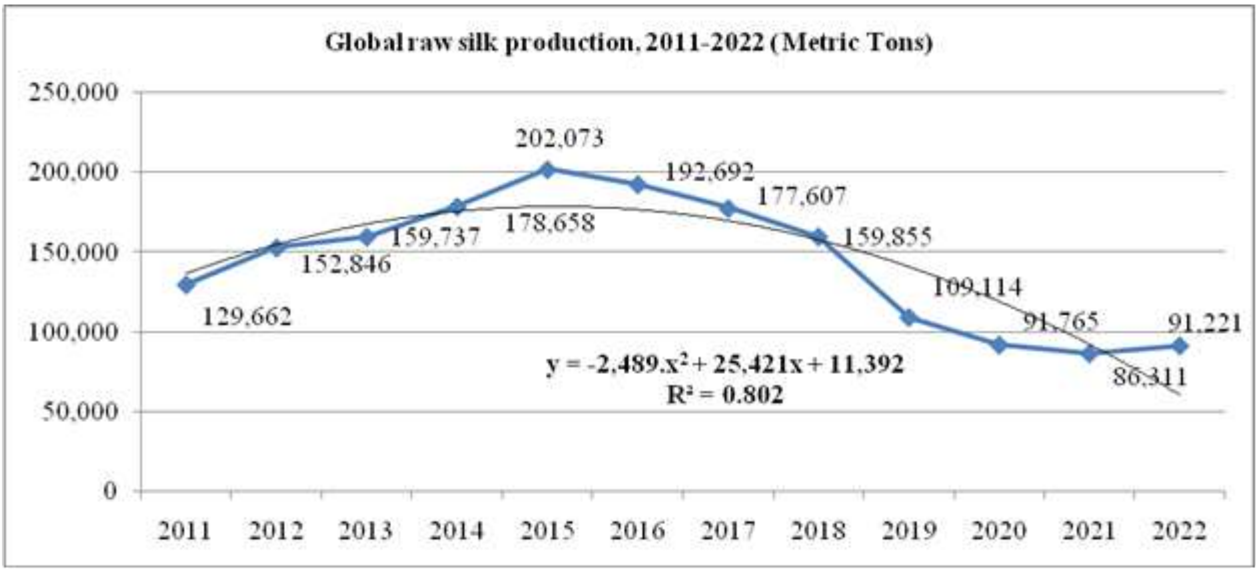

Fig. 2. Global raw production, 2011-2022 (Metric Tons)
Source: Own design based on the data from [3, 4].

Taking into comparison the two sub-periods, we noticed that in the period 2017-2022, the global raw silk production accounted for 715,773 MT, being by 29.53% smaller than the production carried out in the period 2011-2016 (Table 2).

Table 2. Differences in global raw silk production between the period 2017-2002 versus 2011-2016

2017-2022	2011-2016	Absolute differences 2017-2022 versus 2011-2016 (MT)	Relative differences 2017-2022 versus 2011-2016 (%)
715,773	1,015,668	- 299, 895	-29.53%

Source: Own calculation.

Regression equation regarding the determination relationship of raw silk production (y) by silkworm cocoons production (x)

The regression equation reflecting the connection between raw silk production considered Y- the dependent variable and silkworm cocoons production considered the independent variable X is shown in Table 3.

The regression equation shows that an increase by one metric tons in silkworm cocoons production will determine an increase by 0.3561 metric tons in raw silk production.

The determination coefficient, R square = 0.8632 tells us that 86.32 % of the variation in raw silk production is determined by the variation in silkworm cocoons production.

The correlation coefficient r = 0.929 reflects that between the two productions it is a positive and strong relationship.

Table 3. Regression statistics for Y- raw silk production depending on x- silkworm cocoons production

Variable	Coefficient	St. Error	t - stat	Prob.
Regression analysis for Y- Raw silk production; X- Silkworm cocoons production				
C-constant	-66, 384.44	26,922.10	-2.465	0.0333
X - Silkworm cocoons production	0.3561	0.0448	7.944	1.251
R squared	0.8632	Mean of dependent var. Y	144,286.75	
Adjusted R squared	0.8495	St. Dev. of dependent var.	41,467.38	
St. Error of regression	16,084.08			
Sum squared residuals	2,586,978,912			
Regression equation: y = -66,384.044 + 0.3561 x				

Source: Own calculation.

Raw silk production in the top six producing countries

China is the world leader in silk production. Its production increased in the analyzed interval from 2011 till 2015, when it reached the peak level, accounting for 170,000 MT, and then it started to decline accounting for only 50,000 MT in 2022, after the minimum level of 46,700 MT in 2021.

Therefore, in the analyzed interval, silk production in China decreased from 104,000 MT in 2011 to 50,000 MT in 2022, meaning a loss of 52% (Fig. 3).

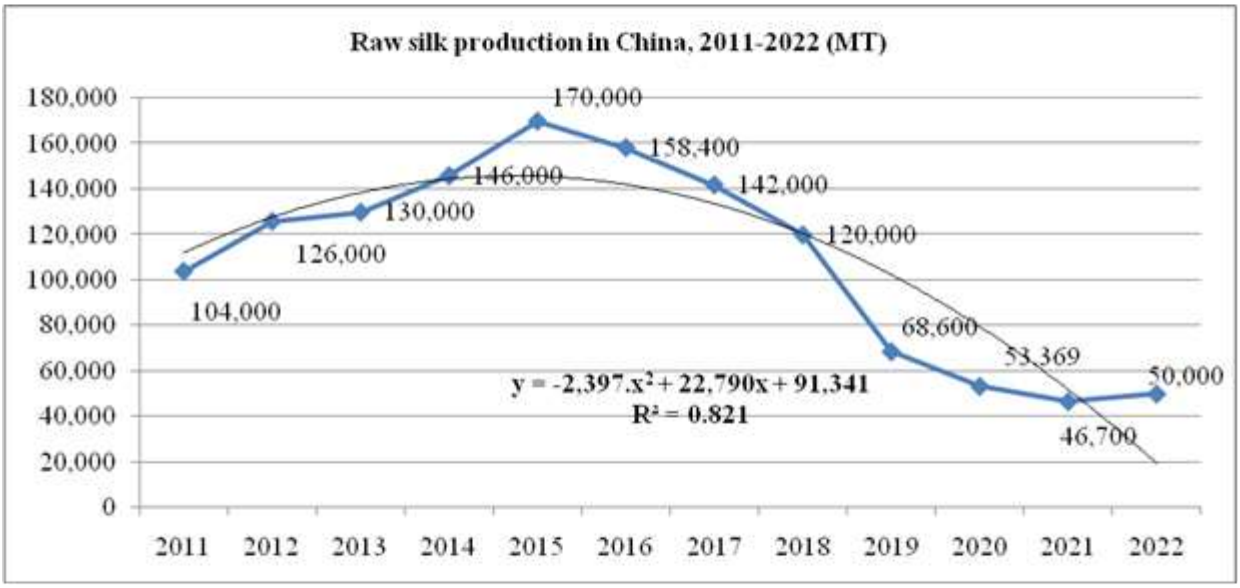

Fig. 3. Dynamics of raw silk production in China, 2011-2022 (MT)
Source: Own design based on the data from [3, 4].

India comes on the 2nd position after China, but it has a completely different evolution of raw silk production. In the analyzed interval it registered a continuous increasing trend from 23,060 MT in 2011, the lowest level, to 36,582 MT in 2022, the maximum level, which was by 58.6% higher than in the first year of the study (Fig. 4).

Despite of the production growth, the demand in India is high and for this reason the country is also a silk importer [7].

Uzbekistan is ranked the third at the global level for its raw silk production. Its production is much smaller than the one of China and India. In 2011, it was 110.6 times smaller than in China and 24.5 times smaller than in India. In the analyzed interval, this country had an increasing evolution of silk production, raising from 940 MT, the lowest level in 2011 to 2,037 MT in 2022, the maximum level (Fig. 5).

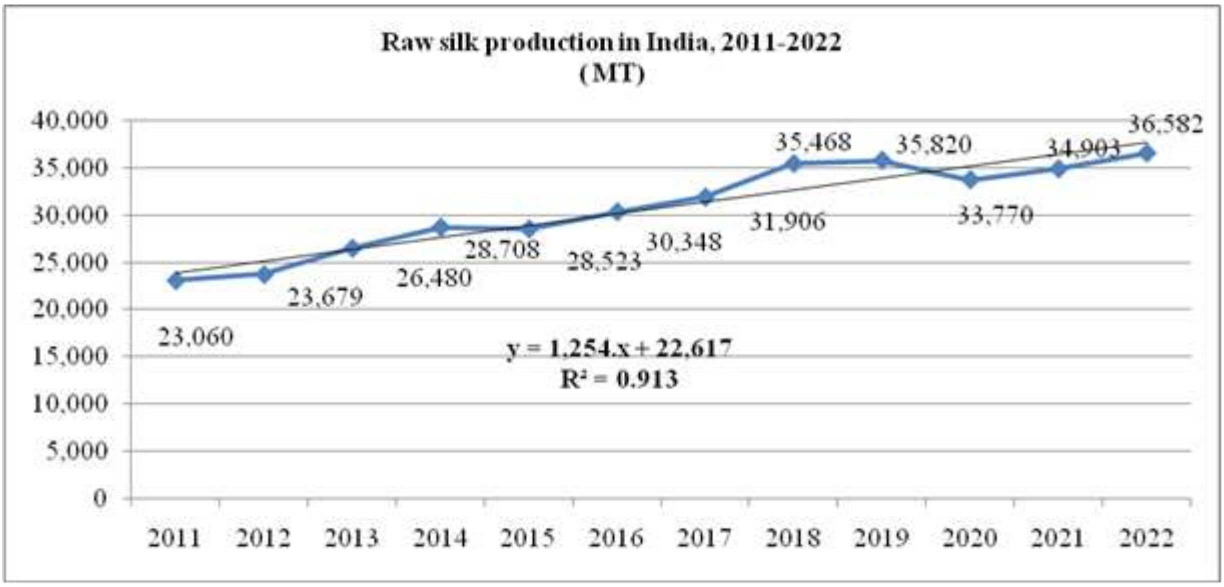

Fig. 4. Dynamics of raw silk production in India, 2011-2022 (MT)
Source: Own design based on the data from [3, 4].

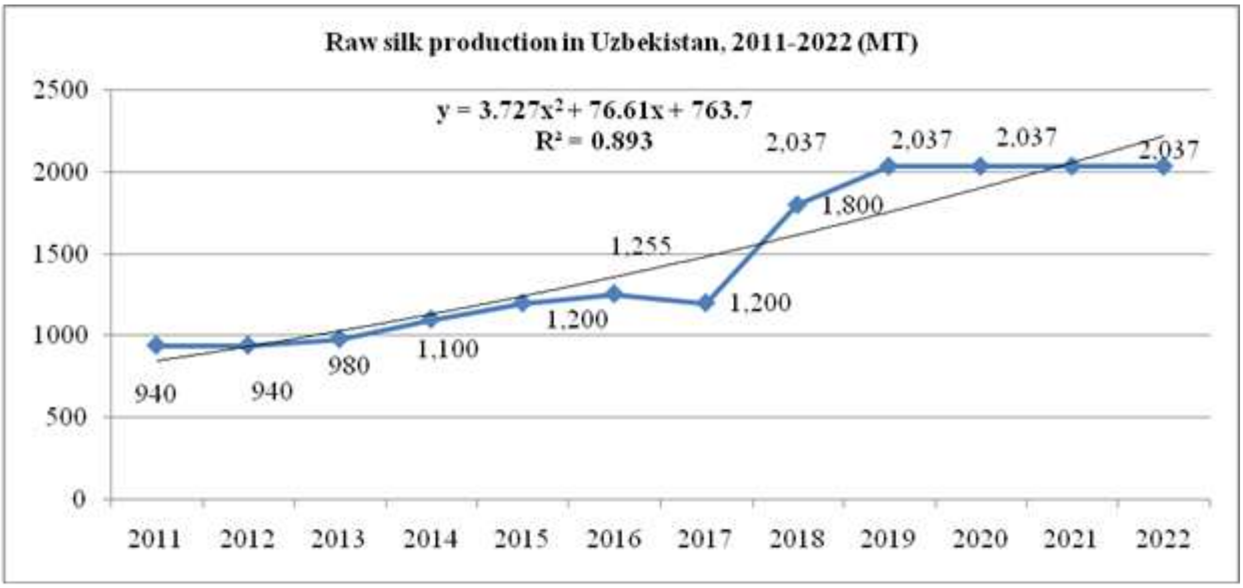

Fig. 5. Dynamics of raw silk production in Uzbekistan, 2011-2022 (MT)
Source: Own design based on the data from [3, 4].

Vietnam is on the fourth position regarding its silk production. It registered a relatively upward tendency in the analyzed interval, because in the first six years, production declined from 500 MT in 2011 to 420 MT in 2014, but, then it started to increase year by year, so that in 2021 and 2022 it reached 1,067 MT, the peak level being 2.13 times higher than in 2011 (Fig. 6).

Thailand is situated on the fifth position in the world for silk production. Its production declined from 655 MT in 2011 to 436 MT in 2022, meaning a loss of 35.5%. However, the dynamics had an ascending trend in the first six years up to 712 MT in 2016, but then, in the following six years, it recorded a continuous decrease from 680 MT in 2017 to 436 MT in 2022 (Fig. 7).

Brazil is ranked the sixth in the hierarchy of the silk producing countries. Its raw silk production recorded a relatively increasing trend from 558 MT in 2011 to 650 MT in 2016, but then, it started to decline since 2019 up to 375 MT in 2022, which marked the lowest level in the analyzed interval.

In 2022, silk production was by 32.8% smaller than in 2011 (Fig. 8).

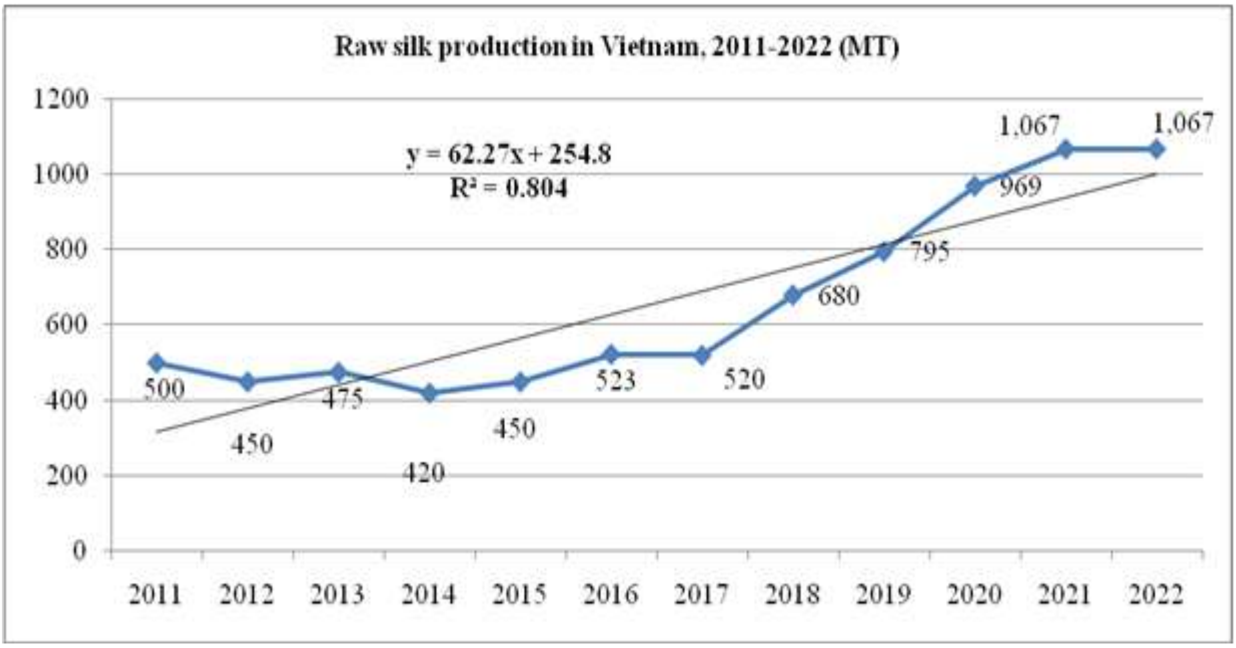

Fig. 6. Dynamics of raw silk production in Vietnam, 2011-2022 (MT)
Source: Own design based on the data from [3, 4].

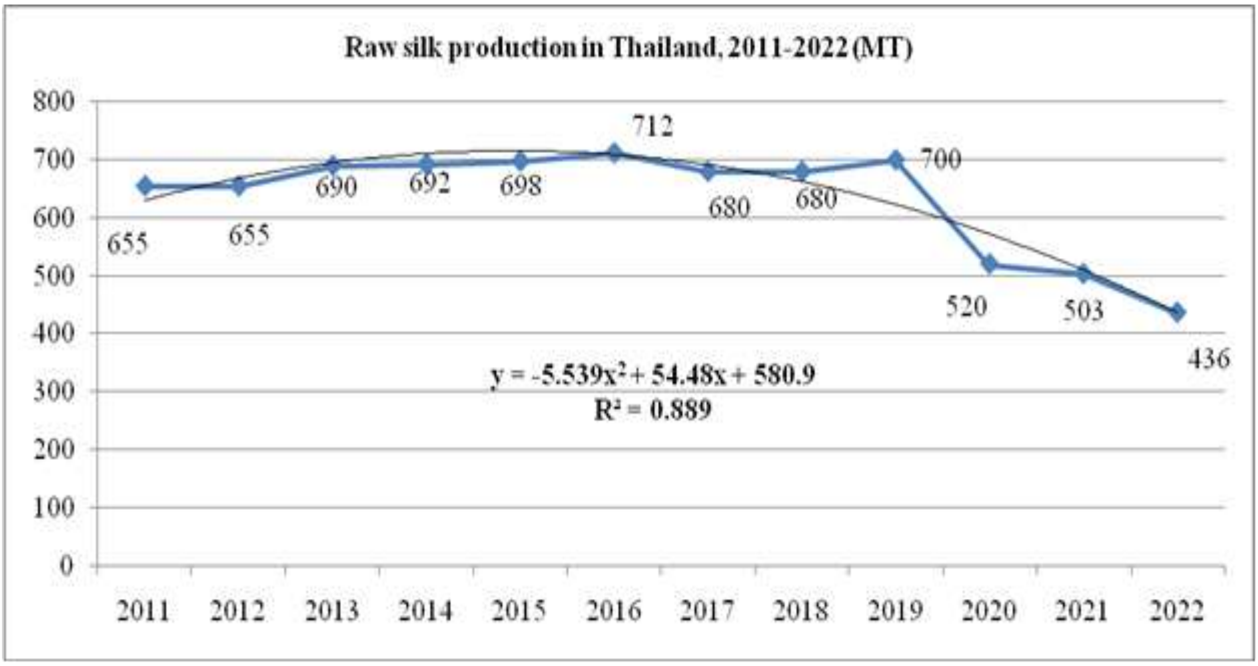

Fig. 7. Dynamics of raw silk production in Thailand, 2011-2022 (MT)
Source: Own design based on the data from [3, 4].

Silk production and international trade was affected during the Covid-19 pandemic in many producing countries, but mainly in China where both producers, silk industry enterprises and traders were facing disturbances and losses during the lockdown [5].

Production differences among the top six silk producing countries

Table 4 shows the absolute and relative differences in raw silk production among the six top producing countries at the global level.

China registered in the last six years a production by 42.4% smaller than in the first six years (Table 4).

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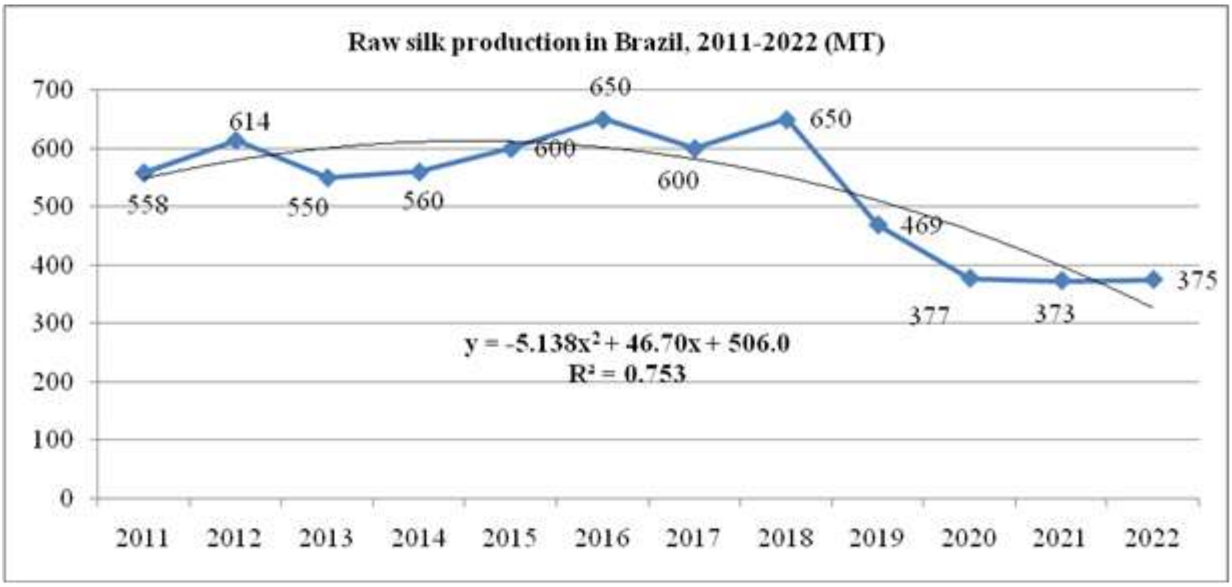

Fig. 8. Dynamics of raw silk production in Thailand, 2011-2022 (MT)
Source: Own design based on the data from [3, 4].

India recorded a surplus of production accounting for +59.7% in the last six years compared to the first six years.

Uzbekistan also had a positive result, accounting for +73.7% surplus of production in the second period of six years versus the first period.

Vietnam also recorded an additional production accounting for +80.9% in the last six years versus the first ones.

Thailand carried out a loss by -14.22% in the last interval versus the first period.

Brazil achieved a decline by -19.5% in the last sub-period versus the first one (Table 4).

Table 4. Production differences among the six top silk producing countries in the period 2017-2022 versus 2011-2016

	China	India	Uzbekistan	Vietnam	Thailand	Brazil
2011-2016	834,400	130,450	6,415	2,818	4,102	3,531
2017-2022	480,669	208,449	11,148	5,098	3,519	2,844
Absolute differences (MT)	-353,731	+77, 999	+4,733	+2,280	-583	-688
Relative differences (%)	-42.4%	+59.79%	+73,78%	+80.90	-14.22	-19.5

Source: Own calculation.

This situation of production variation and trend from a country to another has led to important changes in each country contribution to the global raw silk production.

If in 2011 and also in 2016 and 2017, China contributed by about 80% to the global raw silk production, in the year 2022 its weight accounted for only 54.8%. This means a decline by 25.2 pp.

In case of India, its share in the global silk production increased from 17.7% in 2011 to 40.1% in 2022, meaning an increase by 22.4 pp.

Uzbekistan also had an ascending trend and its contribution raised from 0.7% to 2.2%, that is by +0.15 pp.

Vietnam increased its weight from 0.3% to 1.2%, meaning +0.9 pp.

Thailand and Brazil maintained their low shares at 0.5%, and, respectively, 0.4% (Table 5).

The figures in Table 5 reflects that all these six countries produce about 99.2% of the global raw silk production. Also, that China and India together accounts for 94.9% in the global silk production.

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Table 5. The share of the top six raw silk producing countries in the global production (%)

	2011	2016	2017	2022
China	80.2	82.2	80.0	54.8
India	17.7	15.7	18.0	40.1
Uzbekistan	0.7	0.6	0.7	2.2
Vietnam	0.3	0.3	0.3	1.2
Thailand	0.5	0.4	0.4	0.5
Brazil	0.4	0.3	0.3	0.4
Total 6 countries	99.8	99.5	99.7	99.2

Source: Own calculation.

Descriptive statistics for the indicators analyzed in this study

Descriptive statistics is presented in Table 6.

Table 6. Descriptive statistics regarding silkworm cocoons production and raw silk production in the period 2011-2022

	Mean	St. Error	St. Dev.	Kurtosis	Skewness	Minimum Maximum	CV %
Global silkworm cocoons production	591,576.3	31,229.72	108, 182.9	-0.88314	-0.22442	Min 414, 788 Max 750,309	18.28
Global raw silk production	144,295.08	11,970.60	41,467.38	-1.48555	-0.2065	Min 86,311 Max 202,073	28.73
Silk raw production in:							
China	109, 589.1	12,786.25	44,292.88	-1.44677	-0.34389	Min 46,700 Max 170,000	40.41
India	30,770.58	1,366.07	4,732.23	-1.1745	-0.39794	Min 23,060 Max 36,582	15.37
Uzbekistan	1,463.58	138.31	478.12	-2.0022	0.29598	Min 940 Max 2,037	32.66
Vietnam	659.66	72.26	250.34	-1.05429	0.83026	Min 420 Max 1,067	38.10
Thailand	635.08	26.89	93.17	0.4556	-1.3748	Min 436 Max 712	14.67
Brazil	531.33	30.59	105.96	-1.1625	-0.6513	Min 373 Max 650	19.94

Source: Own determination.

The coefficient of variation reflects a high variability regarding both silkworm cocoons production and raw silk production at the global level. In almost all the countries, silk production had a large variability in the analyzed interval 2011-2022.

Global silkworm cocoons production registered CV = 18.28% reflecting a relative homogeneity of the data, and that the mean is partially significant. The same significance has the CV% = 15.57% in India , 14.67% in Thailand and 19.99% in Brazil.

Global raw silk production recorded a CV% = 28.73%, also CV= 40.41% in China, CV = 32.66% in Uzbekistan and CV = 39.10% in Vietnam reflected that the data are heterogeneous and the mean is not representative (Table 6).

Problems in silk worm rearing and silk industry

Even thou production has a descending trend, it is expected to increase in the future because demand and consumption need the extend of the silk production and trade in the international market.

However, there are some restrictive factors which could have a negative influence as presented below:

-Silk producing and processing on a large scale involves high costs compared to other textile products.

-Along the silk chain including silk worm rearing, cocoons collection and reeling, silk fiber extraction, there are needed: skilled labor force and important material and financial resources.

- Mulberry tree growing requires specific climate conditions and also has specific production costs, but it could be a profitable activity [17].

-Pests and diseases could affect silk worms and diminish cocoon and silk production.

-These high costs will limit the extend of production in the small farms [22].

-Silk accounts among the most production costing fabrics as in order to produce 1 kg cocoons it is needed of 2,500 silk worms for which eggs have to be procured, feedstuff has to be assured, and other materials, water, electricity as well [8].

-Fluctuations in silk cocoon and silk price are a limiting factor of the extend of the silk market.

-Also, the lack of skilled work force in sericiculture where usually there are used unskilled workers, who have to be trained what to do.

-Transportation of silk cocoons and silk from the place of production to the place of processing is also costing.

-The lack of enough storage capacity could also be a limiting factor.

-Disturbances along the silk supply chain, like during the Covid-19 pandemic could have a negative impact on silk market.

-The growth in the production cost in mulberry tree growing is also a restraining factor as not all the growers are able to cover these expenses.

-China is facing these aspects which have led to a deep decline in raw silk production starting from the year 2015 as mentioned above [8].

-In conventional silk worm rearing there are ethical problems because the worms are boiled alive, being still in silk cocoons. One trillion worms are boiled annually to produce silk.

-Compared to cotton and wool, silk requires more energy and water.

-During the silk worm rearing, it is produced carbon monoxide which could determine allergies, irritations and respiratory problems to the workers.

-When diseases appear in silk worm growing, the eggs have to be destroyed.

-Silk exposed to sun could be degraded losing its resistance [8].

CONCLUSIONS

Silk cocoons production decreased at the global level by 17.4% in the interval 2011-2017 from 501,772 MT in the year 2011 to 414,788 MT in 2022.

This aspect had a deep influence on raw silk production which in 2022 was by 30% smaller than in 2011 and by 55% smaller than the peak registered in 2015. In 2022, it accounted for only 91,221 MT.

According to the regression equation, an increase by one metric tons in silkworm cocoons production could determine a growth by 0.3561 metric tons in raw silk production. About 86.32 % of the variation in raw silk production is determined by the variation in silkworm cocoons production ,according the R square value and between the two productions it is a positive and strong relationship as conformed by the correlation coefficient r = 0.929.

In China, Thailand and Brazil, raw silk production declined in the interval 2011 - 2022 by - 52%, -33.5%, -23%.

In India, Uzbekistan and Vietnam, raw silk production has substantially increased in the period 2011-2022 by 58.6%, 116.7% and 113.4%.

About 99.2 % of the global raw silk production is achieved in these six countries. In fact, the highest contribution is given by China, 54.8% and India, 40.1% in the year 2022.

A new orientation is at present to natural fibers, silk being one of the most preferred in the fashion, textiles, cosmetics and medical world due to its special features (skin and eco-friendly, and biodegradable).

The growth in input price and silk price variations, the increased production costs will affect the small sericiculturists who will not be able to keep pace and be flexible to adapt to these disturbances. Other restraining factors have been presented in this study and have not to be ignored.

But, at proved so far, for the developing countries, silkworm rearing and silk production sector are a source of jobs, income, could be profitable activities, which could contribute to the reduction of poverty, hungry, gender discrimination, biodiversity preservation, soil protection, and to the continuous sustainable development of the rural areas.

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THE DEPENDENCE OF PIGLET PRODUCTIVITY ON THE METHOD OF FEED PREPARATION AND THE FEEDING OF PIGLETS

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Abstract

The article investigated the productivity of piglets and the efficiency of their rearing in relation to the type of feed preparation and the type of feeding, and the influence of these factors on growth intensity, piglet survival rate, feed costs and feed costs for rearing a piglet on farms in the Kingdom of Denmark, using data from the consultancy Svine Rådgivningen's open source evaluation analysis of DB-Tjek pig farms for 2021. It was found that preparing feed from own raw materials in the farms' capacities had no influence on the growth intensity of piglets during rearing and feed conversion during this period. At the same time, these farms had 9.15% lower costs per 1 kg of piglet growth, which contributed to a 1.05% reduction in the cost of a piglet at the end of rearing compared to farms feeding piglets exclusively with purchased feed. It was shown that the growth intensity of piglets did not depend on the feeding method, while liquid feeding contributed to a 4.99% improvement in feed conversion, resulting in a 3.03% reduction in the share of feed costs in the rearing of 1 animal. In addition, liquid feeding enabled a 0.67% reduction in the proportion of veterinary costs per animal. The feeding method was found to have a probable influence on the preservation of the piglets and the conversion of the feed during their rearing, but no significant influence on the intensity of the animals' growth and the feed costs of their rearing. At the same time, the method of feed preparation had no significant influence on any of the indicators studied.

Key words: *pigs rearing, feed type, feed mixtures, intensity of growth, gains*

INTRODUCTION

Complete feeding is a key tool for the efficient functioning of pig farms, which includes the development of nutritious rations based on a high-quality feed base and the use of feeding systems that intensify the process of feed intake and improve digestion in pigs [5, 25, 31, 33].
Advances in swine nutrition are increasing pig productivity by more accurately balancing rations in terms of energy and nutrient content [14]. However, pig productivity will increase even further if a rational system of feeding and feed preparation is applied for a balanced complete diet [19, 29].
Many farmers who have their own acreage and grow grain in large quantities prefer to produce feed for their own production on their farms. The advantages of on-farm production of feed mixtures are lower costs [20, 27], clear certainty of the quality of this feed, reduction of the risk of fungal, bacteriological and viral contamination of the feed, the

possibility of rapid adjustment of the composition of the feed. When using a liquid feeding system, in addition to these advantages, there is also the possibility of reducing the price of the feed, as a number of by-products are used, such as milk whey, canned corn kernels with cobs, brewer's grains and brewer's yeast, as well as other by-products from food and organic production [8, 46]. At the same time, the production of own feed mixtures requires additional investment in containers and space for storing the components of these mixtures, additional equipment for grinding and mixing the feed components and granulating them. This process, in turn, requires additional working time and appropriate qualification of the personnel preparing these feeds. Time and equipment are also required to control the quality of mixing and the chemical composition of the finished feed mixtures [7, 34]. In addition, mixers with limited dosage of the various components are usually installed in the feed kitchens of pig farms. In contrast, the equipment of specialized compound feed plants can introduce a large number of components with different dosage levels at the same time [15, 39]. Logistics and storage conditions for feed components are also improved in large specialized compound feed mills. In addition, many countries have a number of restrictions on producing feed on their own farms [13]. For example, according to information [11], in Denmark, pig farms that intend to produce feed mixes on their own farms must obtain a permit from the Danish Directorate of Crop Production, followed by feed quality control at the same level as feed mills. Therefore, pig enterprises in Denmark buy about half of their feed from specialized enterprises.

In pig farming, two feeding methods are most common: liquid and dry feeding; wet feeding is less common [12]. Dry feeding was widely used among pig farmers. Dry feeding of pigs became widespread during the industrialization of agriculture due to cheaper equipment and maintenance [30]. In addition, dry feed ensured a better hygienic condition not only of the feeding equipment but also of the whole farm, was easier to store, and was more convenient to use because it ensured free access and consumption by the animals [18, 35]. It was also reported that prolonged consumption of dry feed improved digestion of its components, which begins in the oral cavity. At the same time, the delay of individual pigs near the feeding facility led to hierarchical tensions in the group due to the longer waiting time of the other animals. In addition, studies have shown that pigs fed dry feed gained weight better than those fed liquid feed containing food industry waste [10, 22, 24].

The liquid feeding method, on the other hand, is not new, although it is less common in pig farms today. It is based either on the use of cheap waste from the food industry or on the production and preparation of a liquid feed mixture from the same ingredients as dry feed, but with prior rehydration using agricultural feed plants [4]. It is known that the method of preparation, transportation, and distribution of wet and liquid feeds is technically more complicated and more expensive to maintain [42]. In addition, liquid feeding requires additional attention and preventive measures to ensure the hygienic requirements of the feed and the condition of the equipment [9].

So one of the main advantages of liquid feeding is the possibility of using cheap waste from the food industry. Considering that 70% of the costs in pork production are related to feed, the use of cheap products in the composition of complete and balanced rations for pigs significantly reduces the cost of pork [1, 40]. In particular, it is known that the type of liquid or dry feeding used for growing pigs can have a noticeable effect not only on growth but also on feed consumption [24]. Each feeding method has its advantages and disadvantages that can increase or decrease the overall productivity of pigs [25]. Liquid feeding usually uses the same feedstuffs as dry feeding, but with additional hydration or fermentation of the ration ingredients. For post-weaning piglets, liquid feed meets their physiological needs to a greater extent than dry feed [43]. In addition, the components of liquid migration (cereal grains, dairy products) contain lactic acid bacteria, which ferment the feed mixture, lower its pH value and thus have a preservative effect. Lactic acid prevents the multiplication of pathogenic microflora in the feed and thus improves the balance of the intestinal microorganisms of pigs [23, 36]. In addition, the effect of liquid feed on the gastrointestinal tract of pigs is known, which translates into improved secretion of gastrointestinal hormones [42]. In addition, fermentation of liquid feed has a positive effect on the fattening qualities of pigs [41], increases average daily gains [21] and reduces feed conversion [17]. Liquid feed can be more easily digestible and provide a broad spectrum of nutrients [45]. As a result, pigs fed liquid feed mixtures may have a higher growth rate in both rearing and fattening [26, 35]. Liquid feed is usually more palatable, resulting in higher consumption compared to dry feed. The pigs usually absorb the feed better when it is prepared in liquid form, resulting in a higher consumption rate compared to dry feeding [25, 26, 28], so that they reach the desired live weight faster [47]. Another positive aspect of using liquid feed in rearing is the reduction of stress in newly weaned piglets that are fed liquid feed during the initial adjustment [6].

Disadvantages of liquid feeding include: High initial investment and skilled process management personnel are required, as the risk of losses can be high if the technology is breached at any stage [8, 18, 24].

The aim of the study was to investigate the influence of the way piglets are fed during rearing and the way the feed mixtures are prepared on their productivity and rearing efficiency.

MATERIALS AND METHODS

The object of the study was the productive qualities and economic indicators of rearing hybrid piglets obtained from F_1 sows of the Danish Landrace and Danish Large White breeds inseminated with semen from Danish Durok boars under different feeding methods and methods of feed preparation in this technological group.

The subject of the study was the technological processes in the rearing of hybrid piglets on farms in the Kingdom of Denmark. The indicators of productivity and efficiency of pig rearing were studied using the data from the consultancy Svine Rådgivningen from the open sources of the rating analysis of the DB - Tjek pig farms for the year 2021.

In order to investigate the dependence of the piglets' productivity during rearing and their efficiency on the type of feed preparation before feeding, all the farms studied were divided into two groups. The first group, which was taken under control, included farms in which feed mixes for raising piglets were prepared from their own grain raw materials on the territory of enterprises at their own facilities for mixing feed components. The second group, which was an experimental group, included pig farms that were used for rearing piglets exclusively bought at feed mills.

In the second phase of the study, we analysed the dependence of piglet productivity and the efficiency of their rearing on dry and liquid feeding. For this purpose, all the farms studied were divided into two groups according to the type of feed they used during piglet rearing. The first group comprised farms that used traditional dry piglet feeding from weaning to fattening. This group of piglets was the control group. The second group (experimental) consisted of farms that used liquid feeding during piglet rearing.

In the third research phase, we investigated the influence of the method of feed preparation and the type of feeding on the leading productivity indicators using a two-factor analysis of variance.

The following performance indicators were identified for the study: survival of piglets during rearing, their average daily feed consumption and its conversion, and the absolute and average daily live weight gains of the animals. The added value of raising piglets and the share of feed and veterinary care in it are also analysed.

RESULTS AND DISCUSSIONS

The results of the study are shown in Table. 1 show that farms that used their own feed raw materials and prepared mixed feed on their farms gave piglets with a slightly lower initial live weight to rearing, while the weight of piglets at the end of the rearing period proved to be reliably ($p \leq 0.01$) 1.66 kg higher in this group of farms than in farms that used only purchased feed. This fact is probably ($p \leq 0.01$) due to a 1.76 kg higher absolute growth of the animals in this group of farms, which in turn was reliably ($p \leq 0.01$) caused by a 3.51 days longer rearing period of the piglets. At the same time, the group of farms using purchased feed was likely to have 0.53% better preservation of piglets ($p \leq 0.01$). In this group there was also a tendency for a slight decrease in daily feed consumption and its conversion, which we believe is also related to the shorter duration of rearing.

Table 1. Productivity of piglets during rearing depends on the method of feed preparation

Indicator	**The method of preparing fodder**	
	The feed is made on the farm	**The fodder is bought ready-made**
Number of farms considered (n)	116	51
Weight of piglets at the beginning of rearing, kg	6.75±0.13	6.85±0.17
Duration of rearing, days	55.61±0.83	52.10±0.71**
Weight of piglets at the end of the rearing period, kg	32.29±0.25	30.63±0.49**
Preservation of piglets during the rearing period, %	97.5±0.16	98.03±0.096**
Absolute growth, kg	25.54±0.28	23.78±0.45**
Average daily gain, g	462.02±4.72	457.0±7.83
Average daily feed consumption, kg	0.87±0.011	0.85±0.019
Feed consumption per 1 kg gain, kg	1.71±0.015	1.70±0.022

* – P ≤0.05; ** – P ≤0.01; *** – P ≤0.001.
Source: own calculations.

The different duration of piglet rearing in the control and experimental groups of farms also led to a difference in feed consumption and costs of piglet rearing (Table 2). Thus, the cost of rearing piglets in the second group was 1.16% higher than in the first group, which in our opinion, is due to their slightly higher live weight. During the rearing period, piglets in the first group probably consumed ($p \leq 0.01$) 3.31 kg (7.57%) more feed per head, which we believe is due to a longer rearing period and greater mass at the end of this period. But the expenditure on these feeds turned out to be somewhat lower in the group with their own preparation, which is due, to their lower cost. These factors also contributed to significantly lower feed costs by 9.15% ($p \leq 0.001$) per 1 kg of piglet growth.

Table 2. Efficiency of raising piglets depending on the method feed preparation

Indicator	**The method of preparing fodder**	
	The feed is made on the farm	**The fodder is bought ready-made**
The cost of a piglet at the beginning of rearing, DKK	260.14±1.76	263.17±3.65
Feed consumption per animal, kg	43.71±0.61	40.40±0.84**
Feed consumption per head, DKK	109.18±1.75	110.36±1.04
Feed consumption per 1 kg growth, DKK	4.26±0.04	4.65±0.090***
The cost of rearing one animal, DKK	190.71±2.54	192.42±4.70
The cost of the piglet at the end of rearing, DKK	450.86±2.71	455.58±2.41
The share of feed in the cost of rearing a piglet, %	57.79±1.20	58.42±2.34
Veterinary costs for 1 animal, DKK	5.47±0.37	5.70±0.81
The share of veterinary losses in the cost of rearing a piglet, %	2.91±0.21	3.06±0.45

** – P ≤0.01; *** – P ≤0.001.
Source: own calculations.

Despite the longer rearing period of the piglets in the first group and their higher weight at the end of this period, the cost of rearing an animal was found to be 0.9% lower compared to the analogues in the second group, which, together with the lower cost of piglets at the beginning of rearing, resulted in a 1.05% reduction in the cost of piglets after they were reared.

The main expenses for rearing piglets are feed and veterinary care. In our research, we observed a trend towards a 0.63% lower share of feed in the costs of rearing an animal on farms that prepared the feed on their own premises. On these farms, the costs of preventive and medical measures for piglets were 4.20% lower, which naturally led to a 0.15% decrease in their share of the total costs of rearing an animal.

Thus, preparing feed from their own raw materials within the capacity of their farms had no effect on the growth intensity of piglets during rearing and feed conversion during this period. At the same time, these farms had 9.15% lower costs per 1 kg of piglet growth, which contributed to a 1.05% reduction in the cost of a piglet after the completion of rearing compared to farms that fed piglets exclusively with purchased feed.

When analyzing the dependence of piglet productivity of piglets on growing-out on the type of feed they were fed during this period (Table 3), it was found that in farms that used liquid feed, piglets were placed on growing-out with probably ($p \leq 0.05$) 0.57 kg less live weight, but were removed from rearing with probably 1.42 kg ($p \leq 0.05$) more live weight, compared to farms that used dry feed for rearing. This is probably caused ($p \leq 0.05$) due to the 3.96 days longer rearing time of the animals.

This factor also probably contributed ($p \leq 0.001$) to 2.0 kg higher absolute gains during the rearing of piglets in the experimental group. As long as there is no significant difference in growth rate between piglets with different feeding methods.

Table 3. The productivity of piglets in rearing depends on the method of feeding

Indicator	Method of feeding	
	Dry	Liquid
Number of farms considered (n)	110	57
Weight of piglets at the beginning of rearing, kg	6.85±0.11	6.28±0.26*
Duration of rearing, days	54.06±0.62	58.02±1.56*
Weight of piglets at the end of the rearing period, kg	31.62±0.24	33.04±0.54*
Preservation of piglets during the rearing period, %	97.76±0.12	96.98±0.24**
Absolute growth, kg	24.76±0.24	26.76±0.46***
Average daily growth, g	460.13±4.41	463.2±10.02
Average daily feed consumption, kg	0.79±0.01	0.76±0.02
Feed consumption per 1 kg of gain, kg	1.72±0.01	1.64±0.03*

* – $P \leq 0.05$; ** – $P \leq 0.01$; *** – $P \leq 0.001$.

Source: own calculations.

A tendency to reduce daily feed consumption by 0.03 kg was observed with liquid feeding, which probably ($p \leq 0.05$) resulted in 0.08 kg better feed conversion at almost the same growth intensity. At the same time, the preservation of piglets during rearing was probably ($p \leq 0.01$) 0.78% better on farms using the dry feeding method.

With liquid feeding, the feed cost for an adult piglet was 4.05% higher (Table 4), resulting in a 3.44% increase in feed cost for head growth. We explain this by a longer growth period and correspondingly larger absolute increases in live weight during this period. In the group of farms rearing piglets with liquid feeding, the cost of 1 kg of growth was 4.99% lower ($p \leq 0.001$).

With liquid feeding, the cost of a piglet was probably ($p \leq 0.01$) 7.22% lower at the beginning of rearing due to the lower weight of piglets, while it was only 0.72% lower at the end of this period, with a higher live weight during this period. This was probably caused ($p \leq 0.001$) due to the 8.32% higher cost of raising the animals. While the cost of 1 kg growth of piglets during rearing practically did not differ in both farm groups.

Table 4. The efficiency of raising piglets depending on the method of their feeding

Indicator	Method of feeding	
	Dry	Liquid
Feed consumption per animal, kg	42.51±0.55	44.23±0.55
Feed cost per animal during rearing, DKK	109.07±1.54	112.82±4.85
Feed cost for 1 kg of growth, DKK	4.41±0.05	4.19±0.03***
Cost of one piglet at the beginning of rearing, DKK	263.43±2.23	244.4±5.83**
Cost of pig at the end of rearing, DKK	452.68±2.00	449.4±3.32
The cost of rearing one animal, Danish kroner	189.26±2.43	205.0±3.87***
The cost of 1 kg of piglet growth during rearing, DKK	7.64	7.66
The share of feed in the cost of raising an animal, %	58.35±1.13	55.32±3.45
Veterinary costs for 1 animal, DKK	5.64±0.40	4.18±0.5
The share of veterinary costs in the cost of raising an animal, %	3.04±0.22	2.37±0.27*

* – P ≤0.05; ** – P ≤0.01; *** – P ≤0.001.
Source: own calculations.

The research showed that the cost of veterinary care of a piglet during rearing was 25.89% higher, which also caused a 0.67% higher share of these costs in the total cost of rearing in the farms with dry feeding. In this group of farms, the share of feed in the total cost of raising an animal was 5.19% higher.
Thus, the growth intensity of piglets did not depend on the type of feeding, while liquid feeding contributed to a 4.99% improvement in feed conversion, which resulted in a 3.03% reduction in the share of feed costs in raising an animal. In addition, liquid feeding reduced the proportion of veterinary costs per animal by 0.67%.
According to the calculations of the influence of the factors of feed preparation and feeding method, no probable influence of these factors on the average daily growth of piglets was found (Table 5).

Table 5. The influence of the method of feed preparation and feeding of piglets on the average daily growth

Source of variance	Sum of squares	Degrees of freedom	Middle square	F_{fact}	F_{crit} at α = 0.05	P-significance	% contribution to the factor sum of squares	% contribution to the total amount of squares
General, Cy	103,023.99	79						
Factorial, Cx	474.93	1	12413					
Method of feeding, A	82.54	1	83	0.06	3.97	0.8053	17.4%	0.1%
The method of preparing fodder, V	392.38	2	196	0.15	3.12	0.8649	82.6%	0.4%
Interaction, AB	0.00	0		0.00			0.0%	0.0%
Remainder, Cz	102,549.06	76	1349					99.5%

Source: own calculations.

While piglet survival during rearing was probably influenced by feeding method at a level of 6.1%, the absence of a probable influence of feed preparation method and its interaction on this indicator was found (Table 6). Unaccounted for factors accounted for 89.8% of the total variance.

Table 6. The influence of the method of feed preparation and feeding of piglets on the survival of growing piglets

Source of variance	**Sum of squares**	**Degrees of freedom**	**Middle square**	**F_{fact}**	**F_{crit} at α = 0.05**	**P-significance**	**% contribution to the factor sum of squares**	**% contribution to the total amount of squares**
General, Cy	88.52	79						
Factorial, Cx	8.99	1	12,413.24					
Method of feeding, A	5.40	1	5.4	5.16	3.97	0.0260	60.1%	6.1%
The method of preparing fodder, V	3.59	2	1.8	1.72	3.12	0.1867	39.9%	4.1%
Interaction, AB	0.00	0		0.00			0.0%	0.0%
Remainder, Cz	79.53	76	1.0					89.8%

Source: own calculations.

The method of feeding piglets during rearing also probably had a 6.5% influence on feed conversion, with 91.9% influenced by factors not considered (Table 7). In contrast, the method of feed preparation and its interaction with the feeding method probably had no influence on feed conversion during rearing.

Table 7. The influence of the method of feed preparation and the feeding of piglets on feed conversion ratio

Source of variance	**Sum of squares**	**Degrees of freedom**	**Middle square**	**F_{fact}**	**F_{crit} at α = 0.05**	**P-significance**	**% contribution to the factor sum of squares**	**% contribution to the total amount of squares**
General, Cy	1.00	79						
Factorial, Cx	0.08	1	12,413.24					
Method of feeding, A	0.07	1	0.0651	5.37	3.97	0.0232	80.7%	6.5%
The method of preparing fodder, V	0.02	2	0.0078	0.64	3.12	0.5293	19.3%	1.6%
Interaction, AB	0.00	0		0.00			0.0%	0.0%
Remainder, Cz	0.92	76	0.0121					91.9%

Source: own calculations.

The feed cost of one piglet was not significantly influenced by the method of preparation of feed and the method of their feeding (Table 8). Thus, the feeding method had a probable influence on the preservation of piglets and feed conversion during piglet rearing and had no significant effect on the growth intensity of the animals and the feed cost of their rearing. At the same time, the method of feed preparation had no significant influence on any of the studied indicators.

According to reports [2, 30], the lifelong productivity of young pigs, i.e. growth and development of animals, occurs due to the complex interaction of the hereditary basis of the organism with specific environmental conditions and is an important background for the realization of the genetic potential of animal productivity.

In this regard, the share of feeding in the influencing factors is 60-70%, genotype - 20-25%, and microclimate and maintenance - 15-20%. However, we could not confirm such a high influence of the feeding method on the productivity of the young animals during rearing. In our study, the feeding factor had a less significant effect, namely: 6.1% on the survival rate of piglets, which is more consistent with reports [30], where it was 1.5%.

Table 8. The influence of the method of preparation of fodder and feeding of piglets on the cost of rearing one head of piglets

Source of variance	Sum of squares	Degrees of freedom	Middle square	F_{fact}	F_{crit} at α = 0.05	P-significance	% contribution to the factor sum of squares	% contribution to the total amount of squares
General, Cy	13,675.55	79						
Factorial, Cx	297.99	1						
Method of feeding, A	123.01	1	123.0	0.70	3.97	0.4058	41.3%	0.9%
The method of preparing fodder, V	174.98	2	87.5	0.50	3.12	0.6103	58.7%	1.3%
Interaction, AB	0.00	0		0.00			0.0%	0.0%
Remainder, Cz	13,377.56	76	176.0					97.8%

Source: own calculations.

Also the factor of feeding method had an influence of 6.5 % on feed conversion, which is also more consistent with data [30], where it was 1.0 %. We did not find a probable dependence of the average daily growth on the influence of the feeding factor, in contrast to other data [30], where the influence of this factor was observed at a level of 12.6%.

Our results of a higher absolute growth rate in pigs fed liquid feed compared to counterparts fed dry feed were in agreement with reports [32, 35], where a probable difference in this rate was found when different feeding methods were used. However, in contrast to other scientific works [21, 25, 26, 30], which indicated higher average daily gain in pigs kept in liquid feeding systems compared to peers consuming dry feed, we found no significant difference in the mentioned indicator, similar to the results of other researchers [43]. The absence of a difference in average daily gains in our experiment also contradicts reports of a probable excess of this indicator in animals fed dry diets compared with their counterparts fed liquid diets [3, 24].

At the same time, we could not confirm the presence of a probable excess of survival in pigs fed liquid, in contrast to other authors [30, 32] who reported equal survival values for pigs fed both liquid and dry diets.

We also noted an increase in feed consumption per 1 kg of growth when pigs were fed liquid diets, similar to other researchers who also observed a deterioration of this indicator in animals fed liquid feed and an improvement in pigs fed dry feed [30, 43]. However, other work [17, 44] indicated an improvement in feed conversion in pigs fed liquid feed, which was not consistent with our result.

According to the data [38], piglets that were raised on a liquid type of feeding consumed about 12.4% more feed, which was not confirmed in our experiment, since the pigs in our experiment did not have a significant difference in this indicator. According to [16, 28], feed intake in pigs was improved by using dry granular mixes, which is similar to the results of our current study, which did not agree with the findings [37] on improved feed intake with liquid feeding.

CONCLUSIONS

Piglet growth intensity during rearing and feed conversion during this period were not dependent on the type of feed preparation. Preparation of feed from own raw materials in own facilities allowed to reduce the cost of means per 1 kg of growth of piglets by 9.15% and the cost of a piglet after completion of rearing by 1.05%, compared to farms that fed piglets exclusively with purchased feed.

The liquid feeding method contributed to a 4.99% improvement in feed conversion, a 3.03% reduction in the share of feed costs, and a 0.67% reduction in the share of veterinary costs in the cost of raising an animal. The growth intensity of piglets did not depend on the feeding method.

Feeding method probably affected piglet preservation and feed conversion during rearing and had no effect on animal growth intensity or rearing feed costs. The method of feed preparation had no significant effect on any of the parameters studied.

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GROWTH INTENSITY AND FEEDING EFFICIENCY OF SURGICALLY AND IMMUNOLOGICALLY CASTRATED MALE PIGS ON A LIQUID TYPE OF FEEDING

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Abstract

In the article, the intensity of growth and preservation of surgically and immunologically castrated boars of the PIC-337 line of English breeding, their fattening qualities, consumption of feed and its cost during their rearing and fattening, and the economic efficiency of using immunological castration. It was established that when piglets were immunocastrated compared to their surgical castration under liquid feeding, average daily gains increased by 1.41% during rearing, and by 9.95%, during fattening and improved feed conversion during rearing by 13.0%, fattening by 3.15% and by 4.90% from birth to slaughter. Immunological castration contributed to the growth of absolute gains during fattening by 9.68% and by 7.70% of the live weight of animals at the end of fattening. At the same time, immunocastrated animals consumed 4.52% more feed during their lifetime, the cost of which was 5.38% higher compared to surgically castrated animals, and taking into account the cost of vaccination, it was 9.04% higher. At the same time, the cost of fodder and vaccine per 1 kg of gain turned out to be higher by only 1.17%. The cost per head of immunocastrated male pigs was 8.30% lower in the growing period, but 10.16% higher in the fattening period and 5.5% in the results of these two periods. As a result, at the end of fattening, the cost of one head was 7.44% higher, and the sales price without VAT was 7.70% higher compared to surgically castrated animals, which made it possible to get 8.00% more income from the sale of one head of animals of this group.

Key words**:** *castration, cost, growth, feed costs, income, pigs, profitability*

INTRODUCTION

Immunological castration of male pigs is currently a widespread practice in the pig industry, however, not yet widely enough compared to surgical castration [3]. At the same time, the use of physical castration is declining, as consumers increasingly criticize the pork production system in the sense of animal welfare [10, 11]. An alternative to surgical castration of pigs is the fattening of uncastrated male pigs and immunocastration. In recent decades, an immune castration method using a gonadotropin-releasing hormone (GnRH) vaccine has been developed and implemented for use in pork production to eliminate boar taint [12, 13]. Immunocastration is designed to address the issue of animal welfare while simultaneously ensuring sustainable and economically viable pork production [24, 30]. The double vaccine immunocastration procedure is based on using the first injection of a drug to activate the boar's immune system without changing the size or function of the genital organs [18]. The next step is to administer a second dose of the vaccine injection at least 4 weeks later to block the release of GnRH from the hypothalamus and finally stop the production of luteinizing and follicle-stimulating hormones by the anterior pituitary and inhibition of testicular development [13, 19]. Pork producers can benefit from the production of androgens and estrogens by boars, which optimizes the assimilation of nutrients from the feed and the deposition of protein before starting the second dose of vaccine [7]. The period of application of the second dose of the vaccine is of significant importance and affects the probability of occurrence of unpleasant boar odor [4, 16, 17]. According to reports [2], highlighted according to the recommendations of the vaccine manufacturer, the second dose should be administered no later than 4 weeks before slaughter, so that the compounds that cause the boar odor in an uncastrated male can be eliminated by natural metabolism in order to prevent the development of unpleasant smell. Although the main recommendation [2] is to administer the second dose 4-5 weeks before slaughter. Previous studies [1] reported that there is minimal risk of boar taint if pigs are slaughtered within 10 weeks of the second dose of vaccine. Providing secondary immunization as early as 2 weeks before slaughter did not affect average daily gain, feed conversion, carcass quality, and concentrations of boar taint while reducing feed intake and reducing fat deposition [17]. Data from [4] found that surgically castrated and immunocastrated pigs had different carcass weights at slaughter. Longer feeding times in immunocastrated pigs may reduce lean meat yield due to increased subcutaneous fat deposition, but this may be offset by increased intramuscular fat deposition, which may improve pork quality [4]. Higher carcass weight and fat thickness were also reported in immunocastrates compared to surgically castrated counterparts [23].

The effect of immunocastration on growth, performance, and carcass properties depends on feeding method, carcass weight at slaughter, time of immunization, and genotype [20]. According to reports [23, 28], immune vaccination has a positive effect on the average daily gains of fattening pigs. Foreign researchers [21] conducted a study to study the influence of genotypes and sex on growth, productivity, and carcass quality using surgical and immune castration and found higher gains in pigs that were immunocastrated similar to the statements of other authors [26, 33]. Immunocastration to control boar taint offers several advantages for both consumers and agribusiness compared to physical castration. First of all, immunocastration improves animal welfare because it involves no painful procedures and reduces antagonistic, aggressive behavior in male pigs [5, 6]. Comparing the performance of surgically castrated boars with immunocastrated ones, scientists found that feed efficiency and lean meat yield from carcasses were higher in immunocastrated animals [12], which entailed economic and environmental benefits due to reduced feed costs and reduction of nitrogen emissions [15]. Similar statements were made in other works. In particular, it is common knowledge that surgical castration is an inexpensive veterinary procedure compared to immunological one. For its implementation, the farmer does not need to purchase an expensive vaccine or purchase injection equipment and personnel training, organization of veterinary monitoring of subcutaneous reaction in vaccinated piglets [14, 23]. However, surgically castrated males typically consume 10–15% more feed than immunocastrated males to produce the same amount of pork [27], which minimizes the cost of surgical castration. It has already been proven that feed consumption is more effective in immunocastrated wild boars than in surgically castrated ones, which will compensate for the higher costs of the immunological castration procedure [8]. A similar publication [9] reported that the lower cost of production of 1 kg of meat obtained from the carcass of immunocastrates, compared to the cost of products obtained from surgically castrated counterparts, indicates that during the period of growing boars, from live weight of 30 kg to slaughter farmers in Denmark save 17.7 feed units per head when growing immunocastrates compared to surgical castrates. Similar conclusions were reached by other scientists [32], who proved that the costs of growing boars using immunocastration are compensated by higher animal productivity and better feed conversion. According to the data [29], during the fattening period, the best feed conversion was demonstrated by immuno-castrated animals, which spent 0.09 2.8% less feed per kilogram of growth compared to non-castrated animals and 11.4% compared to surgically castrated animals. A significant overall economic effect on the profitability of individual farms that sold pork from surgical castrates was observed in particular in the USA, due to increased demand for meat obtained in a more humane way [22]. However, other scientists [10, 25] take the opposite position and report that one of the problems of implementing immunocastration is that it can increase operational costs throughout the pork production chain, starting with farms and ending with the final product, as the profit does not always cover the cost of purchasing the vaccine. At the same time, another study became widespread [31], in which the authors established the absence of a significant effect of the use of the immune castration method on the profit of pig farms compared to the surgical method. Thus, despite long-term research and detailed study of the problem, there are still opposing views on the specifics of the influence of the castration method on the intensity of growth of pigs and the economic efficiency of pork production, which prompts further research in this direction, which remains relevant.

The aim of the work was to establish the dependence of the intensity of growth of piglets and to investigate the economic effect of the use of surgical and immune castration methods in the conditions of the industrial pig complex of the steppe zone of Ukraine.

MATERIALS AND METHODS

The research object was the technological processes of growing and fattening hybrid male pigs obtained from half-blood sows of the Great White and Landrace breeds, inseminated with the sperm of terminal boars of the PIC-337 line of English breeding. Productive indicators, feed payment, and economic efficiency of fattening pigs using surgical and immunological castration of pigs served as material for research. The research was conducted in LLC "NVP "Globynsky Pig Complex" of Kremenchuk District, Poltava Region. They were conducted during the farrowing of sows of a weekly technological group with a number of 350 heads at breeding complex No. 2, in the village of Two groups of 300 boars each were selected from Obiznivka (Table 1).

Table 1. Scheme of the experiment

Indicator	Method of castration	
	surgical	**immunological**
Group assignment	**Group I**	**Group II**
The number of piglets at the beginning of the experiment, pigs	300	300
Surgical castration in age, days	3	-
The method of feeding piglets during the suckling period	liquid	liquid
Duration of suckling period in piglets, days	21	21
The method of feeding piglets during the growing period	liquid portioned	liquid portioned
Duration of raising piglets, days	51	51
The method of feeding pigs during the fattening period	liquid	liquid
Duration of the first (growing) fattening period, days	50	50
Vaccination with the "Improvak" vaccine at age, days	-	112
Duration of the second (final) fattening period, days	55	55
Revaccination with the "Improvak" vaccine at age, days	-	140
Age of pigs at the end of fattening, days	178	178

Source: own calculations.

In forming experimental groups, two or four normally developed strands of similar weight were selected from each nest for study. On the first day of life, they were weighed individually and marked with red (control group) and blue (experimental group) number clips. The animals in the first I group (control group) were surgically castrated on the third day of life. The animals in the II group (experimental group) were left uncastrated.

During the weaning period, the piglets of both experimental groups were housed together with their sows in identical farrowing compartments (Foto. 1). During this period, the sows were fed full-rational compound feed for lactating sows, balanced in terms of basic nutrients, produced at the Globino compound feed plant from the company's own cereal raw materials and a mineral-vitamin premix from Cargill. Piglets of both experimental groups were fed liquid pig milk substitute Opticare Milk from the Dutch company Swinco International from the second day of their lives with the help of the Cullina Mix Pro feed kitchen from the Big Dutchman company.

Photo. 1. Conditions for keeping experimental piglets during the suckling period
Source: processed photo of LLC "Globinsky Pig Complex".

The experimental piglets were kept together with the sow in individual farrowing pens of 1.8 m x 2.5 m in size. Sows were kept fixed in the center of the machine throughout the lactation period.

The microclimate in the farrowing areas was maintained using equipment from the German company Big Dutchman and a negative pressure air exchange system. The creation of suitable conditions for suckling piglets was achieved through the use of special sections with floor heating in the piglet resting room and infrared lamps, which were additionally used in the first days of life.

Manure removal from the premises was carried out by a sewage system, which was used at regular intervals during the cleaning and disinfection phase of the area.

The sows were watered by means of an automatic nipple drinker located on the side of the feeder. The suckling piglets were watered using bowl-shaped automatic drinkers located in the manure area of the machine.

The feed was transported from the storage containers to the feeders by means of a chain-disc conveyor. Dosing was done by continuously operating Sov Max feed dispensers from the company HOG SLAT Ukraine. The sows were fed indefinitely from the second day of their lactation.

The veterinary preventive measures for the animals in the two experimental groups were identical. Throughout the suckling period, the weaning of the piglets in the experimental groups and the weight of the weaned animals were recorded. On the day of weaning, all experimental animals were weighed individually and transported by special vehicles to the piglet rearing workshop No. 3 of LLC "NVP "Globynsky Pig Complex" in the village of Demydovka. In the rearing workshop the experimental animals were placed in separate pens measuring 6 m by 8.5 m, which were located in one section, 150 in each (Fig. 2). Each pen has 60% slotted and 40% solid underfloor heating.

Air was exchanged in the extension by means of a uniform pressurised ventilation system using supply and exhaust air roof fans, the operation of which was coordinated by the control unit.

Manure removal from the tubs under the machines was done at the expense of a periodic sewage system, two times during the study period. For pigs feeding was used 8-feeder and 8-cup feeder.

The piglets in this farm were fed chopped pre-starter mixed feed of formula 0–9 kg, which was also used in the post-weaning period until pigs reached an midle weight of 9 kg. When the average weight of the animals in the group

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was 9 kg, they were switched to feeding pre-starter mixed feed with the recipe 9–12 kg.

Photo 2. Conditions for keeping experimental piglets during the rearing period
Source: processed photo of LLC "Globinsky Pig Complex".

When the animals in the group had reached an average weight of 12 kg, they were switched to feeding complete feeds of the 12–30 kg formula produced at the Globino compound feed plant.
The distribution of the feed by the fattening farms, the transport to the feeders and the distribution to the animals as well as the feeding of the piglets of the experimental groups were carried out with the Spotmix II feeding system of the Austrian company Schauer. Feeding was done in liquid lumps in the ratio of 2,700 g of water per 1,000 g of dry feed, the feeding front was 8 cm per head, and the number of feedings reached 22–23 times per day. Fodder accounting for each feed place is carried out by the feed kitchen control system when dry fodder is unloaded into the pipelines. Veterinary, sanitary and preventive measures were the same for piglets of all groups during rearing were carried out according to an identical scheme. Every day during this period, the elimination of experimental piglets and their weight were recorded. After the piglets of both experimental groups reached 72 days after birth, all experimental piglets and piglets were weighed individually, loaded into special cars, and transported for fattening to feedlot No. 3 of LLC "NVP "Globynsky Pig Complex" located near the village of Hrynky placed them in pens on a completely slotted concrete floor, 50 heads in each, at the rate of 0.75 m^2 per head (Fig. 3).
Air exchange in the pig house was performed using a negative ventilation system from the German company Big Dutchman.

Photo 3. Conditions for keeping experimental pigs during the fattening period
Source: processed photo of LLC "Globinsky Pig Complex".

Manure removal from the farm was performed when the grate baths were filled every three to four weeks using a periodic vacuum gravity system. The pigs were watered using 6 automatic drinkers with height-adjustable nipples attached to the side walls of the pens. Preparation, transportation, and distribution of feed to the animals of the experimental groups was carried out with the help of the equipment of the Austrian company Weda using a liquid type of feeding, with a ratio of dry feed to water of 1 to 2.9.
The frequency of feeding during the experiment was 12 times per day, according to the feeding curve programmed in the control system of the feed kitchen. From the 72nd day of life, all the experimental animals were switched for five days to feeding with a compound feed of the recipe Grover 30–60 for the first phase of fattening, produced by the Globyno compound feed plant. Upon reaching the age of 120 days, the animals of both experimental groups were transferred to feed with finishing compound feed recipe 60–90 kg, produced by the Globino compound feed plant, for five days, until they reached an average weight of 90 kg in both experimental groups. At this weight, they were gradually transferred to feeding with finishing compound feed recipe 90-130 produced by

the Globino compound feed plant for the final stage of fattening, which was fed to the animals until the end of fattening. Feed accounting in each machine was carried out automatically with the help of the feed kitchen control system.

Animals in the experimental group were inoculated on the 112th day of life with the Improvak vaccine from Zoetis at a rate of 2 ml per head, and at 140 days of age they were re-administered the same vaccine at the same dose. At the end of feeding, all experimental animals were weighed individually. During the fattening period, all technological and veterinary preventive measures were the same for both experimental groups of animals, also during this period the elimination of pigs and their reasons, the date of elimination, and the weight of the animals that were eliminated were taken into account.

Based on the research results, the growth intensity, the preservation of surgically and immunologically castrated boars and their fattening qualities, payment of feed in stages and their costs during rearing and fattening were determined. Based on these data, the economic efficiency of immunological castration during rearing and fattening of male hybrid pigs in a liquid feeding system was calculated.

The results of the experiment were processed biometrically using application programs in the MS Excel 2016.

RESULTS AND DISCUSSIONS

During the experimental period, uneven productivity was observed in surgically and immunologically castrated pigs (Table 2).

As shown in the research results, the live weight of piglets at the beginning of the experiment was absolutely equal, while the weight of animals in the second group at the end of the weaning period was reliably ($p<0.05$) 0.27 kg or 4.1% higher than that of the peer 1 group.

This was due to the 13 g and 5.1% higher average daily gains in the animals of the experimental group, which in turn led to a 0.27 kg and 5.1% ($p<0.05$) increase in absolute gains during this period and caused higher indicators of piglet weight.

Table 2. Growth, preservation and fattening qualities of surgically and immunologically castrated male pigs, n = 30

Indicator	Group I	Group II
The number of boars in the group at the beginning of the experiment, pigs	300	300
Average weight of experimental animals at birth, kg	1.33±0.013	1.33±0.017
Preservation of piglets in the suckling period, %	94.3	93.67
Average weight of one piglet at weaning, kg	6.62±0.071	6.89±0.113*
Absolute growth of 1 head during the suckling period, kg	5.29±0.071	5.57±0.107*
Average daily growth in the subsucking period, g	252±5.8	265±7.4
Preservation of piglets during the rearing period, %	97.5	98.6
Absolute growth of 1 head during the growing period, kg	23.7±0.11	23.9±0.13
The average weight of 1 head at the end of growing, kg	30.3±0.12	30.8±0.13**
Average daily growth during the growing season, g	461±6.7	467±8.9
Average weight of 1 head of pigs at the end of fattening, kg	124.6±1.24	134.2±1.36***
Duration of fattening, days	105.5	105.1
Average age at weaning, days	177.7	177.2
Preservation of piglets during fattening, %	96.4	97.0
Absolute growth of 1 head for fattening, kg	94.3±1.17	103.4±1.32***
Average daily growth during fattening, g	895±7.2	985±10.3***

* – $P < 0.05$; ** – $P < 0.01$; *** – $P < 0.001$
Source: own calculations.

In addition, 0.63% better preservation in the post-weaning period was observed in non-castrated piglets, probably related to the absence of postoperative stress and postoperative complications.

During the growth period, the intensity of growth was almost the same in both groups, probably due to the stress of the piglets after weaning. This resulted in almost equal absolute growth during the growth period. However, the live weight of the pigs at the end of this period was reliably ($p<0.05$) 0.5 kg or 1.7% higher in the non-castrated boars compared to their castrated counterparts, mainly due to higher absolute growth in the post-weaning period.

At the same time, the preservation of piglets, in contrast to the weaning period, in the growing period was 1.1% worse in the experimental group compared to the control group.

A completely different picture was seen during the pig fattening period. During this period, the animals in the experimental group probably ($p<0.001$) had a 90 g or 10.1% higher average daily gain. This, in turn, led to an increase in absolute gains during fattening by 9.1 kg or 9.7% ($p<0.001$), contributing to an increase in the average live weight of the animals on the 177th day of life by 9.6 kg or 7.7%.

It should also be noted that immunocastrated animals were 0.6% better preservation during the fattening period compared to surgically castrated animals.

During the growth and fattening period, the animals in the control and experimental groups consumed unequal amounts of feed with different formulations (Table 3). During this period, piglets in the experimental group consumed 0.1 kg or 12.2% less feed per day compared to the castrated animals.

At the same time, the animals in the research group consumed 1.90% more of the first starter and 19.55% more of the second starter per pig compared to the surgically castrated males. At the same time, they consumed 6.27 kg or 18.68% less starter feed than their castrated counterparts. In general, they consumed 5.27 kg (12.39%) less feed during rearing than the surgically castrated boars.

However, taking into account the slightly higher growth intensity in the suspension period and in the period of allocation of the piglets of the experimental group and the lower amount of feed eaten, the recovery in this group was 0.23 kg or 12.9% better than in the surgical castrates.

Table 3. Feed costs of different recipes during the period of rearing and fattening of surgically and immunologically castrated males, n=30

Indicator	Group I	Group II
Average daily consumption of fodder during the growing period, kg	0.82	0.72
Prestarter recipe 0-9 consumed per 1 piglet, kg	4.22	4.30
Prestarter recipe 9-12 per 1 piglet, kg	4.72	5.64
Starter compound feed of recipe 12-25 per 1 piglet was consumed, kg	33.58	27.3
Combined feed was consumed (prestarter and starter for 1 piglet, kg	42.51	37.25
Fodder conversion during the growing period, kg/kg	1.78	1.55
Consumption of grower compound feed recipe 30-60 per 1 piglet transferred to the meat processing plant, kg	58.02	86.38
Consumption of finished combined feed of the recipe 60-90 kg per 1 piglet transferred to the meat processing plant, kg	78.40	81.40
Consumption of finished combined feed of the recipe 90-130 kg per 1 piglet transferred to the meat processing plant, kg	135.59	123.70
Average daily feed consumption during fattening, kg	2.57	2.73
Feed conversion during the fattening period, kg/kg	2.87	2.77

Source: own calculations.

After the transition to fattening, uncastrated piglets consumed 28.36 kg (48.87%) more rearing feed per head compared to surgically castrated piglets. They also ate 3.0 kg (3.82%) more of the first finishing feed, while they ate 11.89 kg (8.77%) less of the 90-130 kg formula finishing feed. In general, immunocastrated piglets ate 14.2 kg (4.52%) less feed per head than surgically castrated piglets during the growing and finishing period.

Considering the different costs of compound feed of different formulations and the unequal consumption in the control and experimental groups, there were different feed costs for rearing and fattening 1 animal (Table 4).

Table 4. Economic efficiency of breeding and fattening of surgically and immunologically castrated piglets

Indicator	Group I	Group II
The cost of the first pre-starter feed for 1 piglet, EUR	4.14	4.22
The cost of the second pre-starter feed for 1 piglet, EUR	2.55	3.05
The cost of starter feed per 1 piglet, EUR	10.89	8.85
The cost of fodder for 1 piglet in the weaning period and the growing-out period, EUR	17.58	16.12
The cost of nursery fodder for 1 delivered piglet, EUR	13.33	19.85
The cost of the first finishing feed for 1 delivered head, EUR	14.39	14.94
The cost of the second finishing feed for 1 delivered piglet, EUR	22.44	20.47
The cost of all feed per 1 piglet, EUR	67,74	71.38
The cost of fodder per 1 kg of growth, EUR	0.55	0.54
The cost of the vaccine per 1 piglet, EUR	0.001	2.480
The cost of feed and vaccine per piglet, UAH	66.79	73.81
The cost of fodder and vaccine per 1 kg of gain, EUR	0.54	0.56

Source: own calculations.

Thus, during the growth period, the feed cost for one piglet was higher by EUR 1.45 or 8.29% for the animals in the control group. During the fattening period, the cost of fattening an animal was EUR 5.09 or 10.17% higher for immunocastrated animals compared to surgically castrated animals due to higher feed consumption in general and especially more expensive feed for rearing and first finishing fattening. However, taking into account the higher growth intensity and greater absolute growth, the feed cost for 1 kg growth was EUR 0.01 or 2.23% lower for immunocastrated males.

At the same time, EUR 2.48 was spent on vaccinating one head of pigs on the farm. The feed cost for a head of immunocastrated pigs thus increases by this amount and amounts to EUR 73.81, which is EUR 6.12 or 9.04% higher than for surgically castrated animals. However, due to the higher growth intensity and the associated larger absolute gains of an animal during growth and fattening, the cost of feed and vaccine per 1 kg of growth was almost the same and amounted to EUR 0.006 or 1.17% higher in immunocastrated pigs compared to surgically castrated ones.

Due to the uneven growth of pigs during ontogeny and the uneven cost of feeding different formulations during this period, the cost of rearing piglets differed at different stages of life (Table 5).

Table 5. Economic efficiency of breeding and fattening of surgically and immunologically castrated piglets

Indicator	Group I	Group II
The cost of one piglet when transferred for breeding, EUR	24.81	25.85
The cost of rearing 1 piglet, EUR	21.98	20.16
Cost of fattening 1 piglet, EUR	64.87	71.46
Cost of rearing and fattening 1 piglet, EUR	86.86	91.64
Cost of one head at the end of fattening, EUR	111.67	119.97
Realization price of one head at the end of fattening without VAT, EUR	211.83	228.14
Income from growing and fattening one piglet, EUR	100.16	108.17
Profitability of raising one piglet,%	89.69	90.16
The cost of fodder and vaccine per 1 kg of gain, EUR	0.55	0.56
The cost of one kilogram of growth, EUR	0.91	0.90
Sales price of one kilogram of gain, hryvnias	1.72	1.72
Income from cultivation and fattening per 1 kg of growth, EUR	0.81	0.81
Profitability of growing one kilogram of growth,%	89.69	90.16

Source: own calculations.

Due to the higher average weight of piglets at weaning, the cost of one piglet at rearing was EUR 1.04 or 4.21 % higher in the experimental group than in the control group.

In turn, the cost of rearing the surgically castrated piglets in the control group was EUR 1.82, or 8.30%, higher than that of the non-castrated ones. The cost of fattening the animals from the experimental group, on the other hand, was higher. For their fattening, EUR 6.59 (10.16%) more was spent in the group of surgically castrated animals than in the group of immunologically castrated counterparts.

Due to these price variations, this indicator, which is based on the results of rearing and fattening, was EUR 4.77 higher for immunocastrated animals than for surgically castrated ones, or 5.50%. Taking into account the cost of a piglet at the time of rearing, the cost per animal at the end of the fattening period was EUR 8.30 or 7.44% higher for pigs in the second group, while the selling price for an animal in this group was 7.70% or EUR 16.31 higher.

Taking into account the different cost prices and the different selling prices, the proceeds from rearing and fattening of surgically and immunologically castrated male pigs were different. Thus, the revenue from the sale of the animals of the second group was EUR 8.00 or 8.00% higher than that of the animals of the control group. There was also no significant difference between surgically and immunocastrated pigs in terms of a 1 kg increase in live weight. Thus, the feed cost was EUR 0.006 higher in immunocastrated boars, while the cost of 1 kg gain was EUR 0.003 higher in surgically castrated animals. At the same time, the selling price for 1 kg gain in surgically castrated animals is higher by EUR 0.001, while the income from rearing and fattening of immunocastrated pigs is higher by only EUR 0.001 higher for animals of the second group.

In turn, the profitability of obtaining 1 kilogram of growth was only 0.47% higher in immunologically castrated animals. That is, no difference in the economic growth rates of surgically castrated and immunologically castrated pigs has been established.

Thus, immunocastration of piglets compared to surgical castration under liquid feeding was found to increase average daily gain during rearing by 1.41% and during fattening by 9.95% and absolute gain during fattening by 9.68%, improve feed conversion during rearing by 13.0% and during fattening by 3.15% and by 4.90% from birth to slaughter. Immunocastrated animals reached a 7.70% higher weight at the end of fattening than surgically castrated animals.

At the same time, immunocastrated animals consumed 4.52% more feed during their lifetime, the cost of which was 5.38% higher compared to surgically castrated animals, and when the cost of vaccination was taken into account, it was 9.04% higher. The cost of feed and vaccines per 1 kg of gain was 1.17% higher in immunocastrated animals than in surgically castrated animals. The cost of immunocastrated male pigs was 8.30% lower in the rearing phase, but 10.16% higher in the fattening phase, and 5.5% higher in the results of these two phases. As a result, the cost of an animal at the end of the fattening period was 7.44% higher and the selling price without VAT was 7.70% higher than for surgically castrated animals, generating 8.00% more income from the sale of an animal in this group.

Our results regarding increased growth intensity of immunocastrates compared to surgically castrated animals are consistent with data [21, 26, 28, 33] emphasizing improvement in indicators of average daily and absolute gains when immunococulation is used to eliminate boar taint in male pigs. Similar to the results of studies by foreign researchers [12, 15, 32] that indicated an improvement in feed consumption when immunocastration was used, we also obtained data that allowed us to detect an increase in this rate, contradicting other reports that indicated that surgically castrated males tended to consume 10–15% more feed than immunocastrated males [27]. The data [29] on improvement of fattening indicators of immunocastrated piglets based on feed conversion index compared to surgically castrated piglets were also confirmed in our current study, where we obtained better values of this indicator in immunocastrated boars during rearing and fattening.

Contrary to the data of many researchers [9, 22] about the positive effect of using the method of immune castration on the profitability of pork production and contrary to the conclusions of other authors [22] about the decrease in profit when growing immunocastrates, we found no significant difference in the efficiency of rearing and fattening of surgically castrated and immunologically castrated pigs, as reported by other scientists [31].

CONCLUSIONS

Increase in average daily gains during rearing and fattening, improvement in feed conversion during rearing and fattening and from birth to slaughter, increase in absolute gains during rearing and live weight of animals after completion of rearing, feed consumption and their value in immunocastrated male pigs compared to surgically castrated. The cost of fattening immunocastrated male pigs was found to be higher, as was their selling price, so that a higher revenue could be obtained from the sale of an immunocastrated animal compared with surgically castrated pigs. The profitability of raising a head and a kilogram did not differ significantly among the different castration methods in each animal group.

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FROM CHALETS TO COMMERCE: EXPLORING HOW THE STRASBOURG CHRISTMAS MARKET IS AMPLIFYING LOCAL PRODUCERS' PRESENCE IN ALSACE, FRANCE

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Abstract

This study examines the impact of the Strasbourg Christmas Market on local producers in Alsace, France, focusing on its role in rural tourism and consumer preferences for sustainability and bio products. Combining online survey data from Christmas tourists and analysis of existing reports, the research investigates the market's influence on producer visibility and consumer behavior. Findings inform strategies for promoting rural economic development and sustainable practices.

Key words**:** *rural tourism, sustainability, consumer behaviour, branding, culture*

INTRODUCTION

Strasbourg, known as the European capital of Christmas, proudly upholds ancient traditions linked to this festive season.

Dating back to the Middle Ages, children eagerly anticipate the arrival of Saint Nicholas on December 6th. Saint Nicholas, the Bishop of Myra in Asia Minor during the 4th century, is revered as the patron saint of children, with his legacy spanning centuries.

In both Catholic and Protestant traditions, Saint Nicholas and the Christkindel, respectively, hold special significance.

The latter tradition, stemming from the Scandinavian Saint Lucy, involves delivering gifts to well-behaved children on December 24th.

The Christkindelsmarik, Strasbourg's renowned Christmas market, bears her name since its establishment in 1570 [7].

Moreover, the Alsace region is making strides in the agrotourism sector, particularly highlighted during the Christmas market. Within the Grand Est region, encompassing Alsace, resides a population of 5,555,186 individuals, representing 8.5% of the metropolitan population.

Encompassing an area of 57,430 km², which accounts for 10.5% of the metropolitan area, it hosts a remarkable 5,132 municipalities).

The economic impact of tourism within the Grand Est region is noteworthy, with annual statistics boasting 21.6 million tourists, 56.6 million visitors, and €4.6 billion in generated revenues [7].

On the other hand, the communication and brand positioning of the region and its Christmas Markets embrace an eco-responsible angle [15].

For the 2023 edition of Strasbourg Capital of Christmas, numerous initiatives related to the event's eco-responsibility are being implemented. Among these initiatives, one can find waste sorting and reduction, eco-friendly lighting, reusable cups, and carbon footprint reduction measures [7].

Considering the presence of local producers offering organic products and the implementation of sustainable initiatives, it can be assumed that these factors play a significant role in influencing buyer intent at the market.

The research methodology encompasses a blend of primary and secondary data collection techniques to effectively address this hypothesis. Primary data acquisition involves the deployment of an online survey targeting individuals actively engaged in Christmas tourism.

Following the dissemination of a 10-question online survey focused on consumer preferences regarding bioproduct purchases, a total of 211 responses were garnered. Subsequent scrutiny identified 195 responses as meeting eligibility criteria and demonstrating comprehensive insights. Additionally, existing reports, studies, and publications concerning the Strasbourg Christmas Market, rural tourism dynamics in Alsace, and consumer behavior within the sustainability and bioproduct domain were leveraged to augment understanding of prevalent rural tourism patterns within the designated geographical location.

It is hypothesized that visitors are attracted not solely by the festive ambiance but also by their inclination to endorse eco-friendly initiatives and procure locally sourced, sustainable products.

The results indicate that despite the inclusion of local producers within the Strasbourg Christmas Market, coupled with the provision of rural tourism attractions, there exists no direct correlation between their presence and heightened purchasing inclination among visitors for rural or traditional commodities. This observation persists notwithstanding the tourists' primary objective of immersing themselves in authentic local customs and their discernible affinity towards locally sourced products.

The Christmas market highlights a series of smaller cities and rural areas grouped together in a circuit for rural tourism, creating incentives for local communities and producers to benefit from the influx of tourists attracted to the area.

For example, activities are linked in smaller local Christmas markets in Orbey, Ungersheim, Grendelbruch, Colmar, etc.

Despite our analysis revealing the absence of a direct correlation between the presence of certain factors and an increased propensity towards purchasing rural or traditional commodities among visitors, the precise determinants influencing purchase decisions remain elusive.

This ambiguity underscores the necessity for further exploration, establishing a critical starting point for forthcoming analyses.

This study aims to provide a comprehensive understanding of the relationship between the Strasbourg Christmas Market, local producers, rural tourism patterns, and consumer preferences for sustainable products and rural development.

Literature review

Identity preservation in tourism development

The Strasbourg Christmas Market serves as a vibrant showcase of Alsace's cultural heritage and traditions.

Through the prominent display and promotion of locally crafted goods, traditional cuisine, and age-old practices, the market actively contributes to the preservation and continuation of the region's cultural legacy. The (re-)presentation of cultural heritage in these forms creates a unique set of interactions between landscapes, local communities, tourists and heritage organisations [4].

Local producers play a central role in this endeavor, showcasing their expertise and craftsmanship to a diverse audience of visitors.

By providing a platform for these artisans to share their skills and stories, the market fosters a strong sense of community pride and identity among both producers and attendees alike.

Moreover, the market serves as a living museum of Alsace's cultural heritage, where visitors can experience firsthand the customs and rituals that have been passed down through generations.

The benefits of heritage tourism include high tourist arrivals and receipts, the multiplier effects within the industry and creation of employment opportunities for the local community [6], all while providing a sensory experience that immerses visitors in the traditions of the region.

Cultural tourism and rural development

The distinction between culture and tourism has historically been clear-cut, with cultural tourism traditionally defined by visits to renowned cultural sites rather than leisure activities like beach vacations.

However, this demarcation has blurred in recent years as cultural tourism has evolved beyond mere monument visits to encompass immersion in the way of life of different destinations [13].

This shift has given rise to the wine, or Christmas routes in the case of the Alsace region.

On the global tourist market, the interest of tourism consumers in tangible and intangible cultural heritage is growing, as well as the interest in rural tourism in a peaceful rural environment with traditional values [16].

This goes hand in hand with a growing interest in authentic community engagement, slow travel, and high-quality experiences that emphasize local practices, gastronomy, and traditions.

Rural areas, once overlooked, now serve as prime destinations offering picturesque landscapes and nature-based attractions, appealing to tourists seeking to experience destinations like locals [2].

This trend underscores a shift towards meaningful, experiential tourism that highlights the unique cultural and natural elements of a destination, catering to travellers' desire for authenticity and connection.

The success of a sustainable tourist destination in the global tourism market is impossible without a well-designed vision.

The vision of sustainable tourist destinations must start from the primary need to raise the quality of the local population of the tourist destination, preserve the tradition and inherited cultural and historical destination values, and the need to design an integrated tourist product that will provide consumers in tourism with a pleasant and unforgettable experience [16].

While the statement emphasizes the importance of a well-designed vision for sustainable tourist destinations, it presents a somewhat idealized view of the complexities involved.

While raising the quality of life for local populations is indeed a critical aspect of sustainable tourism development, it's important to recognize that this goal can sometimes conflict with other objectives, such as economic growth and environmental conservation.

Cultural landscapes

Landscapes (urban or rural; natural or manmade) serves as tangible expressions of cultural values, practices, and identities.

They are viewed as dynamic entities shaped by human activities and perceptions over time.

While conserving historical evidence, these cultural landscapes should continue as living systems economically and culturally viable within the framework of their authenticity and integrity [11].

This involves engaging with local communities to understand the significance of specific sites, traditions, gatherings, and practices, and integrating this knowledge into tourism planning and management processes. By doing so, destination managers can ensure that tourism initiatives are sensitive to local cultural identities and contribute positively to their preservation and exposure.

Consumer behavior

The paramount importance of brand loyalty for businesses navigating the competitive marketplace, particularly within the context of rural tourism and eco-responsible endeavors, is underscored by the dynamic relationship between brand loyalty and its multifaceted effects on consumer perceptions, behavior, and buyer intent.

As evidenced by peers, brand loyalty not only cultivates a positive brand image through consistent positive experiences and reliability [12] but also transforms customers into brand advocates, thereby amplifying word-of-mouth marketing [1].

This emotional connection forged through brand loyalty not only bolsters resistance to competitive influences but also instills a willingness among consumers to pay premium prices.

Such emotional attachment extends to various facets of consumer behavior, encompassing purchasing decisions, brand advocacy, and

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participation in loyalty programs. Additionally, the role of brand loyalty in reducing perceived risks associated with purchases positively influences buyer intent [10].
Notably, within the realm of rural tourism and eco-responsible initiatives, brand loyalty takes on added significance.
By aligning with sustainable practices and community engagement, brands can deepen their emotional connection with consumers, thereby enhancing loyalty and contributing to the conservation of natural and cultural heritage.
In this context, this study aimed to assess the impact of the Strasbourg Christmas Market on local producers in Alsace, France, focusing on its role in rural tourism and consumer preferences for sustainability and bio products.

MATERIALS AND METHODS

The current research employs a blend of mixed research methods to investigate the subject matter comprehensively.
Combining the two approaches can produce more scientifically sound and transferable results by synergistically integrating qualitative stakeholder engagement with quantitative outcomes to inform action/intervention planning, implementation, evaluation, and monitoring [9].
To gain preliminary insights into the specified research objectives, secondary data, such as existing reports, studies, and publications related to the Strasbourg Christmas Market, rural tourism trends in Alsace, and consumer behaviour in the context of sustainability and bio products, were utilized to enhance comprehension of prevailing rural tourism trends within the designated region.
Starting with an overview of employment in the tourism sector in France, we notice that the average employment rate is slightly higher in the Alsace region compared to the national average, suggesting a well-developed range of activities within the sector in Alsace.

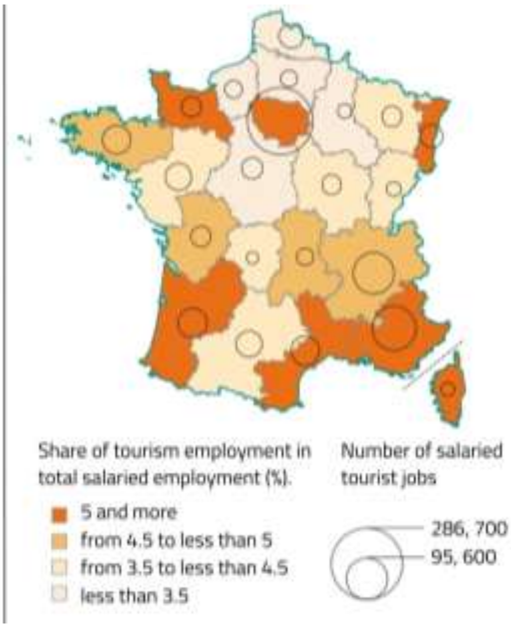

Fig. 1. Tourism employment by region
Source: INSEE, DADS 2009, estimated of salaried tourism employment [8].

To gain a broader and more comprehensive understanding of job distribution within this sector, we have examined the shares of activity sectors in total tourism employment.

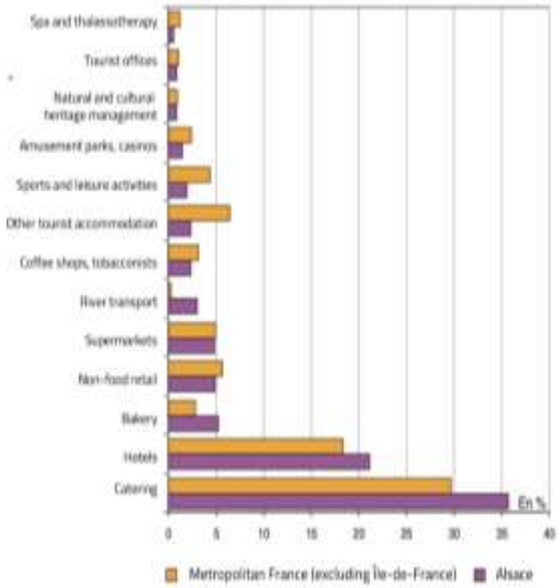

Fig. 2. Share of activity sectors in total tourism employment
Source: INSEE, DADS 2009, estimated of salaried tourism employment [8].

In relation to the geographical distribution within the Alsace region, we have examined tourism employment according to geotourism zones.

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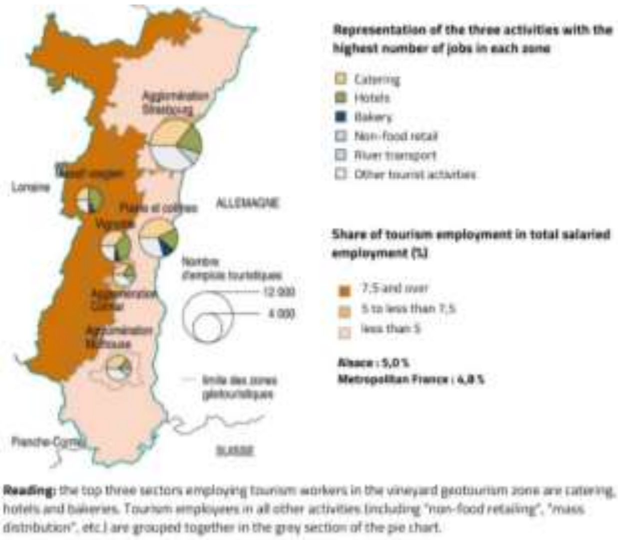

Fig. 3. The main sectors of activity of tourism employment by geotourism
Source: INSEE, DADS 2009, estimated of salaried tourism employment [8].

Based on these datasets, it is evident that despite the region's emphasis on rural tourism, the primary sources of revenue and employment stem from a more traditional centred around significant metropolitan area.

Concerning the visitor profile of the Grand Est region, including Alsace, the majority consists of couples and families or groups of close acquaintances.The ascendancy of regional products and local markets as preferred attractions within the Alsace region is palpable, albeit still ascending the hierarchy of visitor preferences. These elements consistently garner heightened favorability compared to alternative activities when individuals opt to explore the cultural and gastronomic offerings of the region [5].

Fig. 4. Activities in the Grand Est
Source: ARTGE, Customer Marketing Survey, 2018-2019 (total sample of 12,249 visitors) [3].

The primary motivations for visiting are historical heritage, museums, and memorial sites (32%), followed by visiting family or friends (24%), and exploring cities, villages, and sites of cultural significance, tradition, and folklore (24%) [3].

The research methodology comprises secondary but also primary data collection methods to address the research objectives effectively.

Primary data will be gathered through an online survey targeting individuals who engage in Christmas tourism.

A total of 211 responses were gathered subsequent to the dissemination of a 10-question online survey pertaining to consumer preferences concerning bioproduct purchases. Among these, 195 responses were deemed eligible and comprehensive.

The role of psychology in consumer buying behavior is essential because it affects the attitude of human through feeling, emotion desire and response, and usually formed through experience [14].

The survey will explore participants' perceptions, behaviours, and preferences regarding their interactions with local producers, engagement in rural tourism activities, and attitudes towards sustainability, bio products, and CSR initiatives.

Firstly, it seeks to elucidate the influence exerted by participation in the Strasbourg Christmas Market on the prominence and market penetration of local producers in the Alsace region, particularly within the context of rural tourism endeavors.

This inquiry delves into the mechanisms through which involvement in the market platform augments the visibility and market presence of local producers, as well as its impact on rural tourism activities.

The study endeavors to examine the perspectives and experiences of local producers concerning the Strasbourg Christmas Market's role in facilitating their involvement in rural tourism initiatives and its efficacy in attracting visitors to their establishments.

Secondly, the research aims to evaluate the interplay between the presence of local producers at the Strasbourg Christmas

Market, patterns observed in rural tourism, and consumer attitudes towards sustainability and bio products.

It involves investigating the extent to which consumers prioritize the procurement of bio products and locally sourced items while visiting the Strasbourg Christmas Market, and the correlation of such preferences with their interest in rural tourism experiences.

Moreover, the study seeks to uncover the motivations and decision-making criteria that underpin consumers' choices for sustainable and bio products at the market, elucidating how these preferences intersect with their support for local producers and advocacy for rural tourism promotion in the Alsace region. Through these research inquiries, the study endeavors to offer comprehensive insights into the intricate nexus between the Strasbourg Christmas Market, local producer engagement, rural tourism trends, and consumer attitudes towards sustainability and bio products within the context of Alsace's regional dynamics.

The collected data form the form will be analyzed quantitatively for the survey responses to derive insights, patterns, and correlations relevant to the research objectives and the tendencies that were previously identified.

Limitations such as sample bias and data availability constraints will be acknowledged to interpret findings accurately.

The research findings present a preliminary examination aimed at elucidating consumer trends, serving as a foundational study to guide future investigations.

RESULTS AND DISCUSSIONS

The following chapter presents the findings of a study investigating the impact of the Strasbourg Christmas Market on local producers and rural economic development in the Alsace region of France.

Building upon the research objectives and methodology outlined in the preceding sections, this chapter offers insights gleaned from both primary data collected through an online survey targeting Christmas tourists.

The analysis delves into the market's influence on producer visibility, consumer preferences for sustainability and bio products, and the broader dynamics of rural and rural tourism in the region.

The findings suggest that the presence of local producers at the Strasbourg Christmas Market, along with rural tourism offerings, does not necessarily translate into increased purchasing intent among visitors for rural or traditional goods and services.

Specifically, 45.5% of respondents indicated that the presence of local products from local producers does not influence their spending budgets when planning their trip.

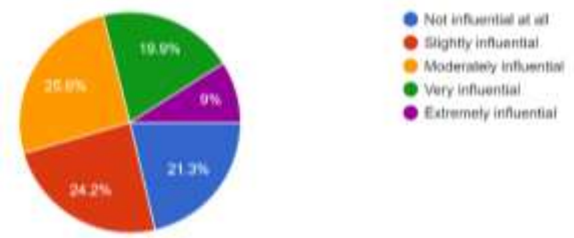

Fig. 5. Influence of bio/local labels on products at the Christmas Market in regards to your buying intent.
Source: Made by the author in Google form.

Additionally, 24.2% expressed active interest in seeking out these types of products and experiences, a figure closely aligned with the reported activities preferred by visiting tourists in the region.

When subjected to a sequence of open-ended inquiries concerning the exhibitors at the Christmas Market, participants exhibited limited substantive understanding of the merchandise on display.

This suggests that the local and organic aspects of the event may serve primarily to establish a sense of trust rather than significantly influencing consumer choices. Notably, the prevailing factors influencing decisions appear to be the aesthetic appeal of decorations and the ambiance of the town, particularly during the festive season.

Despite the overarching objective of events geared towards promoting local producers and heritage foods and crafts, empirical evidence suggests that taste emerges as a paramount determinant in consumer preferences.

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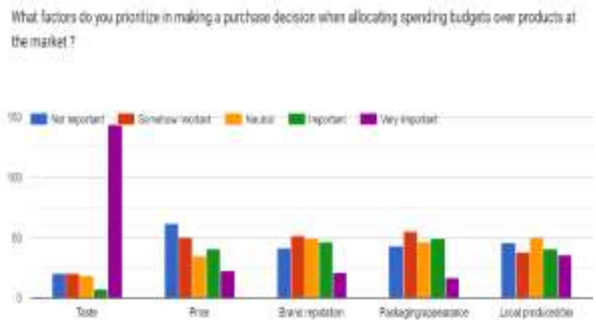

Fig. 6. Purchase decision factors
Source: Made by the author in Google form.

This phenomenon underscores the inherent complexity of consumer choice mechanisms, wherein sensory gratification often takes precedence over symbolic attributions such as locality or organic certification.

From an economic perspective, this divergence between promotional objectives and consumer behavior underscores the necessity for a nuanced understanding of market dynamics and the multifaceted nature of consumer preferences.

It prompts a re-evaluation of marketing strategies employed within such contexts, advocating for approaches that accentuate sensory appeal alongside broader narratives of locality and heritage to effectively resonate with consumer sentiments and foster a symbiotic relationship between promotional objectives and consumer choices.

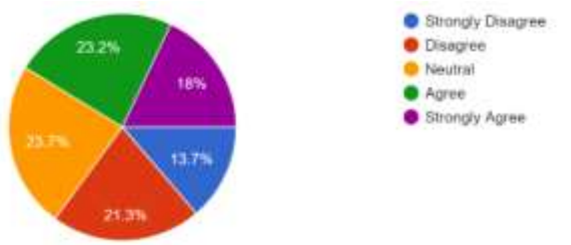

Fig. 7. Buying these products/goods again in the future outside of the Christmas Market
Source: Made by the author in Google form.

The analysis of consumer behavior at the Christmas Market unveils intriguing insights into purchasing patterns and subsequent buyer intent. Our study reveals that a substantial portion, constituting 35% of respondents, express reluctance towards repurchasing these goods beyond the festive market ambiance. Conversely, 41% exhibit an inclination towards future purchases, while 23.7% remain neutral, suggesting an absence of conscious deliberation in their decision-making process.

Upon aggregating the disinterested cohort (35%) with the neutrally inclined (23.7%), a significant 58.7% emerges, reflecting a considerable proportion of visitors who potentially lack a deliberate intent towards future purchases outside the festive context. This observation underscores a critical challenge for producers, as it signifies diminished prospects for client retention and loyalty.

The data imply a predominant occurrence of singular transactions, indicative of a transient engagement rather than enduring patronage.

Such findings underscore the need for strategic interventions aimed at enhancing consumer engagement and fostering brand loyalty amidst transient market dynamics.

Several factors contribute to the limited efficacy of visibility in driving long-term buyer intent.

The transient nature of consumer attention during Christmas markets, the abundance of options, and the lack of post-market engagement strategies all hinder the conversion of initial interest into lasting loyalty.

Strategic marketing interventions, including targeted engagement efforts and community-building initiatives, are essential to augment the impact of visibility.

Future research could explore the effectiveness of various post-market interventions in fostering enduring consumer relationships.

CONCLUSIONS

The Strasbourg Christmas market serves as a significant platform for enhancing the visibility of local rural producers, albeit not being the primary motivation for tourist visitation during this period.

Analyzing datasets sheds light on the tourism dynamics in the Grand Est region, revealing a paradox between the region's focus on rural tourism and the predominance of conventional urban attractions in revenue generation and employment.

Effective collaboration among rural communities, local authorities, and tourism stakeholders emerges as pivotal for harnessing the full potential of rural tourism.

Through concerted efforts to identify and capitalize on the region's inherent strengths such as scenic landscapes, quaint villages, and rich agricultural heritage, a more equitable tourism ecosystem can be cultivated, benefiting both urban and rural locales.

Strategic intervention presents an opportunity to leverage the region's rural assets more effectively.

By showcasing local traditions, folklore, and artisanal craftsmanship, rural areas can distinguish themselves from urban attractions, offering visitors a more profound and immersive experience.

While the presence of local producers and products at such events is desirable, there appears to be insufficient correlation between their participation and revenue generation, as the majority of tourists prioritize factors such as price and taste over a bio label.

However, respondents acknowledge the potential for switching to new products and services based on these considerations, suggesting that the Christmas Market serves as a valuable platform for visibility at the very least.

The question of whether the visibility gained during Christmas markets translates into sustained economic growth for these producers in the medium and long term remains an avenue for further exploration and deeper analysis.

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SHORT FOOD SUPPLY CHAINS: KEY CONCEPTS, BENEFITS, RISKS, EUROPEAN UNION SUPPORT, MODELS FROM ROMANIA, STRATEGIES OF DEVELOPMENT

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Abstract

Short food supply chains represent an alternative channel to the classic food distribution system. Creating viable food supply chains is a challenge facing society today. This article explores the concept of short food supply chains, their emergence and impact on local economies, sustainability and consumer behaviour. Reviewing the literature and theoretical frameworks, the article elucidates the benefits and challenges associated with short supply chains, including increased food quality, reduced carbon footprint and increased community resilience. In addition, an analysis of EU rural development policies is made and the importance of consumer awareness regarding the future development directions of short food supply chains is highlighted.

Key words: *short food supply chains, local economies, distribution system*

INTRODUCTION

The notion of a "short food supply chain" envisages a model of food distribution in which producers and consumers interact directly, with the help of a small number of intermediaries.

These chains may include local markets, farms that sell products directly to consumers, agricultural cooperatives, or other forms of commerce that avoid the traditional distribution channel [3, 9].

The notion of a short food supply chain has started to be used in the agricultural and food context more recently, with the growing interest in food sustainability and promoting local and regional products [8, 27]. The term has gained popularity among agricultural and food researchers, practitioners, and public discussions of how food is produced and distributed [28].

Even though the direct sale from producer to the consumer has been known and practised for a long time, the concept of "short food supply chain" comes to describe this food valorization procedure in a much more coherent way from the point of view of transparency and of viability [21,4, 16, 26].

As the origin and traceability of food products, and sustainable production methods have become important topics for consumers, interest in the notion of a "short food supply chain" has simultaneously increased [5, 6, 15]. In this way, it can be stated that short food supply chains best illustrate the alternative to the traditional food valorization model, promoting a closer connection between producers and consumers [19, 20, 23].

This study aims to analyze short food supply chains, SFSC, regarding the following aspects: concepts, benefits, risks, support from the European Union, models from Romania, impact on local economies, sustainability and consumer behaviour and strategies of development.

MATERIALS AND METHODS

Analyzing the theoretical or conceptual framework that provides the overall framework for short supply chains involves a holistic and interdisciplinary approach to understanding the context, processes and impact of these chains on local rural economies, sustainability and consumer behaviour [14, 18].

In the framework of this research, the existing literature related to short food supply chains follows their operation and impact on some relevant aspects related to sustainability, economic efficiency, social equity, product quality and the impact on local communities.

The benefits and challenges associated with short supply chains were considered, including increased food quality, reduced carbon footprint (by reducing transport distances) economic sustainability challenges (by removing intermediaries producers can get more value for their products) and social sustainability (producers develop new socially embedded relationships based on interaction with the direct consumers of their products based on common goals and interests), but also the community's increased resistance to new.

Analyzing short supply chain methodological frameworks can provide a deeper and more comprehensive understanding of how these chains operate and their impact on various aspects of society and the environment.

RESULTS AND DISCUSSIONS

Key concepts of short food supply chains

Some key concepts characterize these short food value chains in terms of how they are made and implemented [10, 17, 22, 31].

-*Geographic proximity:* this consists of reducing the physical distance from the place of production to the place of sale of food and implicitly promoting local products.

-*Direct relationships:* promote transparency and exchange of information between producers and consumers that increase trust between parties.

-*Promoting the local economy:* these short channels for the valorization of food products support the marketing of local products and bring benefits to producers and implicitly to local communities.

-*Product diversity:* a short food supply chain enables consumers to have access to varied, fresh and high-quality local products.

-*Food quality:* because short supply chains eliminate potential intermediaries between producers and consumers, they benefit from fresher and better quality products.

-*Sustainability:* short food supply chains have a major economic, social and environmental impact, helping to increase producers' incomes, support local communities and reduce the ecological footprint.

-*Respect for the environment:* the reduction of the transport distance has the benefit of a much-reduced carbon footprint and implicitly, to increased sustainability.

-*Inclusiveness and equity:* short food supply chains have two components: an economic one through which they provide opportunities for small producers to capitalize on their products and a social one offering the possibility of reducing inequalities that exist especially in rural areas.

-*Supporting small and family farming:* short distribution channels have a major impact on family farms and small producers in the sense that they have the opportunity to capitalize on their products without the pressure of intermediaries who would artificially raise prices.

-*Community resilience:* Short food supply chains come to support and strengthen rural communities based on direct interactions and cooperation between food producers and their beneficiaries.

These concepts represent the essence of the short-channel idea of distribution and valorization of local products sustainably and responsibly for the development of local communities. (Fig.1).

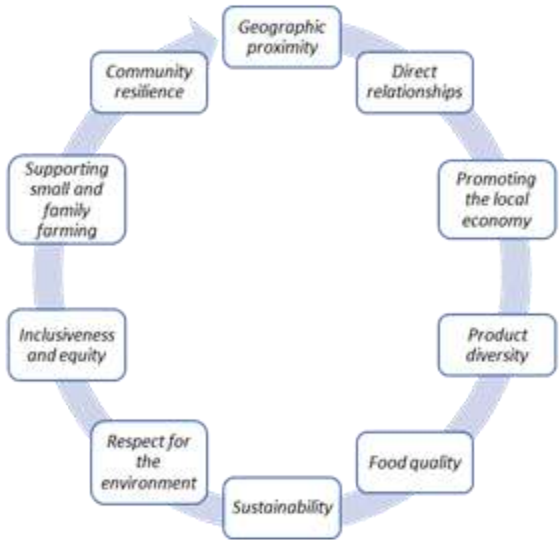

Fig. 1. Short Food Supply Chain- Key concepts
Source: Own determination.

Benefits of implementing short food supply chains

Short food supply chains have a particularly important role in the development of the rural economy, for the consolidation of small farmers, offering the possibility of obtaining benefits for both parties involved: agricultural producers manage to capitalize on their products obtained without the pressure of intermediaries, and consumers receive fresh products, of quality and at fair prices (Fig. 2) [35, 36, 39, 40, 41]:

-*Supporting local producers*: short food supply chains through local outlets give small local producers the chance to market their products directly, allowing them to increase their income.

-*Employment growth*: the emergence and development of this type of distribution channel also offers real benefits through the creation of new jobs at the level of the rural area in the sectors of production, processing or sale of locally obtained products

-*Stimulating rural tourism*: In addition to the services associated with rural tourism (accommodation, meal services or leisure), local markets or fairs that capitalize on the local products of small farmers can represent points of attraction for tourists or visitors to rural areas.

-*Community strengthening*: short food supply chains, on the one hand, can strengthen social ties in rural areas based on interactions and direct links between producers and consumers, and on the other hand, can support local cultural identity by promoting local traditions and crafts.

-*Reducing dependence on long supply chains*: short channels for the valorization of local food, whose principle is the elimination of intermediaries from the agri-food supply chain, represent a viable alternative to the classic agri-food chain. At the same time, the development of local markets in rural areas reduces the dependence on external intermediaries.

-*Environmental sustainability*: shortening food supply chains brings a major benefit to the environment by reducing carbon emissions due to shortening the transport distance of agri-food products to the point of utilization.

Fig. 2. Short Food Supply Chain- Benefits
Source: Own determination.

Potential risks to producers brought by the implementation of short food supply chains

Even though short food supply chains offer economic, social and environmental benefits to farmers, there may also be some risks that can be associated with this type of harnessing local produce, such as (Fig.3) [32]:

-*Vulnerability to climate conditions and extreme events*: due to climate change, extreme weather phenomena (drought, floods or hail) may occur that directly affect small producers who capitalize on their production through short chains and implicitly the availability of food on local markets may be endangered.

-*Dependence on local production conditions*: depending on the location of the farms in the territory, on the local production conditions, there is the possibility that some agri-food products are not disposable or are only available during certain periods, which can reduce the diversity of products available for capitalization through short supply chains.

-*Economic risk for producers*: small producers who capitalize on their production through these short capitalization chains may be more vulnerable compared to classic capitalization chains due to the economic risks they may be exposed to (increase in input prices, the possibility of having access to technology, etc.)

-*Limited production and distribution capacity*: due to the fact that these short distribution channels mainly involve small farmers, who have limited production capacities and obtain relatively small quantities of agri-food products, problems may arise in meeting consumer demand or in ensuring the continuity of products.

-*Food quality and safety*: even if the short capitalization chain offers the possibility of higher transparency regarding the knowledge of the origin of the products, there is a potential risk regarding food safety, and compliance with the regulations of their production, transport and handling.

-*Reliance on interpersonal and social relationships of producers*: one of the characteristics of short food supply chains is the direct relationship between producers and consumers that is created over time. This interpersonal link, for various reasons, can be affected and can negatively influence the operation of the supply chain.

-*Competition with traditional supply chains:* because short supply chains are based on small producers, it is sometimes difficult to compete with traditional food supply chains regarding price and accessibility, affecting their viability and sustainability.

Even if these risks are possible, short food supply chains can be managed in such a way that the negative impact is reduced as much as possible, while enhancing the beneficial effect of this sustainable supply model.

Fig. 3. Short Food Supply Chain - Risks for producers
Source: Own determination.

The influence of short food supply chains on consumer behaviour

Shortening food supply chains can play an important role in changing consumption behaviour and promoting a healthier, more sustainable and more responsible eating pattern [11, 25, 7]. With the implementation of short food supply chains, the consumption behaviour of beneficiaries can be changed and positively influenced through a series of aspects related to education and valorization of locally produced food through sustainable and ethical production practices (Fig. 4).

-*Awareness and education:* short food supply chains provide the opportunity to educate consumers about food provenance, production processes and environmental impact. This can increase consumer awareness and lead them to make more informed and responsible decisions about their diet. Consumers can get information about how the food they buy is grown or produced.

-*Valorizing local and seasonal foods:* by promoting local and seasonal foods, short supply chains can change consumers' perceptions of what is available and acceptable in their diet. Consumers can begin to appreciate and value local and seasonal products for their superior quality, freshness and taste.

-*Preference for fresh and high-quality products:* short supply chains offer fresh, high-quality and sometimes organic or artisanal food products. Consumers are becoming more interested in foods with high nutritional value and prefer local products.

-*Promoting direct relationships with producers:* short supply chains connect consumers directly with local producers. This personal interaction can build trust and loyalty with producers and foster a sense of community and belonging.

-*Support sustainable and ethical practices:* short food supply chains often encourage sustainable and ethical farming and food practices. Consumers can be motivated to choose products that are grown and produced in a socially and environmentally responsible manner.

-*Revaluing food and production processes:* by being directly involved in the food purchasing process, consumers can develop a greater appreciation for the value of food and the work of producers. This can lead to a change in consumer mindsets regarding food waste and an understanding of its impact on supply chains.

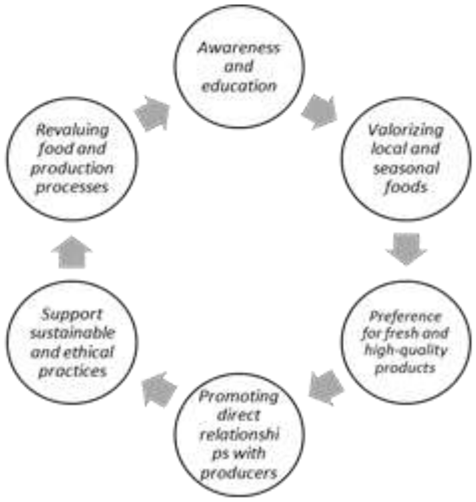

Fig. 4. Short Food Supply Chain- Impact on consumer behaviour
Source: Own determination

The EU support for the development of Short Food Supply Chain

Smart and competitive short supply chains are included in the EU rural development policy, under priority 3: "Promoting the organisation of the food chain, including processing and marketing of agricultural products, animal welfare and risk management in agriculture", through Focus Area 3A: "Improving the competitiveness of primary producers by better integrating them into the agri-food chain through quality schemes, adding value to agricultural products, promoting local markets and short supply circuits, groups and organisations of producers and inter-professional organisations".

Thus, in the European Union there is a variety of alternative models of food supply chains that reflect the diversity and complexity of EU member regions and economies: *local markets and agricultural fairs* that provide spaces for local producers to sell directly to consumers, promoting local produce and creating direct links between farmers and the community; *buyer groups* that organize to purchase agricultural products directly from local farms or agricultural cooperatives, cutting out middlemen and promoting direct relationships; *regional distribution associations or organizations* dealing with the collection and distribution of local products, facilitating access to larger markets and improving the visibility of local producers; *Urban sourcing hubs* are urban logistics centers that facilitate the collection, packaging and distribution of local food products to urban consumers; *online direct selling platforms* where producers register and can sell their products directly to consumers, cutting out traditional middlemen.

These alternative models of food supply chains show current EU trends towards traceability, transparency and supporting local producers. They address existing EU environmental concerns and promote the direct link between producers and consumers for the sustainable development of rural communities. [24, 30].

Models of short food supply chains in Romania

In Romania, short supply chain models are increasingly popular, with increasing awareness of their advantages, both for consumers, local producers and the environment. More and more farmers, producers and consumers have engaged in such models, opening small farms, participating in local markets, establishing direct collaborations between producers and consumers or organizing community networks for direct food distribution.

In 2008, the ASAT Association (Association for the Support of Rural Agriculture) started initially as an informal group of consumers together with a local producer, through the implementation of a community-supported agriculture pilot project [2]. Community-supported agriculture is a partnership between a farmer and a group of consumers, based on a mutual commitment regarding the duration of the collaboration, the payment of a subscription and the distribution of agricultural products. Consumers pay a portion of the annual subscription cost in advance, supporting production costs and generating financial stability for the small farmer. In this way, the farmer is supported for an entire season by a group of consumers who receive a weekly basket of vegetables from his garden. The Ministry of Agriculture and Rural Development highlighted ASAT as a model of good practices of the short food chain, as the first successful step of implementing community-supported agriculture.

"The Peasant's Box" is a community-supported agriculture project that has been operating in Romania since 2012. It is a meeting place between local producers and consumers from cities [13]. Manufacturers offer their products in the form of "boxes" that have been put together to feed a family. The contents of each box are fixed (consumers cannot choose the contents of the box) and may vary according to the seasons of the year. Boxes are delivered periodically: some are delivered weekly (vegetables or dairy) and others are delivered monthly (meat). Also, other boxes are delivered annually, on the occasion of certain holidays.

At the regional level, the Rural Development Research Platform Association implemented the "Taste of Iași" project in 2020, which was financed by the Iași City Hall. The idea of the project was to provide consumers in Iasi with a digital platform to facilitate access to food products directly from local producers [1]. Through the "GustDeIași.ro" digital platform, the aim was to make consumers aware of the importance of short supply chains, as well as to support local producers to capitalize on their products.

In 2020, at the level of the Podișul Mediașului LAG territory, to associate producers to sell local products, the agricultural cooperative " Food from Proximity" was established [12]. To facilitate the cooperation between farmers in the territory of the Mediaș Plateau LAG to commercialize local products through short food chains and the superior valorization of agricultural production, the "Food from Proximity" cooperative implemented the "Goods from the Mediaș Plateau" project. The products are delivered free of charge in an area of 60 km from Mediaș, for a minimum basket of 100 lei.

"The farm near you" is a short supply chain of horticultural products, mainly fruit (strawberries, cherries, blueberries, raspberries), promoted by the Romcăpșuni Association in the online environment and is mainly addressed to consumers who want to know where they come from the fruits they consume [34]. The fruit production is obtained from farms in Giurgiu and Dâmbovița counties, and the customers are mainly from Bucharest and Ilfov so that from the time of picking to the time they reach the consumer does not exceed 24 hours. For customers who prefer online ordering, it can be picked up from 3 fixed refrigerated delivery points, and consumers come and pick them up from there, or by paying a fee of 25 lei, they can receive the fruit at home by courier.

In Bihor county, in Lelești commune, there is the family farm "Goat with three goats" whose main activity is the production of goat's milk cheeses [29]. Considering the main objective of the farm to promote quality and less quantity, its manager believes that direct sales to stable customers through short-chain trade is the most effective solution: "I go with the basket to the customers' house, I get in contact with them, I understand their demands and needs and adapt my offer according to their requirements".

The "Agroecologia" association launched in Cluj-Napoca the "Peasant's Basket" Program. This is a system of distribution of organic and traditional products directly to consumers' homes, on a subscription basis [29]. The producers who joined the project come from the counties of Cluj, Sălaj, Maramureș and Bihor, and the offer of certified organic or traditional products includes fruits and fruit juices, vegetables, sea buckthorn, homemade jam, bellows cheese, sausages, bacon, drumsticks.

"ROMO: from Producer directly to Consumer", a social entrepreneurship project, whose mission is to connect as many local producers as possible with as many consumers as possible. ROMO is an online trading system, based on Facebook, and the ROMO Brașov group is the first group of this type in Romania [37]. According to the two entrepreneurs who laid the foundations of the ROMO project: "our broader vision is to contribute to food security in our country and to the generation of well-being by activating resources at the local level".

Launched in 2021, the startup Green Food is a marketplace through which local vegetables and fruits are sold and which comes with a logistics, and technological solution based on a short supply chain model. Green Food coordinates the supply chain from farm to city, and products are sourced from local or regional neighbourhoods [33]. According to the founder of Green Food: "on the local market, we have the first mover advantage as a supply and trading platform for local vegetables and fruits. We focus on the entire fresh supply chain. We are not just an online platform for ordering products. We offer solutions for decentralized inventory management, managing the commercial and logistical relationship between customers and producers, aggregating the offer and standardizing market information".

It is noted that the first models of short food supply chains in Romania appeared with the increase of the population's interest in a healthier diet, with the desire to understand the traceability of food products, all of which have positive effects on the sustainability of agricultural activities in small farms and the local economy.

Strategies to boost short food supply chains

Implementation of strategies that are adapted to local conditions and existing needs in the community can contribute to the development of these short distribution channels through a series of actions, such as [38]:

-Programs to support local producers: non-governmental organizations can initiate programs to encourage the purchase of food from local producers. This may include facilitating access to markets or promoting local products in local shops and restaurants.

-Consumer education and awareness campaigns: awareness of the benefits of short supply chains and the positive impact on local communities can stimulate demand for local products.

-Supporting local infrastructure through local markets and fairs: developing and promoting local markets and agricultural fairs can provide producers with a platform to sell directly to consumers.

-Public-private partnerships: policies and programs can be developed at the government level to encourage short supply chains, including subsidies or facilities for local producers.

-Online platforms: the existence of a digital platform offers the possibility of access to local products and simplifies the sales process between producers and consumers.

-Certification and labelling: the certification or labelling of locally produced agri-food products, and the implementation of the traceability system, can increase consumer confidence and support the development of this type of commercialization through short capitalization channels.

-Training and consulting programs for manufacturers: the participation of producers in various training programs can result in the efficiency of production processes and the increase of the quality of the obtained products.

-Collaboration between communities: collaboration between producers and consumers can facilitate the exchange of knowledge, and experience, and increase the skills of producers for certain activities.

CONCLUSIONS

The future of short food supply chains could be promising as they can play an increasingly important role in shaping food systems based on clear directions and relevant trends:

-Policy and legislative support: government policies and initiatives that promote and support short chains can contribute to their development and expansion. Agricultural subsidies, European support programs for local agriculture and regulations that facilitate direct sales from producers to consumers can be important tools in promoting short chains.

-Technology integration: the existence of mobile applications for online ordering can support accessibility in accessing and managing short supply chains.

-Innovation and diversification: innovation in products, processes and business models can help diversify and adapt short chains to the ever-changing needs and preferences of consumers. Initiatives such as urban farms and cooperative purchasing systems can expand the scope of short chains and bring additional benefits to communities.

-Increasing cooperation and partnerships: cooperation between producers, consumers, non-governmental organizations and other stakeholders can stimulate the development and diversification of short chains. Partnerships between farms, distribution networks and local institutions can strengthen supply chains and increase their positive impact on communities.

-Increasing focus on sustainability: a growing concern for environmental impact and food sustainability may lead to increased demand for products and practices promoted by short supply chains.

Consumers' option for short food supply chains becomes an alternative once they become more interested in healthier products and thus are oriented towards local products.

In conclusion, short food supply chains will be more valued by consumers and will occupy an increasingly important place in local food systems as their popularity and awareness among consumers increase.

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RESEARCH ON THE EVOLUTION OF EXPENDITURE WITH AGRICULTURAL LAND FERTILIZATION BY ECONOMIC SIZE CLASSES IN ROMANIA DURING THE PERIOD 2007-2021

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Abstract

The chemical fertilizers applied to Romania's soils represent a particularly important aspect in ensuring a qualitative and quantitative production. The expenditures that farmers have to be able to fertilize the soil correctly and with a sufficient amount have become over the years increasingly higher. The paper analyzes in evolution, over two periods of time, 2007-2014 and 2014-2021, 2 aspects: the surfaces of agricultural holdings, by classes of economic size; the main technical-economic indicators of the use of chemical fertilizers in agricultural holdings, namely the expenditures per hectare of agricultural land with chemical fertilizers, in total and by types: N, P_20_5 *and* K_2O *fertilizers, and the expenditures with chemical fertilizers to obtain 100 euros of plant production.The data were retrieved from the FADN platform and statistically interpreted using mean, standard deviation, coefficient of variation, growth rate, t-test of significance.The conclusion that emerges from the analysis undertaken is that there are big differences between the two analyzed periods, in both of them are signs of variations over the years and increases in chemical fertilizer expenses, but the second period, 2014-2021, shows a greater homogeneity of data, even decreases in the higher classes, while the classes (1) 2,000 - < 8,000 EUR and (2) 8,000 - < 25,000 EUR have increased expenditures per ha.*

Key words**:** *expenditure, evolution, chemical fertilizers, Romania, economic size classes*

INTRODUCTION

In Romania, experiments with chemical fertilizers began in 1962, and the effect of nitrogen fertilizers on wheat, corn, sunflower and sugar beet crops was studied [2, 5] continued by experiments using radioactive isotopes [5]. The studies from INCDA Fundulea monitored both the production and its quality [1]. The optimal doses recommended in the 1971s for the culture of corn, on the calcic chernozem from Ileana, were between 100 and 150 kg N/ha and between 60 and 80 kg/ha P_2O_5 [4].
In the European Union, the quality of chemical fertilizers obtained from inorganic materials, by extraction or by chemical processes, is regulated at the level of each member state [8].
Although the reduction of fertilizers applied to crops is a general concern, the shortage of chemical fertilizers and the very high increase in their prices from 2023, caused the European Parliament to adopt a resolution that emphasizes their role in ensuring sufficient food production and quality. The resolution shows that despite the increase in the price of nitrogen-based fertilizers, by 149%, it is necessary to ensure the availability of all types of fertilizers to farmers, even in the short term, being essential for the food supply of EU citizens [6].
One reason for the reduction of the quantities of chemical fertilizers used in agriculture is the need to increase food safety [10], through the development of ecological agriculture, which in 2018 included a number of 10,000 operators [12].
Studies show that one of the causes of the inefficient use of chemical fertilizers is soil erosion, which along with the loss of soil particles caused by the slope of the land, wind and water also carries away the applied chemical fertilizers [11].

In this context, the purpose of this study is to analyze an indicator of fertilization, i.e. the expenditures, a very important factor in the process, that very much influences the quantity of fertilizers applied and also their quality.

MATERIALS AND METHODS

The indicators used to analyze the use of chemical fertilizers were: chemical fertilizers N, P, K expressed in kg of active substance per hectare of agricultural land (kg a.s./ha), and their structure ; fertilization expenditures per hectare of agricultural land (euro/ha); the share of chemical fertilizer expenditures in the total of inputs at the level of the agricultural holding; expenditures with chemical fertilizers to obtain 100 euros of vegetable production.

To determine the degree of dispersion of the indicators over the analyzed period, the coefficient of variation was used, calculated as follows: Cvar (%) = (Standard deviation/Average) *100

To find out the trend of the analyzed indicators, the annual growth rhythm was used calculated with the formula: Growth rhythm (%) = ((geomean (analyzed period)-1) *100. To determine the significance of the difference between the calculated averages, the t-test was used, the interpretation of which was for probabilities of 95%, 99% and 99.9% (t cal>t theoretical)[9].

RESULTS AND DISCUSSIONS

Comparative analysis of the areas of agricultural holdings, by economic size classes, at the level of Romania for the periods 2007-2013 and 2014-2021

The 2023-2027 PAC Plan for Romania emphasizes the reduced consumption of nitrogen fertilizers in Romania since 2018, of 40.3 kg N/ha, compared to the EU 28 average - 77.2 kg N/ha [7].

Table 1. The quantitative and structural evolution of chemical fertilizers used in Romania during the period 1990-2021

Nutrient	MU	1990	1995	2000	2010	2015	2020	2021	Average	St Dev	C(%)	Rhythm(%)
Nitrogen N (total)	thousands to	765	233	239	306	357	469	539	415	191.6	46.1	-5.7
	%	63.1	64.1	78.6	63.6	67.1	63.5	58.4	65	6.3	9.7	-1.3
Phosphate P_2O_5 (total)	thousands to	313	127	56	123	133	188	266	172	89.7	52.1	-2.7
	%	25.8	34.9	18.4	25.7	24.9	25.4	28.8	26	4.9	18.8	1.8
Potash K2O (total)	thousands to	134	3	9	52	43	82	118	63	50.8	80.6	-2.1
	%	11.1	0.9	3.0	10.7	8.0	11.1	12.8	8	4.6	55.4	2.5
Total nutrient	thousands to	1,213	363	304	481	533	738	922	651	327.3	50.3	-4.5
	%	100.0	100.0	100.0	100.0	100.0	100.0	100.0	X	x	x	x

Source: Own calculation on the basis of data from FADN PUBLIC DATABASE SO (europa.eu) [3].

As can be seen in Table 1, the fertilizers quantities used in Romania have many variations in the period 1990-2021 (CV%=46.1%), in evolution and also in their structure. Thus, if in the year 1990, from fertilizer with N a.s., 765 thousand tons were administered (63.1% of the total), in 1995 the quantity decreased to 233 thousand tons (64.1%), later increasing over the years to 306 thousand tons in 2010 (63.6%) and up to 539 thousand tons in 2021 (58.4%).

The fertilizer P_2 O_5 also records large variations throughout the analyzed period (c% = 52.1%), from 313 thousand tons in 1990 to 56 thousand tons in 2000, gradually reaching 266 thousand tons by the end of the period. In the structure of fertilizers, it occupies about a quarter.

The third active substance studied, K_2O, varies over the years between 3 thousand tons and 118 thousand tons in 2021, in the structure occupying weights between 0.9% and 12.8%.

The variation in the amount of fertilizers is closely related to the areas of crops, the expenditures involved in their purchase and administration, and the regulations in force.

Table 2. Evolution of agricultural surfaces in agricultural holdings, in Romania, by classes of economic size, for the period 2007-2013

Economic size classes/MU	2007	2009	2011	2013	Average	St Dev	C(%)	Rhythm
	Ha	Ha	Ha	Ha	Ha	Ha	%	%
(1) 2,000 - < 8,000 EURO	4.1	4.3	4.3	3.6	4.1	0.3	8.2	-2.0
(2) 8,000 - < 25,000 EURO	13.0	11.4	13.1	9.5	11.6	1.6	13.8	-5.0
(3) 25,000 - < 50,000 EURO	48.2	47.1	53.9	37.4	46.2	7.3	15.7	-4.1
(4) 50,000 - < 100,000 EURO	122.9	133.4	138.2	95.6	118.3	20.4	17.2	-4.1
(5) 100,000 - < 500,000 EURO	444.6	440.8	443.6	327.0	410.7	58.2	14.2	-5.0
(6) >= 500,000 EURO	1,554.2	1,375.2	1,411.6	1,253.3	1,415.5	143.0	10.1	-3.5

Source: Own calculation on the basis of data from FADN PUBLIC DATABASE (europa.eu) [3].
(SE025) Total Utilized Agricultural Area (ha)

Table 2 shows the evolution of agricultural areas in agricultural holdings in Romania for the period 2007-2013, from where it can be seen that in the first class, the areas vary slightly around 4.1 ha, the second class has an average variation (CV% =13.8%), with a downward trend, from 13 ha to 9.5 ha in 2013. In the third class of economic size, holdings have decreasing surfaces, the biggest decrease is observed between 2011 and 2013, from 53.9 ha to 37.4 ha. Superior economic size classes, 4,5 and 6, also have important variations, (CV% = middle variation), thus for class 4 the area decreases from 122.9 ha to 95.6 ha, for class 5 the area decreases from 444.6 ha to 327 ha, and in class 6 the area decreases from 1,554.2 ha to 1,253.3 ha.

For all classes of economic size, in the period 2007-2013, the surfaces of agricultural holdings had a decreasing tendency.

Table 3. Evolution of agricultural surfaces in agricultural holdings, in Romania, by economic size classes, for the period 2014-2021

Economic size classes/MU	2014	2016	2018	2019	2021	Average	Deviation	St Dev	C%	Rhythm
	Ha	Ha	Ha	Ha	Ha	Ha	Ha	Ha	%	%
(1) 2,000 - < 8,000 EURO	3.5	3.5	4.5	4.6	4.5	4.0	-0.1	0.6	14.1	4.0
(2) 8,000 - < 25,000 EURO	10.6	9.0	11.6	11.7	12.4	10.7	-0.9	1.6	14.5	2.2
(3) 25,000 - < 50,000 EURO	39.9	31.8	33.1	33.4	33.8	33.8	-12.5	2.7	7.9	-2.3
(4) 50,000 - < 100,000 EURO	97.7	88.9	76.9	76.6	77.7	83.5	-34.8	7.8	9.4	-3.2
(5) 100,000 - < 500,000 EUR	328.1	305.2	282.7	283.1	285.3	297.8	-113.0	17.9	6.0	-2.0
(6) >= 500,000 EURO	1,241.2	1,259.3	1,208.9	1,178.8	1,139.5	1,204.2	-211.3	44.6	3.7	-1.2

Source: Own calculation on the basis of data from FADN PUBLIC DATABASE (europa.eu) [3].

The same evolution was also analyzed in table 3, but taking the data from the period 2014-2021, where, as the data shows, in some classes, the surface areas of holdings increased.

Thus, for class 1, from 2014 until 2021, the area increased from 3.5 ha to 4.5 ha, with an annual rhythm of 4%, for class two the area increased from 10.6 ha to 12.4 ha, with an annual rhythm of 2.2%.

For classes 3, 4, 5 and 6, however, the trend is downward, with annual rhythms between -1.2% and 3.2%.

Thus, at the end of the period for class 3, the area reached 33.8 ha from 39.9 ha, for class 4 to 77.7 ha from 97.7 ha (a decrease by 20 ha), for class 5 the decrease of was even higher, from 328.1 ha to 285.3 ha, and for class 6, the decrease is from 1,241.2 ha to 1,139.5 ha, a decrease of over 100 ha.

We can say that for the small classes of economic size (1 and 2) the areas increased slightly, while for the medium and superior classes of economic size, significant decreases are registered.

Fig. 1. The agricultural surfaces evolution in agricultural holdings, in Romania, by economic size classes, for the periods 2007-2013 and 2014-2021
Source: Own calculation on the basis of data from FADN PUBLIC DATABASE[3]

Table 4. The deviations significance of the agricultural holdings surfaces, by economic size classes, in Romania, for the periods 2007-2013 and 2014-2021

Economic size classes/MU	P1(2007-2013)	P2(2014-2021)	Deviation (P2 vs P1)		Signif.
	Ha	€/ha	€/ha	%	
(1) 2,000 - < 8,000 EUR	4.1	4.0	-0.1	96.9268	N
(2) 8,000 - < 25,000 EUR	11.6	10.7	-0.9	91.92386	N
(3) 25,000 - < 50,000 EUR	46.2	33.8	-12.5	73.07074	***
(4) 50,000 - < 100,000 EUR	118.3	83.5	-34.8	70.60725	***
(5) 100,000 - < 500,000 EUR	410.7	297.8	-113.0	72.4985	***
(6) >= EUR 500,000	1,415.5	1,204.2	-211.3	85.0702	**

Source: Own calculation on the basis of data from FADN PUBLIC DATABASE (europa.eu) [3].

Based on the analyzes undertaken in Tables 2 and 3, we calculated in Table 4 the deviations of the agricultural surfaces for the two periods and their significance, from which it can be seen that for the first two classes the deviations are insignificant, while for classes 3, 4 and 5 the deviations are very significant and for class 6, the deviation is distinctly significant. These significances once again underline the major differences between the two analyzed periods, in the medium and large economic size classes.

Comparative analysis of the main technical and economic indicators of the use of chemical fertilizers in agricultural holdings, by economic size, classes at the level of Romania for the periods 2007-2013 and 2014-2021

Analysis of expenditures per hectare of agricultural land with chemical fertilizers

The following tables show the expenditure with fertilizers per hectare of agricultural land, in evolution, for each economic size class. For the period 2007-2013, the variations are medium for the first 5 classes and large for the 6th class (CV%= 23.3%).

Expenditures per ha are increasing, from 43.52 euros/ha in 2007 to 61.98 euros/ha in 2013, for class 1, from 42.63 euros/ha to 63.69 euros/ha in 2013, for class 2 and from 41.08 euros/ha to 61.96 euros/ha for class 3 of economic size.

Table 5. Evolution of expenditure per hectare of agricultural land with chemical fertilizers, at the level of Romania, by economic size classes, for the period 2007-2013

Economic size classes/MU	2007	2009	2011	2013	Average	St Dev	C%	Rhythm
	€/ha	€/ha	€/ha	€/ha	€/ha	€/ha	%	%
(1) 2,000 - < 8,000 EURO	43.52	47.42	59.16	61.98	53.9	6.6	12.2	6.1
(2) 8,000 - < 25,000 EURO	42.63	49.12	58.35	63.69	55.0	7.4	13.5	6.9
(3) 25,000 - < 50,000 EURO	41.08	50.46	59.77	61.96	54.0	7.4	13.8	7.1
(4) 50,000 - < 100,000 EURO	64.53	46.55	67.55	71.00	61.3	9.1	14.8	1.6
(5) 100,000 - < 500,000 EURO	50.57	62.39	79.12	86.08	69.8	12.9	18.5	9.3
(6) >= 500,000 EURO	49.89	74.70	88.76	109.54	81.4	18.9	23.3	14.0

Source: Own calculation on the basis of data from FADN PUBLIC DATABASE (europa.eu) [3].

For the higher classes of economic size, the expenditure with fertilizers per 1 ha are higher, in class 4, they start from 64.53 euros/ha in 2007 and reach 71 euros/ha in 2013, this class having the lowest annual growth rhythm, 1.6%, while in the other classes the rhythm is between 6.1% and even 14% for class 6. In class 5, expenditures increase a lot over the years, from 50.57 euros/ha, they reach 86.08 euros/ha in 2013, and for class 6, they even exceed double the value in 2007, from 49.89 euros/ha to 109.54 euros/ha.

Table 6. Evolution of expenditure per hectare of agricultural surface with chemical fertilizers, at the level of Romania, by economic size classes, for the period 2014-2021

	2014	2016	2018	2020	2021	Average	A2-A1	St Dev	C%	Rhythm
Economic size classes/MU	€/ha	€/ha	€/ha	€/ha	€/ha	€/ha	€/ha	€/ha	%	%
(1) 2,000 - < 8,000 EURO	64.74	79.71	79.46	79.25	98.90	78.9	25.0	9.4	11.9	6.2
(2) 8,000 - < 25,000 EURO	64.88	82.87	73.17	72.98	90.53	75.7	20.7	7.7	10.2	4.9
(3) 25,000 - < 50,000 EURO	63.60	83.56	68.32	65.51	82.30	70.2	16.2	8.1	11.5	3.8
(4) 50,000 - < 100,000 EURO	70.61	85.53	70.13	69.54	84.36	75.7	14.3	6.8	9.0	2.6
(5) 100,000 - < 500,000 EURO	83.62	102.25	88.09	83.32	103.41	91.1	21.3	8.2	8.9	3.1
(6) >= 500,000 EURO	100.43	100.54	93.57	90.61	108.01	98.7	17.4	6.8	6.9	1.0

Source: Own calculation on the basis of data from FADN PUBLIC DATABASE (europa.eu) [3].

In the second analyzed period, 2014-2021, the variations are medium and even small, and the annual growth rhythms of chemical fertilizers are more moderate, compared to the first period. While the highest growth rhythms in the first period were in the upper classes of economic size, in the period 2014-2021, they are in the lower classes of economic size.

Thus, in class (1) 2,000 - < 8,000 euro, the expenditures per ha with chemical fertilizers increased, from 64.74 euros/ha to 98.9 euros/ha, the variation of the years being average (c%=11, 9%) and the growth rhythm of 6.2%. In class (2) 8,000 - < 25,000 euro, expenditures increased from 64.88 euro/ha to 90.53 euro/ha, with an average variation and an annual growth rhythm of 4.9%. In class (3) 25,000 - < 50,000 euro, expenditures increased from 63.6 euros/ha to 82.3 euros/ha, the variation being an average one (c% 11.5%) and the annual growth rhythm of 3.8%. Starting with class (4) 50,000 - < 100,000 euro, the value of the coefficient of variation is lower and lower, as is the annual growth rhythm. Expenditures per ha increase from 70.61 euro/ha in 2014 to 84.36 euro/ha in 2021 for class (4), from 83.62 euro/ha to 103.41 euro/ha for class (5) 100,000 - < 500,000 euro and from 100.43 euro/ha to 108 euro/ha for class (6) >= 500,000 euro, for the same years. Regarding the significance of the deviations of the expenditures with chemical fertilizers per hectare of agricultural land between the two studied periods, it can be seen from Table 7 that for the first two classes the deviations are very significant, for classes 3, 4 and 5 they are distinctly significant and for the class 6, the deviation is significant.

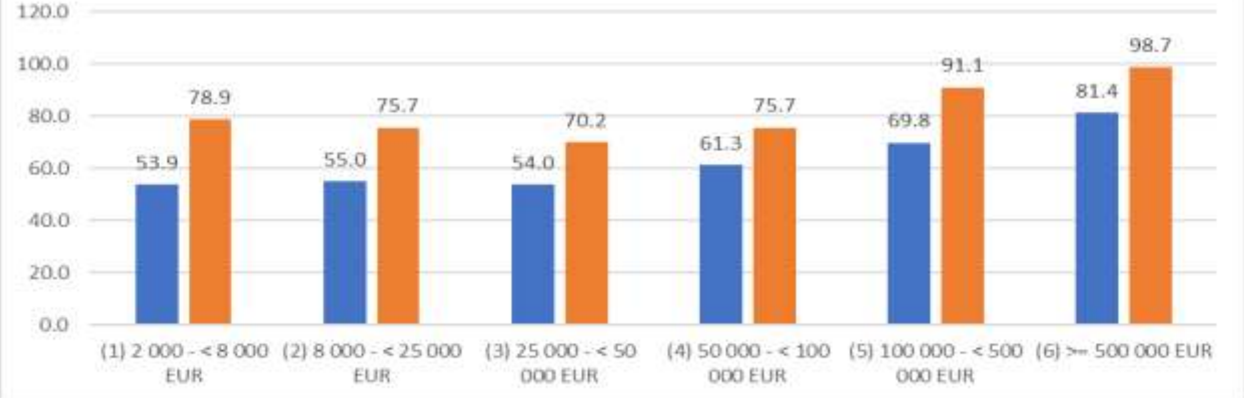

Fig. 2. The evolution of expenditures per hectare of agricultural land with chemical fertilizers, at Romania's level, by economic size classes, for the periods 2007-2013 and 2014-2021

Source: Own calculation on the basis of data from FADN PUBLIC DATABASE [3].

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Table 7. The deviations significance of expenditures with chemical fertilizers per hectare of agricultural land, Romania's level, by economic size classes, for the periods 2007-2013 and 2014-2021

	P1 (2007-2013)	P2 (2014-2021)	Deviation (P2 vs P1)		Signif.
Economic size classes/MU	€/ha	€/ha	€/ha	%	
(1) 2,000 - < 8,000 EURO	53.9	78.9	25.0	146.3359	***
(2) 8,000 - < 25,000 EURO	55.0	75.7	20.7	137.5477	***
(3) 25,000 - < 50,000 EURO	54.0	70.2	16.2	130.0517	**
(4) 50,000 - < 100,000 EURO	61.3	75.7	14.3	123.3433	**
(5) 100,000 - < 500,000 EURO	69.8	91.1	21.3	130.5045	**
(6) >= 500,000 EURO	81.4	98.7	17.4	121.3848	*

Source: Own calculation on the basis of data from FADN PUBLIC DATABASE (europa.eu) [3].

Analysis of the expenditures with chemical fertilizers to obtain 100 euros of plant production

The analysis of chemical fertilizer expenditures is completed with the analysis of the two periods, 2007-2013 and 2014-2021, reporting the expenditures for obtaining 100 euros of vegetable production, by classes of economic size.

Table 8. Theexpendituresevolution with chemical fertilizers to obtain 100 euros of vegetal production, at Romania's level, by economic size classes, for the period 2007-2013

	2007	2009	2011	2013	Average	StDev	C%	Rhythm
Economic size classes/MU	€/€100	€/€100	€/€100	€/€100	€/€100	€/€100	%	%
(1) 2,000 - < 8,000 EURO	6.04	7.26	7.75	7.65	7.3	0.6	8.5	4.0
(2) 8,000 - < 25,000 EURO	5.60	7.30	7.79	7.58	7.1	0.8	11.2	5.2
(3) 25,000 - < 50,000 EURO	7.25	9.38	8.50	9.09	8.5	0.9	10.8	3.8
(4) 50,000 - < 100,000 EURO	14.74	10.45	10.40	10.09	10.8	1.8	16.6	-6.1
(5) 100,000 - < 500,000 EURO	11.07	13.48	11.02	12.18	12.0	0.9	7.6	1.6
(6) >= 500,000 EURO	12.52	15.78	11.04	13.83	12.4	1.9	15.2	1.7

Source: Own calculation on the basis of data from FADN PUBLIC DATABASE (europa.eu) [3].

From the analyse made in Table 8, regarding the period 2007-2013, it can be seen that for class 1, fertilizer expenditures increased from 6 euros to 7.65 euros for obtaining 100 euros of vegetable production, the variation is small, 8.5%, and the annual growth rhythm is 4%.

In class 2, the growth rhythm is slightly higher, 5.2%, and the average variation, 11.2%, from 5.6 euros in 2007 to 7.58 euros in 2013. In class 3, in 2013 it reached 9.09 euros/100 euros of vegetable production, the variation being average, 10.8%. In class 4, a significant decrease in expenditures can be observed, from 14.74 euros to 10 euros/100 euros of plant production, with a variation of 16.6% and a growth rhythm of -6.1%.

In the last classes, 5 and 6, the growth rhythms are low, in class 5 in 2013, 12.18 euros were spent and in class 6, 13.83 euros were spent, still lower values than in 2009.

Table 9. The evolution of expenditures with chemical fertilizers to obtain 100 euros of plant production, at the level of Romania, by economic size classes, for the period 2014-2021

	2014	2016	2018	2020	2021	Average	M2-M1	StDev	C%	Rhythm
Economic size classes/MU	€/€100	€/€100	€/€100	€/€100	€/€100	€/€100	€/€100	€/€100	%	%
(1) 2,000 - < 8,000 EURO	8.31	10.50	9.02	8.37	8.72	9.1	1.8	0.9	10.4	0.7
(2) 8,000 - < 25,000 EURO	8.66	11.18	8.49	8.92	8.98	9.2	2.1	1.0	10.5	0.5
(3) 25,000 - < 50,000 EURO	9.76	12.59	9.07	9.51	9.48	9.9	1.4	1.3	13.0	-0.4
(4) 50,000 - < 100,000 EURO	11.18	12.57	9.93	10.41	9.35	10.8	0.0	1.3	12.1	-2.5
(5) 100,000 - < 500,000 EURO	12.07	13.88	10.88	12.57	10.09	11.9	-0.1	1.4	12.1	-2.5
(6) >= 500,000 EURO	12.58	12.34	11.31	13.67	9.98	12.0	-0.4	1.3	11.0	-3.3

Source: Own calculation on the basis of data from FADN PUBLIC DATABASE SO (europa.eu) [3].

The 2014-2021 period is much more stable, with much smaller differences per year, the growth rhythms are very low and in classes 3-6 even negative.

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The coefficient of variation indicates for all classes of economic size average variations, close to the lower limit of the threshold.
In class 1 in 2021, the amount of expenditures is 8.72 euros/100 euros of plant production, in class 2 of 8.98 euros/100 euros of plant production, in class 3, 9.48 euros and in class 4, 9.35 euros, so for the first classes the values oscillate around 9 euros spent for 100 euros of vegetable production. For grades 5 and 6, the values in 2021 are 10 euros and 9.98 euros/100 euros respectively, much lower values compared to previous years, when 13.88 euros/100 euros were reached in 2016 for class 5 and 13.67 euro/100 euros in 2020 in class 6.

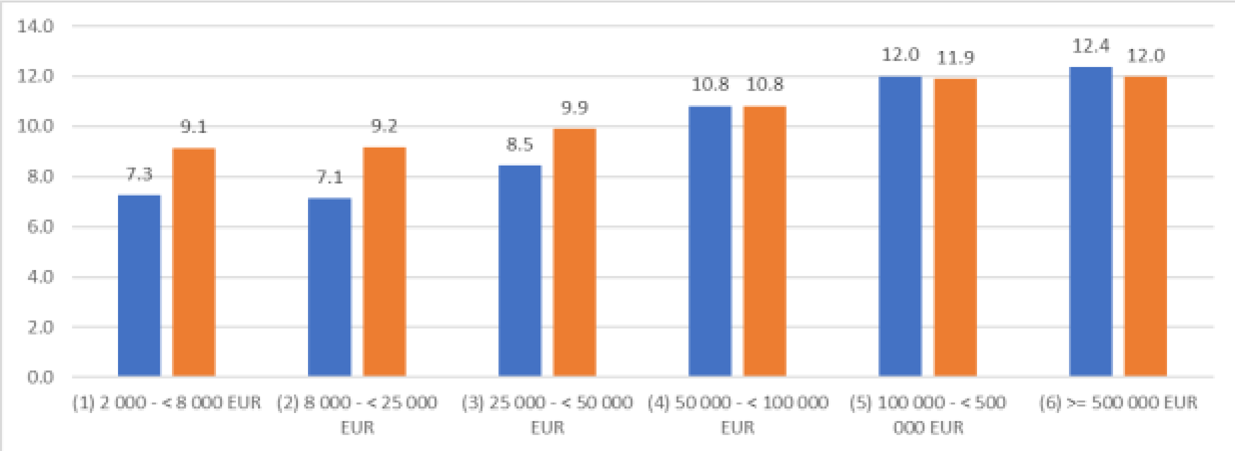

Fig. 3. The evolution of expenditures with chemical fertilizers to obtain 100 euros of plant production, at the level of Romania, by economic size classes, for the periods 2007-2013 and 2014-2021
Source: Own calculation on the basis of data from FADN PUBLIC DATABASE [3].

Table 10. The deviationssignificance of the expenditures with chemical fertilizers to obtain 100 euros of plant production, by economic size classes, in Romania between the period 2007-2013 and 2014-2021

Economic size classes/MU	P1(2007-2013)	P2(2014-2021)	Deviation (P2 vs P1)		Signif.
	€/€100	€/€100	€/€100	%	
(1) 2,000 - < 8,000 EURO	7.3	9.1	1.8	125.41	***
(2) 8,000 - < 25,000 EURO	7.1	9.2	2.1	128.86	***
(3) 25,000 - < 50,000 EURO	8.5	9.9	1.4	117.06	*
(4) 50,000 - < 100,000 EURO	10.8	10.8	0.0	100.00	N
(5) 100,000 - < 500,000 EURO	12.0	11.9	-0.1	99.01	N
(6) >= 500,000 EURO	12.4	12.0	-0.4	96.87	N

Source: Own calculation on the basis of data from FADN PUBLIC DATABASE SO (europa.eu) [3].

Table 10 shows the significance of the deviations of chemical fertilizer expenditures to obtain 100 euros of plant production, between the period 2007-2013 and 2014-2021. For classes 1 and 2 the deviations are very significant, for class 3 significant and for classes 4,5 and 6 they are insignificant.

CONCLUSIONS

From this research, the following conclusions were drawn:
-From 2019, according to Regulation 1009, in the European Union the quality of chemical fertilizers obtained from inorganic materials, by extraction or by chemical processes is regulated at the level of each member state.
-In recent decades, many attempts have been made in order to reduce more and more the quantity of chemical fertilizers applied per ha, due to the influence that is very negative for the soil and for the production'squality. However, the necessity to provide for farmers chemical fertilizers is recognized, which plays a very important role in ensuring food security.
-The total amount of fertilizers administered in Romania varies a lot in the period 1990-2021, from 1,213 thousand tons in 1990, to 304 thousand tons in 2000 and to 922 thousand tons in 2021.
-Analyzing the areas of holdings by economic size classes, it is observed that in the period 2007-2013, they had a decreasing trend, and

for the period 2014-2021 in the small economic size classes (1 and 2) they increased, over time what for the medium and superior classes of economic size, the areas suffered important decreases.

-The analysis of surface deviations over the two time periods revealed major differences in the medium and large economic size classes.

-From the analysis of expenditures with chemical fertilizers per hectare of agricultural land, very large increases can be observed in the first period, especially in the superior classes of economic size, while in the period 2014-2021, the largest increases in the expenditures are in the classes 1, 2 and 3. Expenditures per ha in 2021 are between 82.3 euros and 108 euros, depending on the economic size class.

-From the analysis of the expenditures with chemical fertilizers to obtain 100 euros of vegetable production, increases in the expenditures in the first period are observed, climbing on each step of the economic classes, and increases in classes over the years, especially in classes 1, 2 and 3, with the exception of class 4, where expenditures decreased by more than 4.6 euros/100 euros of vegetable production. In the second period, although there are increases in the dynamics of the years, they are much smaller in classes 1 and 2, and even significant decreases in classes 3-6. These smaller variations in expenditure are necessary for a balance between cultivated areas, crops and the output obtained.

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ASSESSMENT OF THE INFLUENCE OF NEOINDUSTRIALIZATION FACTORS ON THE SUSTAINABLE DEVELOPMENT OF THE RUSSIA AGRICULTURAL SECTOR

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Abstract

The article examines the factors of neo-industrialization and their impact on the functioning of Russian agriculture. The purpose of the work is to identify the key factors of neo-industrialization and assess their impact on the sustainable development of agriculture. The scale of technological changes has been studied, and a comparative analysis of neo-industrial trends in various sectors of the agro-industrial complex has been carried out. The specifics of neo-industrial processes in livestock farming are characterized in detail. A mathematical model of three-factor linear regression has been developed, characterizing the influence of parameters of technological development of Russian agriculture on changes in gross value added. The results of the empirical analysis allow us to conclude that there is a direct relationship between capital-labor ratio and gross value added, as well as between the number of highly productive workers and gross value added. It has been calculated that the investment component has the greatest influence. Thus, the increase in the share of investments in reconstruction and modernization in fixed capital affects the increase in gross value added by 223.7 billion rubles. The practical value of the results lies in the development of mechanisms to stimulate and support the introduction of innovations in agricultural production in order to accelerate neo-industrialization.

Key words: *neo-industrialization, factor analysis, investments, R&D, agricultural sector of the economy, gross value added, organizational and economic mechanism*

INTRODUCTION

In the context of global challenges, the growth of agricultural production and gross domestic product is based on the creation of an innovation and investment model of the agricultural sector that meets the challenges of neo-industrialization. In modern conditions, the task of assessing technological development and prospects for sustainable economic growth in agriculture and other sectors of the agro-industrial complex is becoming more urgent [1, 9]. In the research of domestic and foreign scientists, a stable idea has been formed of neo-industrialization as a process of development of productive forces, ensuring the creation of a fundamentally new scientific, technical and high-tech basis based on automation and computerization of the production process, taking into account balanced technological, socio-economic and environmental development [6, 27].

The effect of the neo-industrialization mechanism is the multiplicative growth of production and increased labor productivity in value chains [24].

The policy of neo-industrialization is aimed at creating conditions for increasing the efficiency of the knowledge-intensive and high-tech sector of the economy and implementing program solutions both for the modernization of main industries and the development of new industries in accordance with the requirements of scientific and technical progress [4, 22].

It is expected that the introduction of one of the breakthrough technologies of artificial intelligence will double the production volumes of the leading countries of the world by 2025 [10].

The strategic action plan in the field of high technologies, as a key direction of Germany's neo-industrialization policy, aims to achieve economic growth and improve the quality of life based on the formation of an innovative environment with the construction of industry 4.0. The key areas are the digitalization of science, education and living conditions [15].

In the UK, the neo-industrialization strategy is aimed at increasing the efficiency of resource use, optimizing production processes based on biotechnology; creation of innovative products based on composite materials; increasing the sustainability of value chains [21].

The neo-industrial concept of China's economy is focused on modernizing agriculture and developing the social sector [28].

The challenges of neo-industrialization are associated with changes in priorities in the hierarchy of competitiveness factors. The introduction of innovations and new knowledge leads to the growth of highly qualified personnel with higher education, an increase in the share of knowledge-intensive industries, and an increase in the output of innovative products, an increase in the scale of production and the development of digital skills of the workforce [7, 16]. Some authors explore the mechanisms of commercial interaction between industrial enterprises, considering such cooperation as one of the most important factors of structural changes in the labor market [8]. H. Kroll., R. Neuhausler identified factors of technological development and presented their contribution to increasing production efficiency [13]. For the Russian economy, the most important areas of transition to neo-industrialization are intersectoral interaction in value chains and the problem of updating the fixed capital of infrastructure sectors [17, 20, 29]. The scientific works of A.I. Tatarkin contain conceptual approaches to the formation of high-tech areas of economic activity and the modernization of traditional industries [25]. It should be noted that there is significant interregional differentiation in the production and use of innovative products, which results in a lack of demand for scientific research results and low capitalization of scientific developments [11,14]. To assess factors and identify neo-industrialization trends, it is recommended to use indicators of technological modernization, human capital, and inter-industry interaction [2, 26]. Positive trends in neo-industrialization are reflected in a stable increase in gross value added, innovative products, growth in labor productivity, growth in capital-labor ratio and capital-labor ratio [18, 19, 23].In developed countries, indicators of capital-labor ratio and capital-labor ratio are a constant object of research and monitoring in order to take appropriate measures of state regulation of innovation activity [3]. To measure labor productivity, the following indicators are used: GDP per hour worked and total factor productivity as the ratio of output to inputs of labor and fixed capital. If the growth of total factor productivity is significantly lower than the growth rate of labor productivity, this indicates a low level of use of innovations and advanced production technologies [12].

The purpose of the work is to identify the key factors of neo-industrialization and assess their impact on the sustainable development of agriculture.

MATERIALS AND METHODS

The methodological basis of the study was the regulatory documents of foreign countries, Russia, open statistical data from Rosstat, the National Research University Higher School of Economics, the Ministry of Agriculture of the Russian Federation, as well as regulatory documents and periodicals.

The conditions and factors of neo-industrialization have been scientifically substantiated, a comparative analysis of non-industrialization trends for various types of economic activity has been carried out, the profile of neo-industrialization of the agricultural sector has been identified, and the key factors of neo-industrialization that contribute to the growth of gross added value have been identified.

The study puts forward a hypothesis: The growth of gross value added occurs due to innovative structural changes as a consequence of technological development. This hypothesis is confirmed by the results of regression analysis, which revealed a positive relationship between the dynamics of gross added value of agriculture and individual indicators of technological development characterizing the process of neo-industrialization.

RESULTS AND DISCUSSIONS

The agricultural sector of the Russian economy has a high level of resource and scientific potential necessary to achieve a scientific and technological breakthrough and ensure national security. The innovative scenario for the development of agriculture involves the wide spread use of resource-saving technologies and biotechnologies in agriculture, covering about 50% of the arable area. According to experts from the Ministry of Agriculture, about 30% of agricultural producers can use precision farming systems, multi-operational agricultural machines and tools, and also regulate high yields and animal productivity. In livestock farming, the main directions of technological development are related to the development of regional models of organic livestock and poultry farming for the production of products with specified quality parameters; introduction of a breeding system form and aging livestock genetic resources; development of complete feed mixtures with new nutritional properties; application of aerospace digital technologies in pasture farming [5].

Table 1 presents the ranking of factors necessary for the successful implementation of innovative new generation technologies.

Table 1. Assessment of the main factors for the introduction of innovative technologies in livestock farming, % of the total number of respondents.

MainFactors	Innovativetechnologies	
	Development of complete feed mixtures with new nutritional properties	Application of aerospace digital technologies in grazing livestock
Employeetraining	7.6	7.6
Development of material and technical base and infrastructure of science	6.2	7.0
Increased government funding	5.8	6.2
Raising business funds	7.1	7.0
Protection of intellectual property rights	6.5	6.6
Support for international cooperation	4.6	5.7

Source: Own calculations based on data [5].

The scale of neo-industrialization of the economy is characterized by the share of products from high-tech and knowledge-intensive industries in the gross domestic product (Fig. 1).

The dynamics of the indicator in the analyzed period were characterized by significant fluctuations: the highest values were achieved in 2020. This situation is associated with underfunding and insufficient government support for the development of high-tech and knowledge-intensive industries: the level of investment in R&D in the high-tech segment of the Russian economy was about 1% in 2022, and the level of patent activity decreased compared to 2021 by 13 percentage points.

The main indicator of sustainable development of the economy and individual industries is gross value added.

Comparison of this indicator for various sectors of the economy for 2012-2022. showed higher growth rates in agriculture (106.7% compared to 2021); in the economy as a whole there was a drop to 98.7% (Fig. 2).

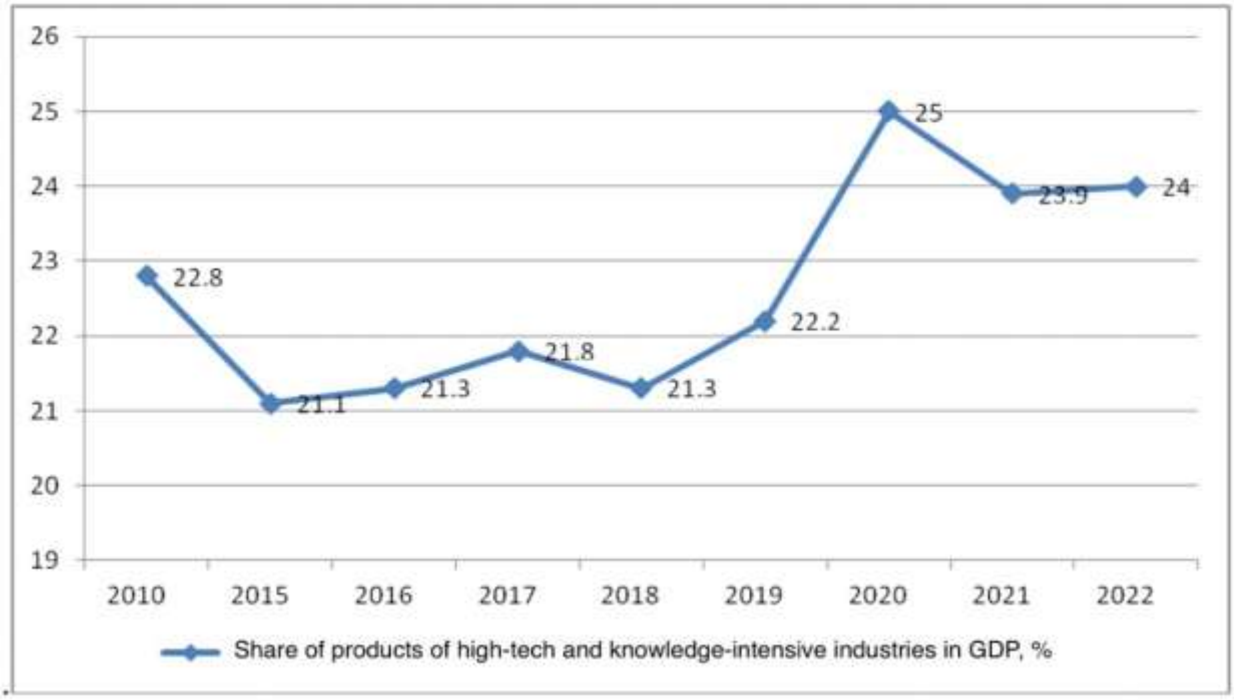

Fig. 1 Share of products from high-tech and knowledge-intensive industries in Russia's gross domestic product, %
Source: Own calculations based on data [5].

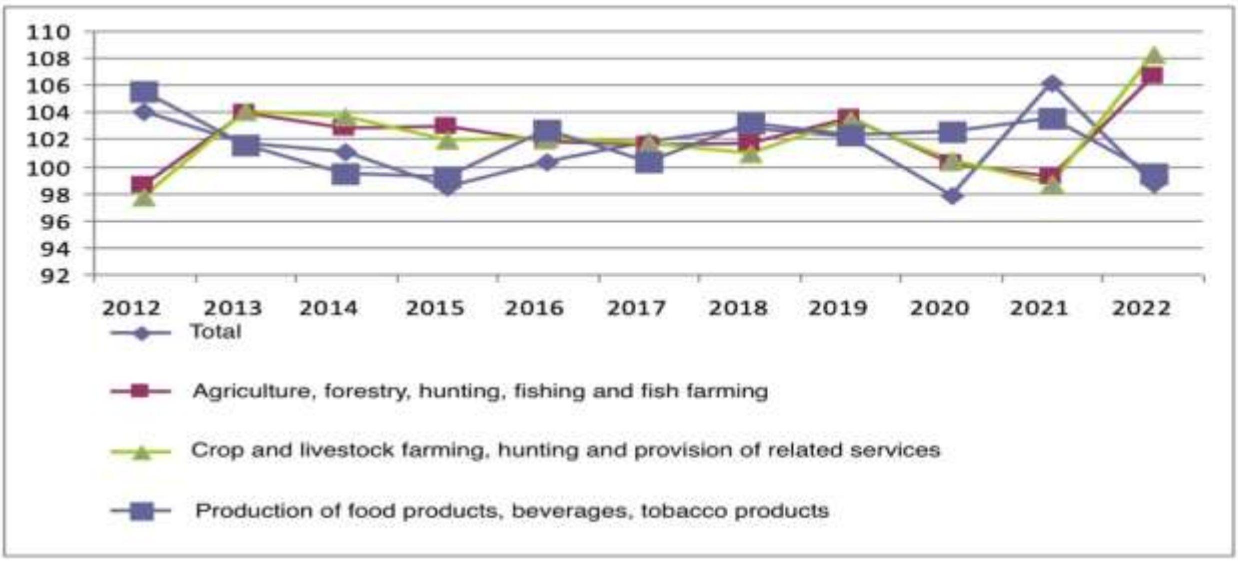

Fig. 2. Indices of physical volume of gross value added by economic sectors, %
Source: Own calculations based on data [5].

To identify the key factors of neo-industrialization, a number of indicators of technological development were used (Table 2).

In the analyzed period, the number of highly productive jobs in agriculture increased significantly (176.1%), which contributed to the rapid growth of production volumes of innovative goods (438.8%).

During the study, the following hypothesis was implemented: the growth of gross added value is realized through the growth of gross added value and structural changes, which justifies the acceleration of the process of neo-industrialization.

To confirm this hypothesis, a relationship was identified between the dynamics of gross value added in agriculture and individual indicators of technological development characterizing the process of agrarian neo-industrialization.

Table 2. Main indicators of neoindustrialization of Russian agriculture

Indicators	2017	2018	2019	2020	2021	2022	2022 as%of 2017
Number of highly productive jobs, thousand units.	438.8	516.6	593.8	653.5	704.2	772.6	176.1
Gross value added, billion rubles. at current prices*	2,896.8	3,101.3	3,390.6	3,811.0	45,490.1	5,317.3	183.6
Share of investments aimed at reconstruction and modernization in the total volume of investments in fixed assets, %*	10.3	9.2	6.3	6.0	7.1	7.3	70.9
Share of investments in machinery, equipment, vehicles in the total volume of investments in fixed capital aimed at reconstruction and modernization %*	12.9	20.3	17.1	19.0	18.4	14.3	110.9
Availability of fixed production assets at full accounting value, billion rubles.	5,791.6	6,462.3	6,575.3	6,908.5	8,006.3	8,502.7	146.8
Volume of innovative goods, works, services, million rubles.	28,446.0	33,829.1	69,559.2	57,832.9	67,339.5	124,824.1	438.8

Source: Own calculations based on data [5].

During the research, a mathematical model of three-factor linear regression was built, characterizing the influence of the parameters of technological development of Russian agriculture on changes in gross value added:

$$Y= -3,810.2+0.546 \quad X1+9.184 \quad X2+223.7 \quad X3 \qquad (1)$$

R^2= 0.94;

where:

Y –gross added value of agriculture, billion rubles.

X1 – capital-labor ratio in agriculture (the ratio of the average annual cost of fixed assets to the average number of workers), thousand rubles.

X2 – number of highly productive jobs in agriculture, thousand units.

X3 –share of investments aimed at reconstruction and modernization in the total volume of investments in fixed capital, %

The coefficient of determination R2 indicates a high degree of connection between the function and the independent variables being studied, which confirms the significance of the developed model.

The database is presented with open statistical data for 2017-2022 on gross value added and indicators of innovative and technological development.

The results of the empirical analysis allow us to conclude that there is a direct relationship between capital-labor ratio and gross value added, as well as between the number of highly productive workers and gross value added.

It has been calculated that the investment component has the greatest influence.

Thus, an increase in the share of investments in the reconstruction and modernization of fixed capital affects the increase in gross value added by 223.7 billion rubles.

The organizational and economic conditions for the development of neo-industrialization of the agricultural sector are associated with institutional transformations, government participation and the development of innovation infrastructure.

CONCLUSIONS

Theoretical and methodological approaches to identifying the most important factors of neo-industrialization are substantiated and an assessment of their impact on the sustainable development of the agricultural sector is presented.

During the research, the following hypothesis was implemented: the growth of gross value added occurs due to innovative structural changes, which reflects the process of neo-industrialization. To confirm the hypothesis put forward, the relationship between the influence of innovative and technological factors on the dynamics of gross value added was assessed. An empirical assessment of the scientific and technological development of agriculture in the context of branches of the agro-industrial complex was carried out. A typical profile of neo-industrial development in livestock farming has been constructed.A mathematical model of three-factor linear regression has been constructed to characterize the influence of the parameters of technological development of Russian agriculture on changes in gross value added. The calculations show that with an increase in the capital-labor ratio by 1 thousand rubles. the gross added value of agriculture also increases by 0.546 billion rubles, and with an increase in the number of highly productive jobs - by 1 thousand units. the increase in gross value added will amount to RUB 9.184 billion.

The results of the empirical analysis allow us to conclude that there is a direct relationship between capital-labor ratio and gross value added, as well as between the number of highly productive workers and gross value added. It has been calculated that the investment component has the greatest influence. Thus, the increase in the share of investments in reconstruction and modernization in fixed capital affects the increase in gross value added by 223.7 billion rubles. The practical value of the results lies in the development of mechanisms to stimulate and support the introduction of innovations in agricultural production in order to accelerate neo-industrialization.

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CHEMICAL FERTILISER AND PESTICIDE USAGE PREFERENCES IN AVOCADO PRODUCTION FARMS: A CASE OF ANTALYA PROVINCE, TÜRKİYE

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Abstract

Avocado cultivation holds substantial economic significance within tropical fruit production, prompting this research to investigate farmers' attitudes and behaviours concerning fertiliser and pesticide usage. Data were gathered through a survey conducted across 75 avocado farms in the Antalya districts of Alanya, Manavgat, Aksu, and Gazipaşa. The results highlighted that the primary challenge faced in chemical fertiliser use was predominantly due to high fertiliser prices (90.7%). Additionally, 76% of respondents expressed their intent to increase fertiliser application, given sufficient economic resources. However, only 25.3% of producers agreed that augmenting fertiliser usage would enhance yields. Regarding pesticide disposal methods, most growers disposed of pesticide packages through burning (60%), while nearly half of them identified collecting and reusing as the optimal approach for pesticide packaging disposal. The majority of producers acknowledge the detrimental environmental impact of excessive chemical usage. Nonetheless, their persistent use of these chemicals and improper disposal methods for leftover chemicals and packaging reveal inadequate awareness of environmental concerns. Similar to fertilisation, issues about agricultural pesticide supply were predominantly centred on the exorbitant rise in prices (94.7%), followed by inadequate spraying equipment (6.7%) and insufficient credit for pesticide procurement (5.3%). Consequently, providing financial support through incentive programmes, subsidies, or low-interest loan opportunities is imperative to mitigate costs associated with fertiliser and pesticide purchases. Simultaneously, developing environmentally conscious agricultural policies, reinforced by legal regulations, is crucial for monitoring and controlling the use of fertilisers and pesticides.

Key words: *avocado, fertiliser, pesticide, preference, production, Türkiye*

INTRODUCTION

Fruit farming is an essential branch of agricultural activity as it provides the necessary vitamins and minerals for healthy nutrition and adds value and export income to the country's economy. To obtain more products per unit area in agricultural production, an effective defence against diseases and pests with fertilisation is an inevitable necessity. Fruit farming should use as much fertiliser as necessary to maximise output; excessive use will raise costs and lower product quality. For this reason, it is imperative to fertilise at the proper moment and dose. In the same way, appropriate action should be taken if diseases and pests result in losses with a financial impact. Agricultural control (cultural, physical, biological, chemical, biotechnological, and integrated control) will greatly reduce yield losses using the proper techniques for pest and disease factors [8]. However, despite the increase in agricultural productivity and total production, the excessive use of intensive production techniques and chemical substances causes significant social, economic, environmental, and ecological problems such as soil erosion, pollution of underground and surface waters, and destruction of natural life. Additionally, intensive use of pesticides against pests causes pests to gain more resistance to these pesticides, thus increasing production costs due to more pesticides [4]. Uncontrolled input practices in agriculture have made farmers reliant on fertilisers and pesticides while also turning the industry that produces and trades these products into a significant problem sector [10]. It is crucial to think about how agricultural products that provide human nutrition are produced and how sensitive the producers are to the environment and human health while producing them, given the adverse effects of intensive agriculture on the environment and human health. Obtaining, assimilating, and applying the correct agricultural information on the farm are all critical issues in the safe use of chemical fertilisers and pesticides.

The amount of input used in agriculture can be said to be low in Türkiye. When compared to developed countries, the use of fertilisers and pesticides per unit area is seen as insufficient. Pesticide use per area of cropland is 2.32 kg in Türkiye, 2.05 kg in Australia, 2.54 kg in the United States of America (USA), 3.44 kg in France, 4.05 kg in Germany, and 10.82 kg in the Netherlands. In terms of pesticide use per capita, Australia is 2.49 kg/cap, Canada is 2.09 kg/cap, Ecuador is 1.93 kg/cap, and Brazil is 1.77 kg/cap. Türkiye is slightly above the world average (0.37 kg/cap) with 0.64 kg/cap [11]. Regarding fertiliser use per area of cropland, it is 126.63 kg/ha in Türkiye, while in developed countries such as Germany, it is 160.51 kg/ha, France is 159.96 kg/ha, the USA is 124.04 kg/ha, and Australia is 83.33 kg/ha. The most fertiliser used in the world is in Kuwait at 641.89 kg/ha, Taiwan at 468.59 kg/ha, Bahrain at 433.61 kg/ha, and Ireland at 412.29 kg/ha. The highest fertiliser use per capita is in New Zealand (188.62 kg/cap), Ireland (140.57 kg/cap), Canada (134.1 kg/cap), Uruguay (118.35 kg/cap), and Lithuania (115.68 kg/cap). Türkiye uses 34.75 kg of fertiliser per capita, which is higher than the global average (25.72 kg/cap) [11]. However, despite Türkiye’s low use of fertilisers and pesticides relative to its land area, intensive farming is practiced in some regions, such as the Mediterranean and Aegean, where there is a high use of fertilisers and pesticides. Therefore, the production activities in these areas need to be evaluated within this framework. Significant contributions could be made in terms of the economy and the ecosystem as a result of avoiding the potential overuse of inputs. In this regard, it is crucial to analyse how pesticides and fertilisers are used during farming.

Considering the detrimental effects of intensive agriculture on the environment and human health is crucial. Therefore, it is essential to pay attention to how agricultural products that contribute to human nutrition are produced and how environmentally friendly the production process is. Fruits play a pivotal role in human nutrition, and avocado stands out compared to other fruits due to its distinctive nutritional profile. It is rich in fat and protein while containing very little sugar. Avocado’s fat-soluble components, including vitamins and unsaturated fatty acids present in the fruit matrix, make it unique [9]. Avocado offers several health benefits related to cardiovascular health, weight management, and healthy ageing, as well as protection against DNA damage and osteoarthritis, promoting eye and skin health, and even cancer prevention [6]. The popularity of avocados has risen among those who desire a healthy diet and lifestyle, resulting in a notable increase in demand, growth, and exports over the past two decades.

The avocado (*Persea Americana*) is a tropical fruit native to North, South, and Central America [13]. Avocado cultivation began commercially in 1911 with the contributions of the ‘Fuerte’ variety from Mexico to California in the USA. Since then, avocado production has witnessed a remarkable global surge, especially with the help of countries such as the USA, Chile, Spain, Indonesia, Israel, and Australia [7, 14]. According to the Food and Agriculture Organization of the United Nations (FAO) [11], production has tripled, rising from 2.7 million metric tonnes in 2000 to 8.7 million metric tonnes in 2021. Furthermore, the harvested area has expanded from 329 thousand ha to 858 thousand ha during the same period (Figure 1). Mexico stands as the largest producer of avocados, accounting for over 28% of global production, with a capacity of 2.4 million metric tonnes in 2021. Following Mexico, notable producers include Colombia (11.3%), Peru (8.9%), and Indonesia (7.7%) [11].

Türkiye began avocado cultivation in the 1970s with the introduction of varieties such as "Fuerte, Hass, Bacon, and Zutano" by researchers. These varieties were later developed in provinces such as Antalya, Muğla, Mersin, and Adana, which have ideal growth conditions for avocados [3]. Avocado production is now concentrated along Türkiye's Mediterranean coast, particularly in Antalya, which is the leading city in avocado production (23,338 metric tonnes), accounting for 83.2% of the total capacity in 2022. Mersin (16,556 metric tonnes) comes in second with 14.7%, while Muğla (140 metric tonnes) is responsible for only 1.4% of the total avocado production. Production is conducted on 2,498 ha in Antalya and 669 ha in Mersin when it comes to the total orchard area. With 356 ha of orchards, the province of Adana comes in third. Regarding yield values, Mersin ranks first with 147 kg per number of fruit-bearing trees, followed by Antalya with 80 kg per number of fruit-bearing trees, and Hatay with 57 kg per number of fruit-bearing trees. It is evident that when considering yield data, Mersin surpasses Antalya, despite the latter having a larger planted area and greater production volume [15]. The most commonly cultivated varieties in Türkiye include Bacon, Hass, Zutano, Fuerte, Pinkerton, Ettinger, and Wurtz [3].

Türkiye's avocado production experienced modest growth until 2006 but has increased significantly since then. Annual production reached 492 metric tonnes in 2006 and has grown nearly eighty-twofold in the last fifteen years, reaching 40,181 metric tonnes in 2022. Furthermore, the total area of land dedicated to avocado orchards has increased from 73.6 ha in 2006 to 27,282 ha in 2022 [11].

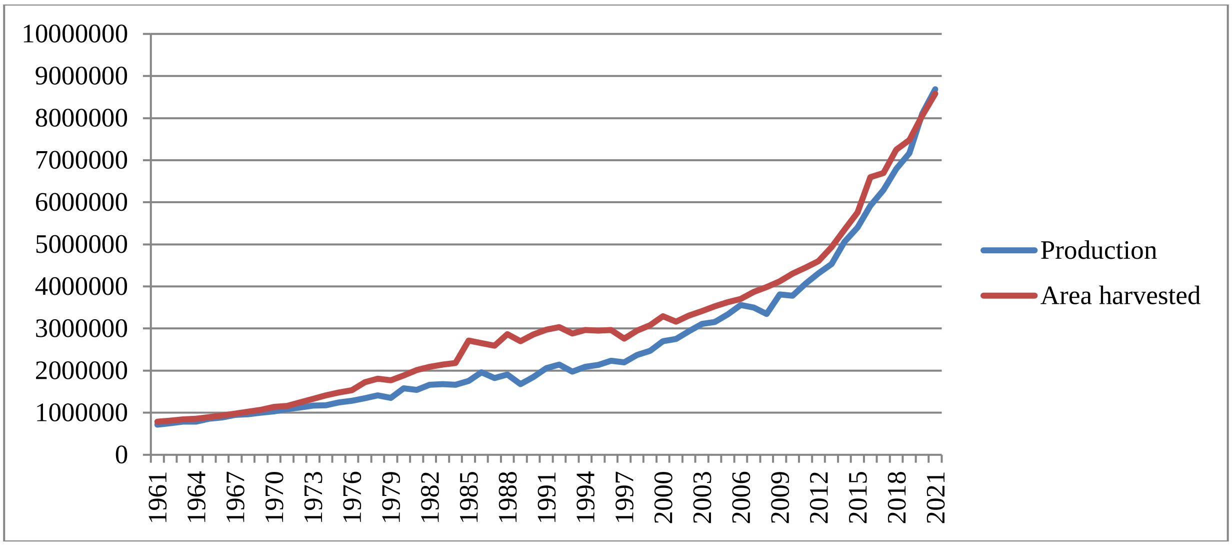

Fig. 1. Avocado production amount (tonnes) and harvested area (da) in the world (1961-2021)
Source: [11].

Regarding the avocado trade in the world, according to FAO [11], Mexico emerged as the top exporting country of avocados, with exports totalling 1.2 million metric tonnes. Peru followed closely with 542 thousand metric tonnes, while the Netherlands, Spain, and Chile exported 415, 141, and 98 thousand metric tonnes, respectively. As the largest importing country, the USA imported 1.2 million metric tonnes. Interestingly, the Netherlands imported 457 thousand metric tonnes in 2021. It is noteworthy that the Netherlands exported significantly despite its lack of avocado production. Türkiye, on the other hand, was a net importer, with export and import quantities of 505 and 6,368 metric tonnes, respectively. In Türkiye, the average yield of avocado cultivation stands at 3.3 tonnes per hectare, which is lower than that of prominent producer countries like Indonesia and Mexico. Notably, El Salvador boasts the highest yield at 34 tonnes per hectare, followed by Samoa (30 tonnes/ha) and Panama (27.7 tonnes/ha).

When examining global data, it becomes evident that Türkiye's yield value is remarkably lower than that of leading countries. From a regional perspective, this trend is observed in Antalya when compared to other major cities. Therefore, it is expected to be highly beneficial for the avocado sector to determine the awareness and preferences of producers regarding fertilisers and pesticides. This information can help enhance the productivity of both Türkiye's and Antalya's avocado yields. This study aims to ascertain the fertiliser and pesticide preferences of avocado producers in Antalya province based on their environmental awareness and information sources. Avocado cultivation is an economically significant tropical fruit production, and this research also seeks to uncover the attitudes and behaviours of farmers towards the use of fertilisers and pesticides. The data was collected from farms where avocado cultivation was carried out intensively, and the findings will shed light on the farmers' practices. In this regard, the study aims to address knowledge gaps and offer valuable insights to avocado farmers and policymakers.

MATERIALS AND METHODS

The data used in this study are primary data gathered by the survey method from avocado farms in the Antalya districts of Alanya, Manavgat, Aksu, and Gazipaşa. The survey data spans the production years 2021–2022.
The first section of the questionnaire addressed the producers' socio-demographic characteristics, the fertilisers used and their usage patterns, the locations where the fertiliser is supplied, the fertiliser preference, the factors that are effective in deciding on fertilisation, and so on. Questions about pesticide use were included in the second section of the questionnaire.
In the research area, 3,119 avocado producers were found to be registered in the Farmer Registration System. The number of farms to be surveyed was determined using the Simple Random Sampling Method [5]. The formula for the method is:

$$N = \frac{n * \sigma^2}{(n-1) * D^2 * \sigma^2} \qquad (1)$$

In the formula,
N: Sample size
n: Number of farms in the population
σ^2: Population variance
D^2: $(d/t)^2$, where d denotes a certain deviation from the mean (10%) and t represents the t table value (1.96), which corresponds to the 90% confidence limit.
In light of this information, the number of farms to be surveyed was computed using the formula in equation (1) as 75, with a 90% confidence limit and a 10% margin of error. The data collected from farmers through surveys was analysed using MS Excel and SPSS 26.0 programmes, and tables were constructed and interpreted. Furthermore, the Food and Agriculture Organization of the United Nations [11], the Turkish Statistical Institute [15], and numerous scientific papers were employed in the study.

RESULTS AND DISCUSSIONS

Descriptive Statistics

In this section, the characteristics of the farmers, such as age, gender, education level, agricultural experience, and avocado farming experience, are discussed. According to the research results, it was determined that all of the producers participating in the study from the research area were male, ranging from 28 to 65, with an average of 42.5. When the distribution of the 75 participants was examined by age range, it was determined that 37.20% were fewer than 40. Additionally, 46.7% of them were between 40 and 49, while the remaining 16.10% were 50 and older. Regarding the educational status of the participants, it was found that 36.80% were primary school graduates, 41.90% had completed secondary school, 19.28% were high school graduates, and 2.02% held university degrees. Most participants had completed secondary school, indicating a concentration of education at this level.
It was determined that the producers had a minimum of one year and a maximum of 32 years of agricultural experience, with an average of 9.8 years of experience. In addition to avocados, these producers engage in various other farming activities, including the

cultivation of tomatoes, peppers, cucumbers, olives, kumquats, bananas, oranges, beekeeping, and small ruminant husbandry. Many of these ancillary activities are carried out on separate land plots distinct from their avocado orchards. It was observed that producers who grow kumquats and oranges alongside avocados often combine these products within the same orchards. This is due to the similar climate requirements of avocados and citrus fruits, leading many citrus producers to cultivate avocados alongside their citrus crops and vice versa. The producers were also asked about their total land holdings. The land availability among these producers ranged from a minimum of one decare (da) to a maximum of 600 da. The average total land holding of them was 18.9 da. In the Antalya region, land parcels are typically relatively small, with a maximum of 10 parcels and a minimum of one parcel per farmer. The average number of parcels owned by the farmers was 1.6. Furthermore, the most preferred avocado variety among the surveyed producers was Hass, chosen by 32.4% of respondents. The second most preferred variety was Fuerte, selected by 22.06% of respondents, and the third one was Zutano, with 16.18% of respondents indicating their preference. It is important to mention that the Hass variety is the most popular avocado globally, as per the literature. This preference is attributed to the Hass variety's high yield, high fruit oil content, exceptional taste, and aroma, making it the most popular and widely exported variety internationally [3].

When examining the production of avocado varieties per da, the Fuerte variety ranks first with an average of 1280.6 kg/da, followed by the Zutano variety in second place with 1074.6 kg/da, and the Bacon variety in third place with 900.5 kg/da. However, it is seen that Hass variety production was 673.8 kg. It can be inferred that the larger fruit size of the Fuerte variety compared to other varieties causes the average kg per da to be high.

Fertiliser Use

Information about the fertiliser use of the surveyed producers is given in Table 1. According to the survey, animal manure was the most frequently employed fertiliser by producers, with a rate of 89.3%. Conversely, zinc (Zn), calcium (Ca), and phosphorus (P) reducers were the least utilised, with a mere 1.3% usage rate. Rooting agents were employed by 60% of the farmers to enhance root development, while humic acid and amino acids were adopted by only 2.7% and 9.3% of producers, respectively. Nitrogen (N) emerged as the predominant choice for promoting plant growth, with a rate of 56% among the respondents surveyed.

The farmers were asked about the purposes for which they used fertilisers, and the following trends emerged: 61.9% of those employing N indicated its usage for plant growth; 62.1% of P users cited its application for enhancing flowering; 60.7% of K users and all Ca users stated their preference for quality and taste enhancement. All producers who utilised iron (Fe) and trace elements reported their use for plant nutrition. A significant 95.5% of those employing animal manure indicated efficiency as their motivation. The majority of humic acid and rooting agent users specified rooting as their intended purpose. While 42.9% of amino acid users preferred rooting as their purpose, 14.3% mentioned its use for improving yield, quality, and taste. All of the producers employing leonardite confirmed its role as a soil conditioner. According to a survey conducted, it was observed that a maximum of 2.6 kg/da of N and 2.5 kg/da of P and K were applied, depending on the frequency of chemical fertiliser usage. Furthermore, 795.6 kg of animal manure was utilised per da, while leonardite, an organic substance, was applied at a rate of 237.3 kg/da.

When the producers were questioned about their fertiliser application practices, they all reported that they administered all types of fertiliser through irrigation, except animal manure, leonardite, and trace elements. While all producers uniformly applied animal manure and leonardite to the soil band, they also administered trace elements via foliar application. It was determined that the producers did not differentiate the types or quantities of fertiliser used among the different varieties in the orchards.

Table 1. Information about the fertiliser use

Qualification	Number of Farmers Using	Number of Usage	Average Usage Amount (kg/da)
Nitrogen (N)	42	239	2.6
Phosphorus (P)	29	86	2.5
Potassium (K)	28	86	2.5
Iron (Fe)	6	11	2.1
Animal Manure	67	86	795.6
Humic Acid	2	10	2.0
Rooter	45	460	2.2
Trace Element	16	80	1.0
Amino acid	7	28	1.3
Leonardite	11	11	237.3
Balanced Fertiliser	11	51	2.4
Manganese (Mn)	2	2	2.0

Source: Author's calculation.

When queried about whether the producers had conducted a soil analysis, the majority (65.3%) responded affirmatively. Among them, 25.3% performed it every six months, 24% did it annually, and 14.7% conducted it biennially. When questioned about why they had not conducted a soil analysis, the majority responded that they refrained due to a lack of concern (42.3%) or because they perceived it as costly (38.5%). The remaining farmers cited reasons such as distrust in the accuracy of soil analysis results, disbelief in its advantages, the perception of it being time-consuming, and a lack of knowledge regarding the procedural aspects.

When asked whether they had leaf analysis done, 56% of the producers who participated in the survey said no. Among them, the majority (39.4%) conducted leaf analysis annually, while 33.3% did it semi-annually and 27.3% biennially. Most producers responded that they refrained due to a lack of concern (35.7%); 26.2% of them stated that they perceived it as costly. It was determined that 14.3% of the producers thought that leaf analysis took a long time, and 7.1% of them said that there were no laboratories performing soil and leaf analysis in their region. The remaining farmers stated reasons such as doubt in the accuracy of leaf analysis data, mistrust about its benefits, and a lack of knowledge about where to apply. For the necessary conditions for soil and leaf analysis, 42.7% of producers believe that analyses should be completed more rapidly, while 32% opine that machines used for measuring soil nutrients should be provided to farmers free of charge. On the other hand, in a study conducted by Yilmaz et al. [18] in the same province of Türkiye, 72% of the producers reported that they had not conducted soil and crop analyses. Reasons provided included the absence of a laboratory in their district (43%), absence of positive outcomes from previous requests (11%), unrealistic recommendations (11%), lack of significance attributed to the issue (11%), and impossibility (9%).

When surveyed about the alterations in fertiliser usage concerning rising fertiliser prices and adjustments based on economic sufficiency, 84% of participating producers reported a reduction in fertiliser usage due to price increases. Additionally, 76% indicated their intention to increase fertiliser application, provided they had sufficient economic resources. Furthermore, the participants were questioned regarding their receipt of training in fertilisation techniques and their willingness to partake in a fertilisation course if one were arranged. 61.3% of the producers reported not having received any training in fertilisation techniques. Among those queried about their potential attendance, 50.7% expressed their intention to attend such a course if organised. When queried about visits by extension agents, the majority (54.7%) of producers indicated that extension agents had not visited them, while 36% reported being unfamiliar with the extension agents. Also, 96% of the producers stated that they are not members of a cooperative or non-governmental organisation.

Subsequently, they were asked about their methodology for determining the type of fertiliser they use. The findings revealed that 41.3% of the producers base their fertiliser choice on recommendations from agricultural engineers, 37.3% rely on suggestions from fertiliser dealers, and 34.7% make their decisions based on their knowledge and experience. Similarly, in a study carried out in the Thrace region [2], farmers primarily relied on the agricultural engineer (41.48%), followed by their own experience (37.79%) when deciding on fertiliser use. However, according to a study conducted in Isparta province, Türkiye, the most frequently used source for selecting the type of fertiliser (37.76%) was the producer's own knowledge and experience [17]. Moreover, Pandey and Diwan [12], in their study conducted within intensive agricultural regions in India, discovered that farmers predominantly rely on past experiences when applying fertilisers.

When the survey participants were asked about the challenges encountered in utilising chemical fertilisers, it was discovered that 90.7% of them faced issues attributable to high fertiliser prices. Besides, challenges such as insufficient credit for fertiliser procurement and inadequate regulatory oversight in the fertiliser sector were identified. Likewise, Yuzbasioglu [19], in a study conducted within the Tokat province of Türkiye, identified that the most prevalent issue faced by producers using chemical fertilisers was the escalation in fertiliser prices, accounting for 55.2%. This issue of price increases was followed by challenges such as low purchasing power, diminished product prices, and inadequate subsidies. Conversely, in the study conducted by Yilmaz et al. [18], producers highlighted various issues in order of priority during their interviews: expensive fertilisers used in drip irrigation (24%), bureaucratic hurdles in accessing fertiliser support (13%), insufficient information on fertiliser usage (11%), ineffective fertilisers (11%), lack of oversight in fertiliser sales and counterfeit products (10%), mistrust of dealers (6%), and reliance on foreign countries (1%).

All growers utilise drip irrigation systems, with an additional 2.7% employing mini-spring irrigation systems. Unlike in Mexico, the native region of avocados, furrow irrigation is seldom utilised by growers in the Antalya region. Growers favour drip irrigation systems due to avocados' vulnerability to fungal diseases and the inherent advantages that drip irrigation systems offer over other irrigation methods. The percentage of producers who express agreement (including both 'strongly agree' and 'agree') that increasing fertiliser usage would enhance yields stands at 25.3%. Meanwhile, 37.3% of growers indicated their indecision on the matter. When asked about the environmental impact of excessive fertiliser use, 60% of producers strongly agreed, with an additional 26.7% agreeing.

Pesticide Use

Today, as the adverse impacts of extensive and intensive chemical usage for pest control have become evident, research into the use of controlled pesticides has commenced. Nevertheless, it can be argued that the application of harmful chemicals persists at the producer level.

Since avocado is a relatively new crop in Türkiye, numerous pests do not yet recognise it, resulting in a lower pest population compared to other plants. Among the primary pests identified in the surveyed Antalya region are aphids, slugs, and grasshoppers. When questioned about the pesticides used to manage these pests, 96% of growers reported using copper (Cu) to control fungal diseases that may occur in avocado roots, 10.7% used pesticides for aphids, and 6.7% employed pesticides targeting snails. Surveyed producers were queried about their pesticide application methods, with all stating the utilisation of Cu through drip irrigation on plants and the application of aphids and slug pesticides using a backpack sprayer. When asked about the quantity of pesticides applied per da, it was found that producers applied a minimum of two kg and a maximum of three kg of Cu, averaging 2.3 kg per da. The average quantity used for aphids was determined to be 0.25 g, while for slugs, it was 1.25 kg.

The examination of the criteria employed by growers in determining their spraying practices revealed that 48% of growers applied spray treatments without prior observation of pests and diseases. Additionally, 30.7% of the growers reported reliance on recommendations provided by dealers, while 4% indicated adherence to suggestions offered by the technical staff of the Provincial/District Directorate of Agriculture. Contrarily, in Ates et al.'s [1] study on tomatoes in the Antalya province of Türkiye, the majority of growers (74.4%) applied pesticides upon observing disease symptoms.

When questioned about the sources they relied on for diagnosing diseases and pests, it was revealed that 37.3% of the producers conducted the diagnosis themselves. Another prevalent method employed by the producers for diagnosing diseases and pests was consulting pesticide dealers, which accounted for 40%. Moreover, a minority, 5.3% of the producers, sought a diagnosis from the technical staff of the Provincial/District Directorate of Agriculture. When queried about the sources they relied on for selecting pesticides, it was discovered that producers primarily chose pesticides based on recommendations from pesticide dealers (41.3%) and agricultural engineer consultants (41.3%). Additionally, 26.7% of the producers relied on their knowledge and experience for pesticide selection. A smaller percentage, 10.7%, based their pesticide choices on recommendations from Provincial/District Agriculture personnel, while 6.7% considered soil analysis results. Merely 1.3% of producers relied on information from written sources. According to the study conducted by Yilmaz et al. [17], the most frequently used sources for pesticide use were consulting an agricultural engineer (47.25%) and making decisions based on personal experience (29.97%).

The sources utilised by producers when adjusting pesticide doses are as follows: recommendations from agricultural engineer consultants (41.3%), suggestions from dealers (40%), reliance on their knowledge and experience (28.0%), recommendations from Provincial/District Agriculture personnel (10.7%), and consideration of soil analysis results (9.3%). However, upon analysing whether the recommended pesticide application doses were adhered to, it was found that 81.3% of the participating producers used pesticides below the recommended doses. When questioned about this during the survey, it was deduced that many producers generally applied pesticides slightly below the recommended doses due to escalating pesticide prices. In Ates et al.'s study [1], a substantial proportion of producers followed pesticide dosage instructions: 54.5% utilised the specified amounts on the package, and 25.6% exceeded the recommended doses, totalling 80.1%. Similarly, Yilmaz et al. [18] found that 59% of producers determined spraying doses based on pesticide label instructions, 58% relied on recommendations from pesticide dealers, and 17% used their own knowledge and experience. Moreover, 68% of producers applied the recommended dose precisely, while 32% disregarded the recommendations, with 12.5% increasing the dosage on average. Additionally, Wang and Liu [16] revealed that 61.9% of farmers interviewed in their study used pesticides at the recommended dose, while 21.9% exceeded the recommended dose. When asked, 'Will excessive use of pesticides in production damage the environment?' 94.7% of the producers responded affirmatively. Those who responded positively were further questioned about the perceived damages. It was revealed that 61.3% of them believed excessive pesticide use could lead to crop burning and reduced yields; 52% expressed concerns about harm to domestic and wild animals; and 33.3% anticipated the emergence of rust and stains on the products.

When surveyed about the disposal methods for unused pesticide packages, it was observed that the majority of responding growers disposed of pesticide packages through burning (60%), while 20% buried the packages in the ground post-spraying, and 12% irregularly discarded the packages into the environment. Despite these results, nearly half of the growers (49.3%) indicated that the optimal method for disposing of pesticide packaging was collecting and reusing it. Approximately 32% of respondents suggested that pesticide packaging should be regularly stored in appropriate environmental locations, while an additional 14.7% recommended burying it in the ground. Almost all producers (93.3%) confirmed having leftover or unused pesticides. When questioned about their storage practices for these pesticides, it was revealed that 74.2% stored them in warehouses and storage facilities, 22.6% utilised other storage areas, and 3.2% stored them at home. Upon analysing the issues encountered by the surveyed producers concerning the supply of agricultural pesticides, it was determined that the most prominent problem is the steep and rapid escalation in prices (94.7%), trailed by inadequate spraying equipment (6.7%) and insufficient credit for pesticide procurement (5.3%). Likewise, in Yilmaz et al.'s study [18], farmers identified the most significant issue (96%) related to pesticide use as the sharp and sudden rise in pesticide prices.

CONCLUSIONS

This study aims to understand the fertiliser and pesticide preferences of avocado producers in Antalya province, Türkiye, based on their environmental awareness and information sources. Avocado cultivation is an economically significant tropical fruit production, and this research seeks to uncover the attitudes and behaviours of farmers towards the use of fertilisers and pesticides. The data collected from avocado farms by the survey method in the Antalya districts of Alanya, Manavgat, Aksu, and Gazipaşa will shed light on the farmers' practices and offer valuable insights to avocado farmers and policymakers. The number of farms to be surveyed was determined using the Simple Random Sampling Method, and it was computed as 75.

According to the results, the most preferred avocado variety among the surveyed producers was Hass, chosen by 32.4% of respondents, similar to the rest of the world. It was seen that animal manure was the most frequently employed fertiliser by producers, with a rate of 89.3% when the most used fertiliser was examined. When questioned about their fertiliser application practices, all producers reported that they administered all types of fertiliser through irrigation, except animal manure, leonardite, and trace elements. Furthermore, it was observed that the percentage of those who stated that the amount of fertiliser used decreased with the price increase was 84%. At the same time, 76% indicated their intention to increase fertiliser application, provided they had sufficient economic resources. The difficulties encountered in the use of chemical fertilisers were mostly (90.7%) due to fertiliser prices. Besides, challenges such as insufficient credit for fertiliser procurement and inadequate regulatory oversight in the fertiliser sector were identified. 61.3% of the producers reported not having received any training in fertilisation techniques, and almost all farmers (96%) stated that they are not members of a cooperative or non-governmental organisation.

The percentage of producers who agree that increasing fertiliser usage would enhance yields is only 25.3%. Regarding the environmental impact of excessive fertiliser use, the majority of producers stated that excessive fertiliser use will negatively affect the environment.

Regarding the pesticides used to manage the pests, 96% of growers reported using Cu to control fungal diseases that may occur in avocado roots, 10.7% used pesticides for aphids, and 6.7% employed pesticides targeting snails. Also, producers stated the utilisation of Cu through drip irrigation on plants and the application of aphids and slug pesticides using a backpack sprayer.

When the disposal methods for unused pesticide packages were questioned, the majority of responding growers disposed of pesticide packages through burning (60%), while 20% buried the packages in the ground post-spraying, and 12% irregularly discarded the packages into the environment. Despite these practices, nearly half of the growers indicated that the optimal method for disposing of pesticide packaging was collecting and reusing it. Almost all producers (93.3%) confirmed having leftover or unused pesticides.

Finally, upon analysing the issues encountered by the surveyed producers concerning the supply of agricultural pesticides, it was determined that the most prominent problem is the steep escalation in prices (94.7%), followed by inadequate spraying equipment (6.7%) and insufficient credit for pesticide procurement (5.3%). Consequently, it is evident that the most critical issue is the high cost associated with purchasing fertilisers and pesticides. As a solution, providing financial support such as incentive programmes, subsidies, or low-interest loan opportunities to reduce costs in fertiliser and pesticide purchases may be useful in solving the rapidly increasing price problem that producers face most.

Most producers acknowledge the detrimental impact of excessive chemical usage on the environment. However, their continued use of these chemicals, coupled with inappropriate disposal methods for leftover chemicals and packaging, indicates an inadequate awareness of environmental concerns. This situation not only endangers their health but also poses risks to public health, environmental sustainability, and overall environmental well-being.

Furthermore, the research results underscore the significant role played by pesticide and fertiliser dealers within the agricultural information system in the region. Given that commercial organisations, such as pesticide dealers, primarily operate for profit, relying solely on these entities as the main source of information for producers is not advisable. Such reliance can render producers unable to safeguard their interests, forcing them into a passive role rather than an active one. To foster a more positive framework, this structure needs revision. Counselling services should provide producers with the necessary information while safeguarding their interests. Therefore, organising producers into cooperatives and empowering them to address issues through the employment of expert agricultural engineers is vital for effective and sustainable problem-solving. This approach not only resolves pesticide-related concerns within cooperatives but also tackles various other issues, particularly marketing challenges. Moreover, agricultural training programmes are instrumental in motivating producers to shoulder responsibility for environmental problems. Thus, increased producer awareness of the prudent use of fertilisers and pesticides leads to enhanced product yields with fewer inputs, ultimately reducing unit production costs. Training sessions for producers should continually emphasise the significance of soil and plant analyses in preventing excessive fertiliser use, as well as the necessity of integrated pest management practices during spraying.

Last but not least, the development of agricultural policies with an environmentally conscious approach, coupled with legal regulations, is essential to monitoring and controlling the use of fertilisers and pesticides. The knowledge gained could serve as a significant benchmark for future comparisons in Türkiye as well as assessments with other avocado-producing regions around the world.

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DYNAMICS OF FORMATION OF THE LABOUR MARKET AND EMPLOYMENT OF THE RURAL POPULATION OF UKRAINE: A CASE STUDY OF VINNYTSIA REGION

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Abstract

In the article, we conducted a study of the dynamics of the formation of the labor market and employment of the rural population based on the materials of the Vinnytsia region of Ukraine. According to the results of the research, we found that the presence of fully functioning agricultural enterprises and the size of their main and variable production assets are the dominant factors influencing the employment of peasants in Ukraine. In addition, a rather powerful factor influencing the formation of employment indicators of the rural population is the dynamics of the growth of the number of personal peasant farms, which form a fairly significant share of the gross domestic product of the agricultural sector of Ukraine. In the article, we substantiated that the dominant type of employment in rural areas of the Vinnytsia region of Ukraine is personal farms. In the article, we substantiated that in rural areas of Vinnytsia region, the specific weight of such rural population in 2020 was 74.5% of the total number of employed persons. It is important that employment in peasant farms according to the current legislative field of Ukraine is not an officially registered form of employment, therefore the rural population working in this field actually forms the shadow sector of the economy.

Key words**:** *rural population, personal peasant farms, rural areas, labour market, employment*

INTRODUCTION

Modern approaches to the specifics of the formation of labor resources are marked by the need to take into account many factors affecting the labor market. At the same time, if we also evaluate the issue of ensuring the employment of the rural population of Ukraine, then in the complex this issue becomes especially relevant. In addition, the importance of these issues is determined by the role that agriculture plays in the structure of the national economy of Ukraine. The need to ensure the sustainable development of rural areas and the effective use of labour resources in this sector is strategically vital for the country's economic stability and social growth, especially in the period of hostilities which affected the whole socio-economic system.

In practical terms, it is worth noting that one of the critical problems of sustainable development in rural regions of Ukraine is the need for more employment and economic activity in rural areas. This problem requires systematic government actions to increase productive employment since the development of individual regions and the country's overall economic growth depend on providing jobs and social protection for the rural population. At the same time, it is also essential to consider the dynamics of the formation of labour resources in connection with modern demographic trends, such as migration processes, changes in the distribution of the population by age groups, and the level of education and qualifications of employees. This makes it possible to correctly identify the development potential of the regions and determine the need to implement measures to improve qualifications and functional adaptation of the workforce to the needs of the modern labour market. In addition, in connection with technological progress and the introduction of new management methods in agricultural production, there is a need for reorientation of the workforce and the formation of skills necessary for working with modern agricultural technologies.

The study of the problems of the dynamics of the formation of labour resources and employment of the rural population of Ukraine is actively revealed in modern scientific research. In particular, it is worth noting the works of such scientists and practitioners as M. Dziamulyhch [1-8], A. Popescu [10-23], M. Rudenko [24], T. Shmatkovska [25-26], O. Shubalyi [27] and R. Sodoma [28], who focus on the analysis of demographic processes, the level of employment in the agricultural sector, and ensuring the effectiveness of employment policy. It should be noted that the dominant direction of research in this aspect is the determination of the principles on the basis of which the goals of sustainable development of rural areas will be achieved, as well as the formation of strategies for their socio-economic development under existing resource limitations. However, the dynamic changes taking place in the labor market, as well as the impact of a number of destructive factors on it, forces us to look for new approaches to regulating the employment of the rural population.

Therefore, the study of issues related to the processes of quality formation of labor resources, as well as solving problems in the field of employment of the rural population of Ukraine, is marked by urgency, which is due to the need to develop strategies for the development of rural regions and solve important socio-economic problems of the rural population. The study case regards Vinnytsia region of Ukraine.

MATERIALS AND METHODS

The rural population’s employment rate is the ratio of the employed rural population of working age to the entire rural population of the specified age or the rural population according to the relevant socio-demographic characteristics, including those employed in personal peasant farms.

We set the value of the interval for grouping according to the formula:

$$h = \frac{x_{max} - x_{min}}{n}; \qquad (1)$$

where:
h – interval value;
x_{max} – the maximum value of the grouping feature;
x_{min} is the minimum value of the grouping feature.

To determine the interdependence between factor and performance indicators, economic-mathematical modelling using the equation of linear multiple regression was applied:

$$Y_x = a_0 + a_1 x_1 + a_2 x_2 \qquad (2)$$

where: x_1, x_2 – factor indicators.

In the presented study, the period is limited to 2020 because, starting from the following years, official statistical materials on the economic situation in Ukraine were closed for free access due to the hostilities in the country.

RESULTS AND DISCUSSIONS

We grouped the districts of the Vinnytsia region of Ukraine according to the number of employed rural population. Based on the calculations, a grouping was carried out, according to which four groups of districts of the Vinnytsia region can be distinguished according to the level of employment of villagers. Accordingly, based on the calculated interval series, their distribution by employment level is presented in the following histogram (Fig. 1).

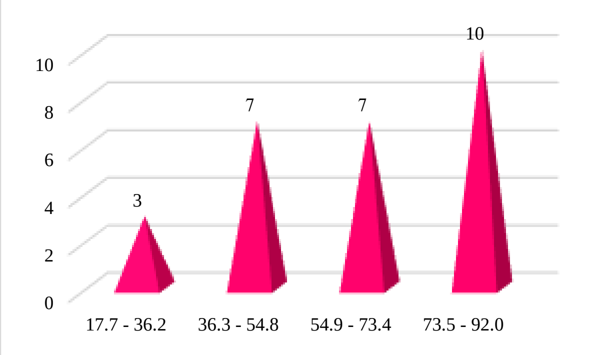

Fig. 1. Interval series of the distribution of districts of the Vinnytsia region of Ukraine by the rural population's employment level in 2020.
Source: own development.

According to the nature of the placement of the districts of the Vinnytsia region of Ukraine on the graph (Fig. 1), it is possible to distinguish their typical groups according to the formula:

$$n = 1 + 3.3221gN, \quad n \approx 4 \qquad (3)$$

where: n – number of groups.

The value of the interval for grouping according to the formula is set:

$$h = \frac{x_{max} - x_{min}}{n} = \frac{92.0 - 17.7}{4} = 18.5$$

....(4)

Based on the results of the calculations, we have developed a map of the grouping of districts of the Vinnytsia region of Ukraine according to the rural population's employment level in 2020 (Fig. 2).

Fig. 2. Cartogram according to the results of the grouping of districts of the Vinnytsia region of Ukraine in terms of the indicator of the level of employment of villagers in 2020, %
Source: own development.

According to the results of our analysis (Fig. 2), it was found that in the north and in the center of the region there is a higher level of employment of peasants. At the same time, in the south of the Vinnytsia region of Ukraine, the level of employment is relatively low and fluctuates mainly in the range of 36.3 - 54.8%, only in the Yampil, Kryzhopil, and

Trostianets districts it reaches 54.9 - 73.4%. We have calculated the indicators of aggregated data of effective grouping by summing the individual investigated characteristics by the number of districts of the Vinnytsia region of Ukraine, which comprise a separate group (Table 1).

Table 1. Results of the effective grouping of the districts of the Vinnytsia region of Ukraine in terms of the employment level of their rural population, 2020.

Indexes	Groups of districts according to the level of employment of the rural population				Total
	I	II	III	IV	
Limits of groups according to the level of employment of the rural population, %	17.7-36.2	36.3-54.8	54.9-73.4	73.5-92.0	X
Number of districts, units	3	7	7	10	27
Number of employed rural population, persons	6,529	59,960	92,961	133,898	293,347
The average registered number of employees employed in agricultural production, total number of persons	2,303	7,310	16,423	14,485	40,511
Produced gross agricultural products in comparative prices of 2012; thousand hryvnias	210,711	592,456	1,086,61 7	1,023,39 7	2,913,08 1
Agricultural land, thousand ha.	65.1	200.1	337.4	354.3	956.8
Number of enterprises, units	23	102	188	205	518
The cost of the primary means of production and working capital in agriculture, million hryvnias.	289.3	666.1	1,046	1,637.1	3,438.5

Source: own calculations are based on [29].

According to the grouping results, four main groups of districts were distinguished in terms of the rural population's employment level. The highest level of employment is observed in the districts belonging to the fourth group of Mohyliv-Podilskyi, Koziatin, Zhmerynka, Lypovets, Tyvriv, Tulchyn, Khmilnyk, Pohrebysche, and Haisyn. This is explained by the fact that there is the largest number of operating agricultural enterprises in these areas and the highest employment in personal peasant farms. In these districts, the employment rate 2020 was 92.0%, 91.8%, 89.1%, 88.9%, 84.7%, 82.1%, 81.7%, and 80.1%, respectively. 75.4%, 74.2%.

Based on the results of the research, we discovered and ascertained a rather dynamic development of rural employment in the studied region in Ukraine. In particular, in 2020, we identified certain trends regarding the reduction of employment of the rural population and the increase in the level of unemployment in the countryside.

According to the results of the analysis of the rural labor market at the regional level, we selected 10 districts of the Vinnytsia region of Ukraine, which, in our opinion, should be assigned to the fourth group, where mainly agricultural enterprises prevail, as well as actively functioning peasant farms.

In addition, the villages of these districts are located not far from the district or regional centres; the villagers have permanent jobs thanks to the developed industry for processing livestock and plant products. In the rest of the villages, people earn money for paid work at regional centres or abroad.

The main factors that affect the rural population's employment must be wages, labour productivity, land security of the rural population, labour resources, gross domestic product production per employed person, social and cultural working conditions, etc.

In this regard, we determined these indicators' interdependence with the rural population's employment level. We revealed the close connection between them using the coefficient of determination. We established the dependence of the level of employment in rural areas on the labor productivity indicator by 4%, on the indicator of labor capital equipment by 14.96%, on the indicator of the number of operating agricultural enterprises by 39.7%, on the indicator of the cost of the main production assets and working capital in agricultural enterprises by 40.85%.

With the help of correlation analysis, the relationship between the level of employment of the rural population in the districts of the Vinnytsia region of Ukraine and the number of operating agricultural enterprises, the cost of primary production, and the working capital in the agricultural enterprises of the studied area were revealed.

For this, an economic-mathematical equation was used, with the help of which the interdependence between the level of employment of the rural population and two-factor characteristics was measured using a linear equation of multiple regression:

$$Y_x = a_0+a_1x_1+a_2x_2 \quad (5)$$

where:

x_1 – number of active agricultural enterprises, units

x_2 – the value of the main production assets and working capital in agricultural enterprises, UAH million.

Thus, the multiple regression equation we obtained has the form:

$$X_{yx1x2} = 4.98+0.11x_1–0.04x_2 \quad (6)$$

The regression coefficient shows how the rural population's employment level will change when the corresponding factor changes by one unit. Thus, a_1=0.11 shows that when the number of operating agricultural enterprises in the district increases by one unit, the level of employment in the village increases by 11%, and when the cost of fixed and circulating production assets in agricultural enterprises decreases by 1 UAH. there will be an increase in the effective indicator by 4%. In addition to the regression equation, the relationship density is characterised by the correlation coefficient, which we determined by the formula:

$$R^2_{yx1x2} = \sqrt{\frac{r^2_{yx1} + r^2_{yx2} - 2r_{yx1}r_{yx2}r_{x1x2}}{1 - r^2_{x1x2}}} = 0.708$$
....(7)

and the coefficient of determination:

$$D = R^2_{yx1x2} \times 100\% = 0.708^2 \times 100\% = 50.2\%$$
....(8)

The correlation coefficient and the coefficient of determination must characterise the density of dependence between the studied indicators and their degree of influence on the effective indicator - the rural population's employment level.

According to the results of the study, it was established that the specific weight of persons older than working age in the total number of employed rural population of the Vinnytsia region of Ukraine grew from 20.7% in 2013 to 24.6% in 2015, followed by a decline until 2018 and only from In 2019, a trend towards an increase in the specific weight of employed persons older than working age was outlined (Fig. 3).

We found that the dominant type of employment in rural areas of the Vinnytsia region of Ukraine is private farms (PF). In rural areas of the Vinnytsia region, the share of such rural population in 2020 was 74.5% of the total number of employed persons.

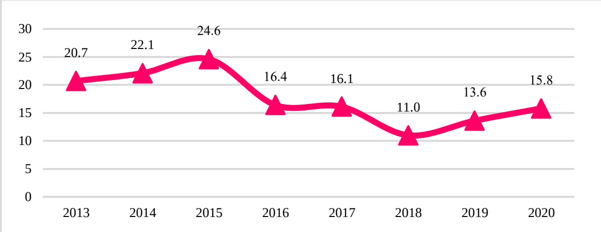

Fig. 3. The share of persons in the age group, older than working age, in the total number of employed rural population of the Vinnytsia region of Ukraine, 2013-2020, %

Source: own calculations.

It is important that employment in peasant farms according to the current legislative field of Ukraine is not an officially registered form of employment, therefore the rural population working in this field actually forms the shadow sector of the economy.

According to the Law of Ukraine «On Personal Peasant Households», members of personal peasant households belong to the employed population, provided that work for them in this household is the main one. Suppose the work for them on this farm is additional [9]. In that case, the members of the peasant farms, after being released from the primary job, are given the status of unemployed and the benefits they enjoy while in this status. According to this method, shadow (unregistered) employment is distributed to the rural population under the following conditions:

- if work in personal peasant farms is not the main one and brings income;
- if employees who are registered as unemployed in the state employment service receive unemployment benefits but work on peasant farms voluntarily,

Also, it is necessary to determine which work in peasant farms is the main one and which is additional, which will provide an opportunity to keep records of those employed in peasant farms more clearly.

The current law needs to develop a precise mechanism for entry and exit from peasant farms because personal peasant farms are subject to accounting as a specific economic activity, not those who run such farms. At the same time, it should be noted that such accounting is aimed at obtaining statistical information and is not the legal factor with which the law connects the creation or termination of the activities of peasant farms. The central executive body should approve the procedure for accounting of peasant farms for statistics.

In addition, we believe that the Law of Ukraine, "On Personal Peasant Farming," is quite relevant for the rural population and requires revisions regarding the status of the employed population and its registration. Also, village councils (local self-government bodies) must register personal farms and people employed on these farms and give them the appropriate status [9].

Since there is no official statistical data on the number of people employed in the rural population on personal farms, we used a questionnaire to determine the number of people employed in the shadow economy, namely, in peasant farms.

The conducted questionnaire survey, which included respondents in a total number of 4 thousand rural population of working age in the Vinnytsia region of Ukraine, showed that 92 persons, or 2.3% of the surveyed respondents, are employed in peasant farms voluntarily, receiving income and 20 persons or 0.5 % have the status of unemployed and are engaged in managing their peasant farms. Suppose the level of unregistered (shadow) employment of 2.8% obtained from the questionnaire survey is extended to the total working-age rural population in the studied region. In that case, the total number of people employed in the shadow economy in the Vinnytsia region of Ukraine is 13.6 thousand.

It is essential that the methodology and program of conducting random surveys of the population on economic activity (labour force survey), developed by the recommendations of the International Labour Organization (ILO), are not sufficiently perfect in Ukraine.

In Ukraine, over many years, a system has been formed that causes overemployment of the population, especially the female rural population. Scientific studies testify to rural women's significant contribution to the agricultural sphere's social production.

In addition, the low level of pension provision for persons of retirement age encourages these people to work in personal peasant farms to obtain additional means of livelihood, primarily food. Therefore, the rural labour market is characterised by the labour of pensioners and teenagers, the economically inactive population, because most of this population is engaged in seasonal work while cultivating crops, harvesting, etc.

Most of the population is employed on personal peasant farms, where labour costs are for about 3 hours and 45 minutes. Daily, those working here can be considered employed in social production, and their employment level should be determined according to the methodology following Ukrainian legislation, considering the recommendations we have proposed.

Suppose the level of unregistered (shadow) employment in peasant farms is added to the general indicator determined by us for the districts of the Vinnytsia region of Ukraine. In that case, we will get the rural population's general employment level according to the proposed methodology following domestic legislation, considering unregistered (shadow) employment in peasant farms (Fig. 4).

Fig. 4. Map of the grouping of districts of the Vinnytsia region of Ukraine according to the level of employment of the rural population in 2020, considering unregistered (shadow) employment in peasant farms
Source: own development.

According to the results of the analysis of the cartogram we received (Fig. 4), it was established that the highest level of employment according to the proposed method is observed in the Mohyliv-Podilskyi district, where the level of unregistered (shadow) employment is 2.8%, in Koziatyn – 1.2%, and in Lypovets – 3%, Zhmerynka – 2.8%, Tulchyn – 2.0%, Tyvriv – 2.8%, Khmilnyk – 2.2%, and the lowest – in Illintsi, Chechelnyk, Chernivtsi districts, where the level of unregistered (shadow) employment respectively, it was 0.5%; 3.3%; 3.0%. The main reason is the hidden employment in the countryside in personal farms.

At the same time, economic losses are losses for the state and the population since some peasants employed in personal peasant farms hide their incomes, receiving unemployment benefits from the state and income from activities on their farms. Regardless of the method of determining the rural population's employment level, the most significant economic losses occur in the Illintsi and Sharhorod districts of the studied region.

Thus, if in the Vinnytsia region of Ukraine, the level of employment in rural areas (in accordance with the current legislation of Ukraine) in 2020 was within the indicator of 70.3%, then this situation is due to employment in own peasant farms, where 42.9% of peasants are employed of the studied region of Ukraine.

CONCLUSIONS

We found that the presence of fully functioning agricultural enterprises and the size of their main and circulating production assets are the dominant factors influencing the employment of peasants in Ukraine. In addition, a rather powerful factor influencing the formation of employment indicators of the rural population is the dynamics of the growth of the number of personal peasant farms, which form a fairly significant share of the gross domestic product of the agricultural sector of Ukraine.

Economic losses are the region's gross domestic product production losses, traced to the hidden (shadow) sector, which could produce more regional output.

Thus, the most significant economic losses are observed in areas with the lowest employment level. In areas with the highest level of employment, economic losses are the smallest, which ultimately negatively affects the value of the gross domestic product of each region.

In this regard, one of the main tasks of the socio-economic development of rural areas should be a socially effective policy regulating the employment of the rural population.

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RESEARCH ON STAKEHOLDER ENGAGEMENT IN PROTECTING THE LOCAL BRAND AS A SUSTAINABLE DESTINATION

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Abstract

The main objective of the research is to identify the degree of involvement of several interested parties in protecting the local brand. In sustainable rural development, as well as in place branding, a challenge is the involvement of multiple stakeholders, especially the "unusual suspects". During the research, numerous other secondary objectives were achieved, and starting hypotheses were established, which are verified at the end of the article.Establishing the objective of the research falls within the current guidelines of the CAP in the agri-food sector, which aims to increase productivity from farm to fork. The study was carried out between March 2022 and October 2023, with questions regarding the involvement of interested parties (producers, local authorities, distributors, etc.) in protecting the local Măcin brand as a sustainable destination.The total sample was 93 interviewees, from which 15 resident specialists of the Dobrogea area, Măcin, Tulcea county were selected to answer the final objective of the study. This exploratory study addresses knowledge gaps through in-depth interviews with key professionals in Tulcea.The results suggest that the potential of the CramaMăcin brand of the destination can be negatively affected by a concentration of restrictive thinking, which prevents the introduction of innovation in the management of the place. Further quantitative research is needed to elaborate these findings in other cities to improve understanding of the uses and interpretations of local branding among stakeholders.

Key words: *branding, wine, rural development, Măcin, marketing local*

INTRODUCTION

The concept of branding has advanced more and more as a way of application from commercial centers, to areas, regions, and states. Practice has shown that the implementation of a brand requires multidisciplinarity on the part of specialists. For example, when we talk about the marking of products and services in parallel, it appears with the marking of producers, of the areas of origin [10], [8] of local tourism [16], [9], of the cities in the vicinity of the areas [5], [2].
In recent years, branding as a discipline has evolved in terms of communication and implementation, evidenced by an evolution of knowledge at different levels [11], [1] local authorities, tourism organizations, and the media.

Local marketing has evolved from what it means to the reputation of the area, to a strategic vision and focused product promotion [6], [7] [17]. Moreover, as the concept of "entrepreneurship" evolved into a business approach, branding emerged in terms of business perceptions and attitudes [12], based on people's experience of places [15], regardless of whether they were referring to an entire city or smaller areas [3].
Recently, branding experts have argued that there are parallels and gaps between brand management and destination management [19] [15].
These have been studied in his previous research [21] [22] which states that this multidisciplinarity can be developed through the establishment of public-private

partnerships and a more balanced approach to the management of a destination [14].

This study also follows research [23] on the management of a future tourist destination, regarding the links between local branding and regional planning for building a local brand, with a focus on professionals involved in managing partnerships.

The starting point of this study is the connections of recent works (Fig. 1) that trace the link between stakeholder theory and place branding [18] for creating destination brands using qualitative methods of target branding strategy, in creating a target image and a branding model. More and more cities and destinations see the importance of involving residents, business owners, and other important stakeholders; however, it is not always easy to execute and often the same people (the usual suspects) participate in participatory activities and take ownership of initiatives and projects, excluding others from doing the same [4].

As entrepreneurship emerged from the background of business management, so did place management marketing, so locality branding originally emerged from business branding [24].

The main objective of the article consists of identifying the degree of involvement of entrepreneurs in protecting the local Măcin brand as a sustainable destination. To achieve this objective, it is necessary to survey to identify the willingness of agricultural and food producers to form short chains, which is the main objective of the survey[8]. Along with this, the research aims at several objectives, presented below, in the form of O1-05.

O1 Determining the degree of involvement of entrepreneurs in the sustainable development of the community (questions 7, 13);

O2 Determining the availability of partners to develop wine businesses with the partner in the Măcin brand area (question 8);

O3 Determining the reasons why the partners choose to get involved in the development of the vineyard area (question 9, 12);

O4 Identification of partners' willingness to raise awareness of the qualities of the local brand and the wine-growing area (question 10, 14);

O5 Determining the reasons why partners recognize that a certain entrepreneurial and local culture can influence the consumption of certain brand products (question 11)

The assumptions from which the research started are presented for each objective and are established based on previous studies, specialist reports, or empirical.

I1. Objective 1, Determining the degree of involvement of entrepreneurs in the sustainable development of the community (questions 7, 13), starts from the hypothesis that 4,558 new jobs were created in the non-agricultural sector in the rural environment, considering the results of some previous research showing that 36% of them are women [6]. At the same time, if we analyze the PNDR support measures, it is found that in the last seven years, more than 3,800 small and medium-sized enterprises (SMEs) that developed non-agricultural investments in the countryside, 1,484 activities related to services, 876 agro-pensions and other 128 projects for craft activities.

I2. Objective 2, Determining the willingness of the partners to develop wine businesses with the partner in the Măcin brand area (question 8), starts from the hypothesis that an irrigation system is being implemented for 80 hectares of the 300 that the Măcin Winery has, said Corina Moroianu, marketing director, Vinuri de Măcin and there is a need for promotion for new markets[9].

I3. Objective 3, Determining the reasons why partners choose to get involved in the development of the wine area (questions 9, 12), starts from the assumption that 50% of the respondents have applied to quality schemes or systems, given that, at the national level, 0.2% of Romanian farmers registered their products in such quality systems, which are voluntary.

According to EU statistics, there are 10 million agricultural holdings in Europe, employing more than 22 million people. According to the EU's operating principle, there is a concern for the promotion and export of traditional products from all member states. EU reports show that in 2017

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PGI/STG sales were 77.1 billion euros (74.8 billion euros excluding STG) of which wines represent 51%, agri-food products 35%, spirits 13%, and 0.1% flavoured vines. The countries whose GI product sales exceeded €5 billion each are France, Italy, Germany, the United Kingdom, and Spain[13]. The logos used as EU symbols to identify protected names prompted the analysis of the impact of identifying these products on the market related to the "country of origin". According to Eurobarometer (2019) it shows that 18% of EU consumers know the PDO and PGI logos and 15% the STG logo, less than 5% know the meaning of PDO in Denmark, Malta, Romania, and the United Kingdom, while 45% of consumers in France know the meaning PDO products [20].

I4. Objective 4, Identifying the availability of partners to raise awareness of the quality of the local brand and the wine-growing area (question 10, 14), starts from the hypothesis that the availability of producers to certify products depends on age, education, specialization in production, form of organization, area, owning animals. This hypothesis has been established empirically.

In scientific research, highlight that the acquisition and marketing of traditional products have a very important economic impact in many regions of the EU, contributing to the preservation of local traditions. Studying the perception of consumers towards the "traditional" concept shows that it is perceived as having to do with customs, special occasions, heritage (transmitted from one generation to another), making products in a specific way, sensory properties, simplicity, and a certain origin. In addition to the seven connecting factors, three more elements are associated with traditional food products, such as health (positive and negative aspects), marketing, and a variety of agri-food products.

I5. Objective 5, Determining the reasons why partners recognize that a certain entrepreneurial and local culture can influence the consumption of certain branded products (question 11), starts from the assumption that the main reasons why producers will register food in quality schemes or systems are to preserve the transmission a tradition from one generation to another, the promotion of the local gastronomic and cultural heritage, the VAT rate reduced to 5%. This hypothesis has been established empirically.

MATERIALS AND METHODS

To achieve this goal, the focus of the research focused on exploring the interpretations and use of place branding by place management professionals from Tulcea County and the area. This was done using in-depth, semi-structured interviews to encourage 'interviewees to respond freely within their frame of reference.The interviewees were selected by adopting snowball sampling, a type of non-probability procedure that provides a comprehensive (though not generalizable) characterization of the place branding process [11].

Interviewees were initially approached via email, which briefly outlined the aims of the study and invited them to participate. Respondents who agreed to participate were then emailed a second time and submitted an informed consent form that outlined the objectives of the research and offered respondents anonymity in exchange for their participation.

Question 1.*Which is your job field?* The answerstothisquestion are presentedbelow in Fig. 1.

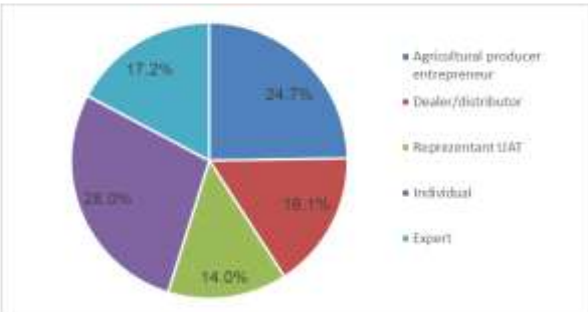

Fig. 1. Graphic representation of respondents' answers to question 1.
Source: own processing based on the investigation.

Most of the respondents work as a producer/entrepreneurs (24.75%), 16.1% as distributors, and 28.0% as individuals, the difference up to 100%, experts in the field of

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marketing (consultants, employees, civil servants) (Figure 1).

Question 2. *From your point of view, what is your relationship with SC ALCOVIN's partner, Crama Măcin?*

The largest share of residents and other stakeholders are little involved in actions to develop the local brand or are too late in such initiatives. In the brand under study, they considered that they were invited too late to offer contributions on the one hand, and on the other hand, they were not asked to offer ideas to the already developed solutions and ideas. In our study, the partners faced challenges in the field of tourism, mostly centered on technology and environmental sustainability, and at the center of attention were issues of sustainable lighting, and green energy (Figure 2).

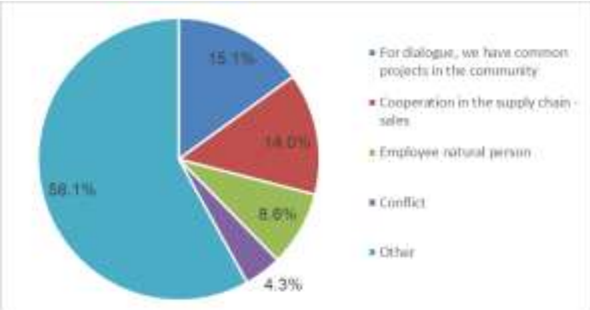

Fig. 2. Graphic representation of respondents' answers to question 2
Source: own processing based on the investigation.

Question 3. *In the wine products sector, you are positioned as?*

Regarding the position in the product chain, we find 35% suppliers, followed by 25% traders (online store) and only 6% processors (Figure 3).

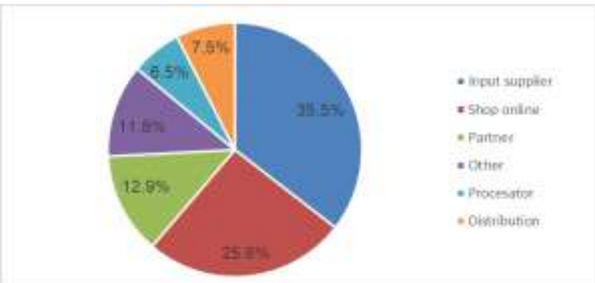

Fig. 3. Graphic representation of respondents' answers to questions 3
Source: own processing based on the investigation.

The wine industry in the Măcin area has certain specific requirements that are influenced by the climatic conditions, the soil, and the local viticulture traditions. Here are some specific aspects of this industry in this region:

Climate and soil: The Măcin area benefits from a temperate-continental climate, favorable for the cultivation of vines. The soils are varied, but in general, they have good characteristics for viticulture, with reddish-brown, loamy-sandy, and loamy soils.

Grape species are grown: A variety of grape varieties are grown in this area, including FeteascăNeagră, Merlot, Cabernet Sauvignon, Chardonnay, and others. The selection of varieties is important according to market requirements and their adaptability to local conditions.

Cultivation Techniques: By tradition, many of the lives in the area are cultivated in traditional ways, but there is also the adoption of modern techniques to increase the efficiency and quality of production. These techniques include irrigation systems, optimal nutrient management, and grape harvesting and processing practices.

Harvesting and processing: The grapes are harvested at the optimal times for each variety, to obtain the optimal quality of the grapes. Further processing is crucial and can involve pressing, fermenting, and bottling the wines.

Specific legislation: There are strict rules and regulations regarding wine production, labeling, marketing, and export. The producers must comply with the rules imposed by the authorities to sell the wines on the market.

Product promotion: In addition to the production itself, wine promotion and marketing are essential to reach consumers in the local and international markets. Participating in specialized fairs, and organizing tastings or collaborations with restaurants and specialized stores are common strategies for promoting wine products.

Adapting to local requirements, combining tradition with modern technologies, and respecting the rules and standards imposed, are essential for success in this industry.

RESULTS AND DISCUSSIONS

The collection of data used for the research was done by designing a survey form.

The answers received from the respondents concern the study of the involvement of natural and legal partners in protecting the local Măcin brand as a sustainable destination, as well as the trends of partners and specialists regarding this subject. Participation in the questionnaire was voluntary, the recorded data are confidential and are used strictly for research purposes, respecting ethical recommendations and confidentiality.

In the following, the results obtained for questions 4-14 of the questionnaire presented in the annex are presented, as well as the graphical representation of the results.

Question 4. *As a local partner, how far (km) are you from Crama Măcin?*

Proximity and distance from the partner are presented in Figure 4: most of the respondents 33% operate at a distance greater than 50 km, 31% below 20 km, and a percentage of 5.5% are between 20 -50 km. The arguments of the company around which we are studying the issue of the Măcin brand were that they are constantly looking for cooperation opportunities. In our experience, projects related to the development of interesting and innovative travel products (often funded by the EU) have strong potential but ultimately fail to penetrate the market. We help our customers and partners master all the steps: market research and potential assessment, development and implementation, marketing and sales.

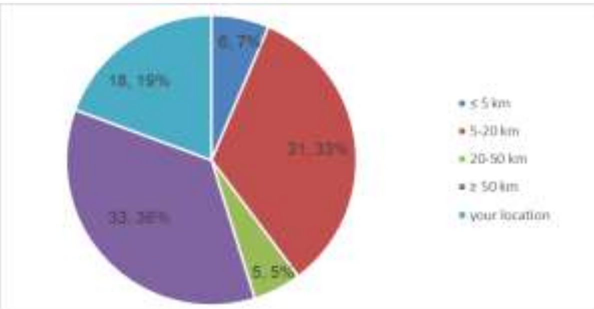

Fig. 4. Graphic representation of respondents' answers to question 4
Source: own processing based on the investigation.

We also constantly promote and train local partners in ideas and innovations for sustainable development goals through workshops, and expert talks and also introduce them to products and services that help them set their agenda towards sustainable operations.

It can be found from the analysis of the questionnaire that respondents who are positioned closer to the key partner, both in the area of distribution and marketing thus participating in a short chain, the product reaching from the producer to the consumer through a small number of intermediaries. The Măcin Winery Park as a local brand (label) could provide exposure to producers, and participants in the value chain and serve as a reference point for all those who want to develop a business or experience new values.

Question 5. *Specify (from your point of view) the suggestive traditional element of the products of the Măcin Winery present on the market?*

It is well known that the development of ecotourism projects would be an opportunity for cooperation with partners in the area. From the reports of the partner Alcovin, the projects related to the development of interesting and innovative wine tourism products have a strong potential but fail to penetrate the domestic and international markets. Our interviewees (Figure 5), the local partners, recognize the notoriety of the Măcin varieties (64.3%). There are over 20% of collaborators from the Măcin area introduced wines into the tourist circuit and associated them with regional gastronomic packages.

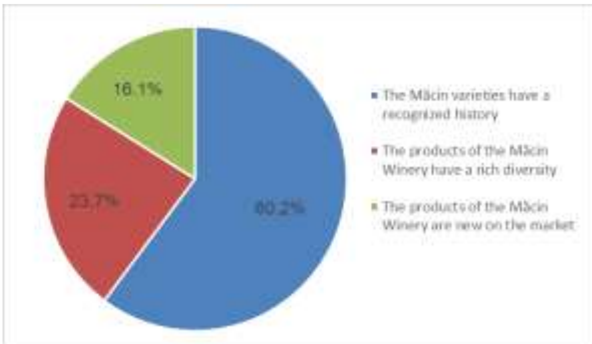

Fig. 5. Graphic representation of respondents' answers to question 5
Source: own processing based on the investigation.

Question 6. *When you want a get away, where do you want to spend your free time?*

Most of the respondents (34%) when they want a getaway appreciate that the Măcin Winery is located near some tourist attractions, and the notoriety of the area attracts them to choose the destination. 3.2% do not know or are undecided when faced with a choice for getaway tourism in the area.

Hiking in the Măcin Mountains is attractive to tourists because the area offers beautiful mountain trails for hiking, trekking, and exploring unique natural landscapes. Horseback or bicycle tours can be arranged to discover the beauty of the mountains and countryside.

Winery visits and wine tastings: Wineries in the Măcin area offer the opportunity to visit vineyards, learn about the wine production process, and participate in local wine tastings. This provides an insight into wine culture and local traditions.

Relaxation in nature: The Măcin area is ideal for relaxation and recovery. Quiet places, such as the banks of the Danube or the nearby forests, are perfect for walks, picnics or simply spending time in the middle of nature.

Exploring nature reserves: There are nature reserves in the area that are worth exploring to admire the biodiversity and natural beauty. The Măcin Mountains Nature Reserve is famous for its rare species of plants and animals.

Attending traditional events: Depending on when you visit, it may be possible to attend local festivals, traditional fairs, or other cultural events that celebrate the customs and traditions specific to the area (Figure 6).

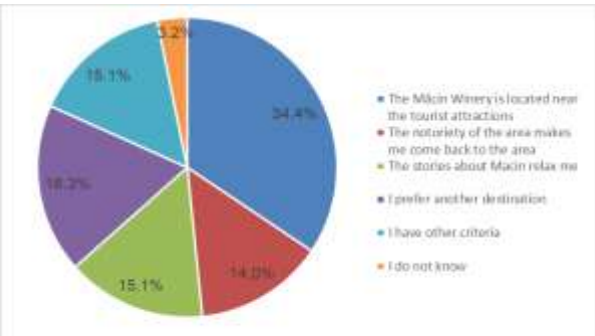

Fig. 6. Graphic representation of respondents' answers to question 6.
Source: own processing based on the investigation.

These suggestions can provide a varied experience for those who want to spend their free time in the Măcin area, allowing them to enjoy the natural beauty, the wine culture, and the authentic atmosphere of the region.

Question 7. *The community development process around the Măcin Winery as a local brand was influenced by?*

The answers to question 7 were related to how the community development process around the Măcin Winery as a local brand was influenced and can be seen in Figure 7.

The history of the place, of area, had a positive impact on wine tourism consumers, as can be seen in Figure 7. The marketing approach depends on the tourist who visits us, SC Alcovin's marketing specialist told us. For example, an exercise in educating the tourism consumer would be the idea of the Măcin Winery Park. At this moment, most of the interviewees are in the middle segment to the highest level and, therefore, to reach the luxury segment and it is a target that we want to reach, to arouse interest and involvement for future partners in tourism and services. Collaboration with regional and national tourism agencies has led to the development and consolidation of sustainability as a wine tourism destination.

Hiking in the Măcin Mountains: This area offers beautiful mountain trails for hiking, trekking, and exploring unique natural landscapes. Horseback or bicycle tours can be arranged to discover the beauty of the mountains and countryside.

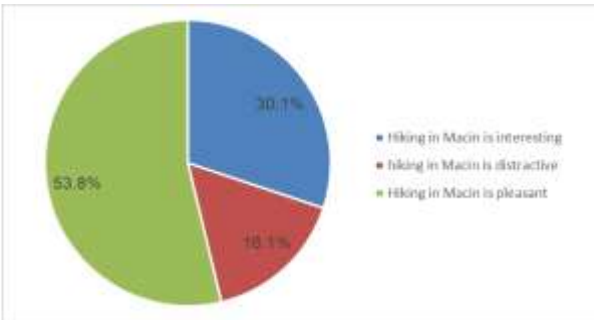

Fig. 7.Graphic representation of respondents' answers to question 7
Source: own processing based on the investigation.

Winery visits and wine tastings: Wineries in the Măcin area offer the opportunity to visit vineyards, learn about the wine production process, and participate in local wine tastings. This provides an insight into wine culture and local traditions.

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These suggestions can provide a varied experience for those who want to spend their free time in the Măcin area, allowing them to enjoy the natural beauty, the wine culture, and the authentic atmosphere of the region.

Question 8. *How did you find out or how were you attracted to participate as a partner in the viticultural activities of the area?*

The answers showed that a lot of tourists (consumers) can be attracted through social networks, at the same time the interviewees are also familiar with the company's website (15%).

Partnerships in viticultural activities or any other economic field can be initiated or attracted in several ways:

Interest and expertise: If there is interest and expertise in the wine industry or the field of business related to viticulture and winemaking, this can be a solid basis for seeking partnerships or collaborations in the Măcin region (Figure 8).

Communication and networking: Participation in wine events, fairs, or exhibitions can facilitate getting to know other players in the industry and the possibility of establishing contacts and partnerships with wineries or local producers in the Măcin area.

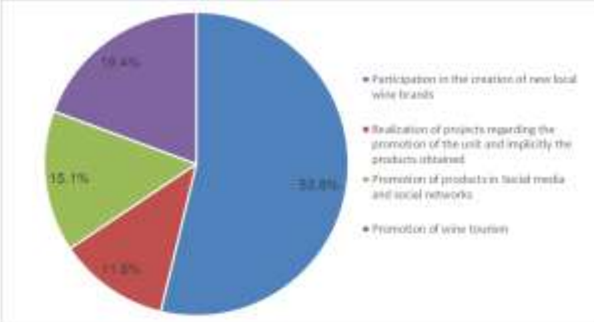

Fig. 8.Graphic representation of respondents' answers to question 8
Source: own processing based on the investigation.

Seeking opportunities: Identifying opportunities for collaboration in the viticulture field may involve researching and evaluating wineries or other actors involved in wine production in the area to find potential partnerships or collaborations within specific projects.

Supporting local development: If there is an interest in supporting the local community and the wine industry in the area, this can be a motivation to look for partnership opportunities that contribute to the sustainable development and growth of this industry.

In general, partnerships in viticulture or other economic fields are often established following a proactive-passive approach, involving research, networking, and identifying opportunities for collaboration that bring mutual benefits to both partners and the community.

Question 9. *Which was your strongest contribution to the development of other economic activities in the area in the last 5 years?*

One of the strongest contributions to the development of other economic activities in the Măcin area can be linked to the wine and wine industry. This industry has the potential to influence and stimulate other economic sectors in the region in several ways (Figure 9).

Tourism: The wine industry and the existence of local wineries and vineyards can attract tourists and wine lovers to the Măcin area. Tourists come to visit wineries, participate in wine tastings, and learn about the wine production process, thus contributing to the growth of local tourism.

Services and hospitality: The development of the wine industry can lead to increased demand for hospitality services such as restaurants, hotels, or rural guesthouses. This provides opportunities for local entrepreneurs to develop businesses that meet the needs of tourists visiting the area.
Local and regional trade: The production and sale of local wines can help increase local and regional trade. Wineries or wine producers can collaborate with other local businesses to promote and sell their products, creating a network effect that supports the local economy.

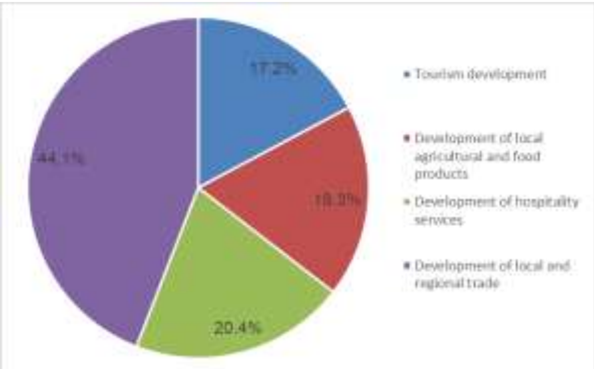

Fig. 9. Graphic representation of respondents' answers to question 9
Source: own processing based on the investigation.

Agriculture and food industry: The wine industry can have a pull effect on the agricultural sector, such as the production of grapes and other related crops. It can also stimulate the development of the local food industry, such as the production of cheeses, bakery products, or other complementary food goods.
Culture and the arts: The wine industry and events associated with it, such as wine festivals or food events, can help promote local culture and the arts by drawing attention to the area's unique traditions and customs.

Question 10. *Your attention for the Măcin area in general is characterized?*
How partners can be attracted to the area is mentioned by the weights obtained by the interviewees, as follows (Figure 10):
The Măcin area is recognized for its natural landscapes, including the Măcin Mountains, the oldest mountain region in Romania, and nature reserves rich in biodiversity. Attention to this area often focuses on the conservation and protection of this unique natural heritage.
Culture and tradition: There is an interest in preserving and promoting local culture and traditions specific to the Măcin area. Cultural events, traditional festivals, and local crafts are valued and supported to preserve the authenticity and cultural identity of the region.
Viticulture and gastronomy: The Măcin area is known for its quality wine production and specific gastronomy. This aspect draws attention to local wineries and producers, as well as traditional food, being promoted to highlight the unique tastes of the region.

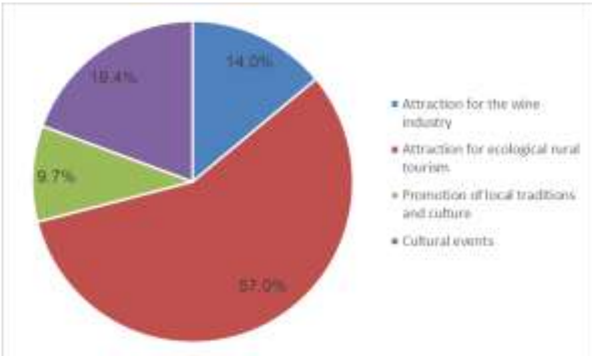

Fig. 10. Graphic representation of respondents' answers to question 10
Source: own processing based on the investigation.

Question 11. *What activities/events related to tradition in the Măcin area are present in your and your family's memory?*
The answers showed that the respondents recognize the importance of participating in activities in the area, they are part of the category of consumers who appreciate local products, fairs, and festivals, and there are no big differences between them when we talk about choosing one category or another.
In summary, the interviewees stated that in the Măcin area and Tulcea county in general, there are a series of specific cultural traditions and events, which are important for the local community and which were part of their and their families' memory.
Religious holidays: Every year, religious holidays such as Easter and Christmas are particularly important times for the local community. Attending religious services and observing the traditions specific to these holidays is an essential aspect of family life.

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Local festivals: The Măcin area hosts various festivals and cultural events throughout the year. Food festivals, folk art exhibitions, or traditional fairs are occasions where the community gathers to celebrate local traditions, traditional food, and traditional crafts.

Specific customs and traditions: There are certain traditions and customs specific to the Măcin area that are passed down from generation to generation. These may include traditional dances, folk songs, local crafts, and stories or legends specific to the area.

Local Folklore: Local tales and stories, traditional songs, and folk dances are an integral part of the culture and traditions of the area. These are often transmitted through cultural events or informal meetings between community members.

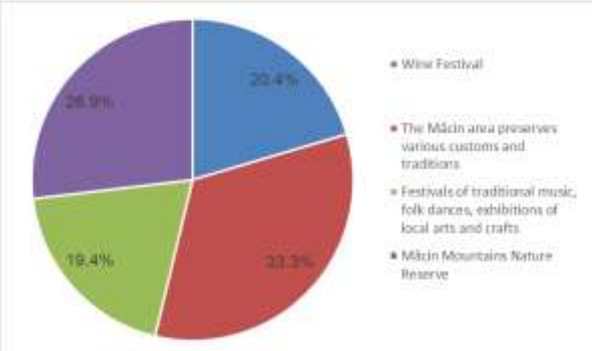

Fig. 11. Graphic representation of respondents' answers to question 11
Source: own processing based on the investigation.

Traditions related to nature: Since the area of Măcin is surrounded by a beautiful natural area, there are traditions and customs related to nature. These include celebrating certain times of the year according to natural cycles or celebrating the harvest and natural resources.

In their families, many of these traditions have been preserved through participation in religious celebrations, involvement in local festival activities, preservation of traditional crafts, and preservation and transmission of folk tales and songs (Figure 11). These elements have contributed to our cultural identity and our strong connection with the Măcin area and its traditions.

Question 12. *How do you rate the level of involvement in the community of the Crama Măcin brand?*

CramaMăcin was perceived as a recognized brand in its area, both for the quality of the wines produced and for its involvement in the local community.

The interviewed respondents and specialists appreciate that the Măcin Winery Brand had a series of initiatives that supported the local community (Figure 12). These include:

Job creation: Through its operations, CramaMăcin has contributed to the creation of jobs in the area, thus providing economic support to the local community.

Promotion of local tourism: Through events such as wine festivals or other activities held within the winery, this brand has contributed to the promotion of tourism in the area, thus drawing attention to the Măcin region and its products.

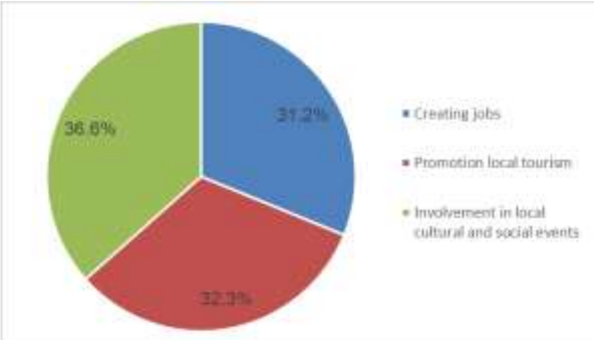

Fig. 12. Graphic representation of respondents' answers to question 12
Source: own processing based on the investigation.

Involvement in local cultural and social events: CramaMăcin has often shown its support for local cultural or social events, either through sponsorship, active participation, or organization.

Question 13. *What is your vision as a short- and medium-term partner towards the sustainability of the Măcin community?*

Most of the respondents (Figure 13) appreciate that encouraging and supporting small businesses, local producers, and sustainable agriculture can strengthen the local economy and create jobs in the Măcin community. Thus, one can contribute to the maintenance of local identity and traditions.

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Promoting responsible tourism: Encouraging tourism in the area, but responsibly and sustainably, can bring benefits to the community. This may involve tourism education to respect the environment, local cultures, and natural resources (Figure 13).

Supporting sustainable agricultural practices: Offering support and resources for sustainable agriculture, such as organic farming techniques or farmer education programs on responsible resource use, can improve food security and protect the environment.

Developing sustainable infrastructure: Investments in green infrastructure, such as waste management systems, renewable energy sources, or water conservation projects, can bring long-term benefits to the community and the environment.

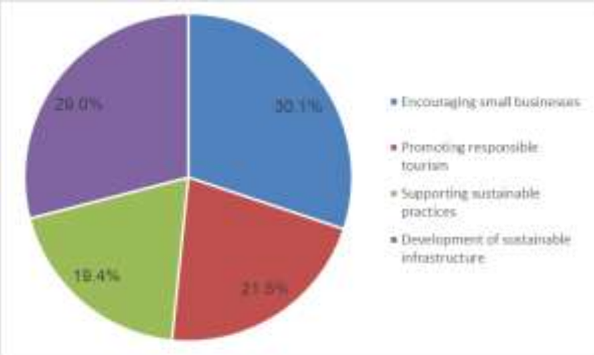

Fig. 13. Graphic representation of respondents' answers to question 13
Source: own processing based on the investigation.

Question 14. *Does the image conveyed by the product of the Măcin Winery wine range tell the story of the place?*

The products of the Măcin Winery range of wines tend to convey a story related to the place where they come from, that is, the Măcin area in Romania (Figure 14). These wines are often associated with the tradition, specific terroir, and history of the area, incorporating elements that reflect the authenticity and specific characteristics of this wine region.

Through its wines, CramaMăcin tries to offer consumers an experience that allows them to discover the essence and identity of this region.

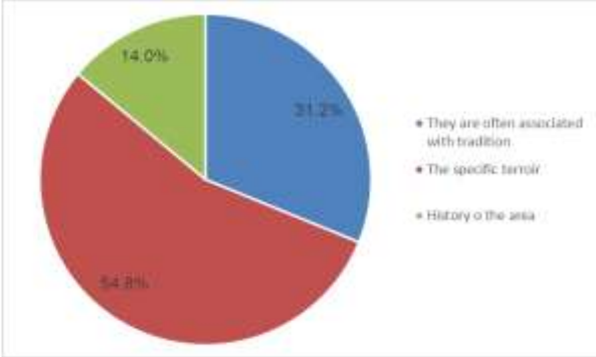

Fig. 14.Graphic representation of respondents' answers to question 14
Source: own processing based on the investigation.

Thus, the image conveyed by the wine ranges can include the following elements:

Reflection of the terroir: Wines can be created to authentically express the characteristics of the soil, climate, and other factors specific to the Măcin region. The aromas, bouquets, and taste profile of these wines can convey a unique balance between local conditions and the production process.

Preservation of traditions: The Măcin Winery could orientate its production towards respecting the traditional methods of wine production or the use of autochthonous varieties specific to the area, thus contributing to the preservation and promotion of the local viticultural heritage.

The connection with nature: The wines could emphasize the close connection between viticulture and the natural environment of the Măcin region. Labels, descriptions, and marketing could highlight the beauty of the landscape, biodiversity, and respect for the environment.

History and cultural heritage: Through wines, CramaMăcin could share the stories and historical traditions of the place, bringing to the fore cultural and historical aspects that give character and depth to the product range.

CONCLUSIONS

Sustainable development: In recent years, the concern for sustainable development has become increasingly visible in the Măcin area, with an emphasis on sustainable agricultural practices, environmental conservation, and supporting the local community to maintain a balance between economic growth and the protection of natural resources. The existence of impressive natural landscapes and activities related to rural tourism, which include hiking, nature tours, and authentic experiences in local communities, attract the attention of those interested in eco-tourism and discovering authentic and authentic destinations.

These characteristics reflect a varied and comprehensive interest in the Măcin area, highlighting the multiple aspects that make this region so special and attractive to people from various fields of interest: from nature conservation and culture to gastronomy and tourism.

Some wine producers, including wineries, have shown an interest in sustainable agricultural practices or environmental conservation, which can help improve the quality of life in the community**.**

It's important to note that the level of community engagement can vary over time and depending on each brand's strategy and priorities. CramaMăcin or other wineries in the area may be involved in more community development initiatives or may have plans to expand their activities in support of the community, but this information may depend on their further development, as of my knowledge date (January 2022). The recommendation is to check the current information and news to have an up-to-date and accurate perspective on the involvement of the Măcin Winery in the local community.

Sustaining local culture and traditions: Promoting and preserving local culture and traditions is an essential aspect of a community's sustainability. Organizing cultural events, and supporting local craftsmen and artists can contribute to preserving the cultural identity of the area.

Partnerships and collaborations: Collaboration with non-governmental organizations, educational institutions, local authorities, and other entities can create strong synergies to implement and support sustainable development projects in the Măcin community.

These actions could contribute to strengthening and improving the sustainability of the Măcin community, aiming to combine economic prosperity, social equity, and environmental protection in a way that provides long-term benefits for the inhabitants and the environment of this region.

In essence, the image conveyed by the Măcin Winery's wine ranges is that of an authentic connection with the region and the local community, offering consumers not only a product but also an experience that introduces them to the cultural, natural, and viticultural universe of the Măcin area.

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THE IMPACT OF THE COVID-19 PANDEMIC ON THE CONSUMPTION OF BEE PRODUCTS IN IZMIR PROVINCE, TURKIYE

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Abstract

The main objective of this study is to examine the consumption preferences, trends, and purchasing behaviors of consumers residing in Izmir Province towards bee products before and after COVID-19. The main material of the study consists of online surveys conducted in March-April 2023 with consumers living in the seven districts of Izmir province with the highest population. The survey form comprises of three sections: consumption and purchasing behaviors of bee products, attitudes towards bee products, and questions on demographic characteristics of consumers. Since the first days when coronavirus cases began to emerge in our country, natural products that support the immune system such as bee products have been met with intense interest. The sustainability of bees and bee products in agriculture is always among the important issues. However, during the pandemic period, people's attention has been more focused on this issue. The value of honey and bee products, the miraculous food of nature, has been better understood, and this has been reflected in sales. If natural and economic conditions are favourable, this rise in the sector will continue.

Key words**:** *apilarnil, royal jelly, honey, perga, propolis, consumers' purchasing behaviour, Izmir province*

INTRODUCTION

Nutrition and health are among the basic needs of people to sustain their lives. A quality nutrition brings healthy living conditions as well as mental and physical development. The concepts of nutrition and health are complementary to each other. Diseases caused by food consumption and the fact that some of the food production falls below quality and safety standards have caused consumers to be more sensitive to food consumption [1]. Historical findings have revealed that honey has been used as a remedy for skin infections, stomach ulcers, eye-ear diseases, and accelerating wound repair after surgical procedures. Additionally, when the substances contained in honey are examined, it has numerous benefits such as antimicrobial, anti-parasite, antioxidant, reducing the symptoms of diseases in the upper respiratory system, prebiotic, painkiller, wound healing, and fertility enhancer [11]. When bee products are mentioned, many products come to mind. The most important and popular bee products are honey, pollen,and beeswax. Apart from these, there are more bee products produced by the honeybee itself.

According to 2022 data, the total number of beehives in the world is 92.26 million, and Asia ranks first in the intercontinental ranking with 43.05 million hives and 835.64 thousand tons of honey production [9]. In 2020, approximately 1.8 million tons of honey were produced in the world. In 2020, China, which has a 25.9% share in world honey production, ranked first with 458 thousand tons of honey production, Turkey, with a 5.9% share in honey production, ranked second with 104 thousand tons, and Iran, with a share of 4.5%, ranked third with 80 thousand tons of honey production [19].In terms of foreign trade, the world export, which was 684 thousand tons in 2017, increased by 5.5% in 2020 and reached 722 thousand tons. In 2020, as in world honey production, China ranked first in the amount of exports, while Turkey, which ranked second in the amount of production, ranked 22nd. In Turkey, honey foreign trade is carried out in two types: strained and honeycomb honey. In 2021, 77.1% of honey exports were in the form of strained honey. Although honey exports increased by 66% in 2021 compared to the previous year and reached 9.98 thousand tons, since most of the honey produced was consumed domestically, a low rate of 10.4% of total honey production was exported in 2021 [19].

Coronaviruses are large, enveloped RNA viruses that cause different respiratory diseases in humans, including upper respiratory tract infections and severe pneumonia. In the past, seven types of coronaviruses infecting humans have been identified and three outbreaks caused by them have been reported. The first was acute and severe respiratory failure syndrome (SARS-CoV), which started in China in 2002, the second was Middle East respiratory syndrome (MERS-CoV), which emerged in Saudi Arabia in 2012. The third is a disease first seen in Wuhan, China in December 2019 and named COVID-19. As the cases in China increased day by day, resulting in deaths and affecting the whole world, the virus moved from the epidemic stage to the pandemic stage. It was declared a pandemic by the World Health Organization with an international call on January 30 [6].

COVID-19 affects the lower respiratory tract and hematologic system, causing symptoms such as fever, cough, and shortness of breath. Until November 28, 2021, 261.51 million COVID-19 cases were reported in the world while global deaths reached 5.22 million. In Turkey, the first case was seen in March 2020. Until November 28, 2021, there were 76 thousand deaths and 8.72 million COVID-19 cases [3].

Psychological, demographic, and social factors affecting consumer behaviour are all under the influence of culture. The culture of a country can has a direct impact on consumption awareness as well as the determination of the products produced in that country. In Europe, America and some Asian countries, there has been a significant level of social awareness about the production and consumption of bee products in the last 30 years. While apitherapy, which is the use of bee products for therapeutic purposes, is practiced almost everywhere in the world, there are very few studies on the use of bee products such as pollen, royal jelly, propolis, and bee venom, the production amounts of which have just started to enter the statistics in our country. The fact that people have recently started to attach importance to their health and are in search of various natural products has led to the progress and improvement of beekeeping activities when considered with the concept of a healthy life. In this sense, it is important for human health to consume bee products in appropriate conditions and levels. In addition, it is also known that honey and other bee products have "antimicrobial, antibacterial, antiviral and antiparasitic" functions based on the "enzymes, vitamins and minerals" they contain [7].

The uncertainty caused by the COVID pandemic has led to changes in consumer behaviour. Consumer demand for food and hygiene products increased in the aftermath of the pandemic.Subsequently, literature on consumer behaviour during the COVID-19 period has emerged, primarilycovering European countries [16]. It is anticipated that this research on bee products, which holds significance for Turkey, will make a substantial contribution to the literature.Additionally, it will serve as a valuable source of data for companies operating in this sector, aiding in decision-making on issues such as investment, product diversification, and development.

The main objective of this research is to examine the consumption preferences, tendencies, and purchasing behaviours of consumers residing in Izmir Province towards bee products before and after COVID-19.

MATERIALS AND METHODS

The primary data for this study were gathered through online surveys conducted in March-April 2023 among residents of the seven most populous districts in Izmir. These selected districts represent 59.33% of Izmir's provincial population. The study also drew insights from prior research on the subject.

Data collection involved the administration of a questionnaire designed specifically for this study through a Google survey form. The questionnaire comprised three sections: consumer behaviors related to the consumption and purchase of bee products, attitudes towards bee products,and demographic characteristics of participants.

The sample size for this study was determined using the proportional sample volume formula [12]. Focusing on the seven central districts of Izmir province.

$$n=\frac{Np(1-p)}{(N-1)\sigma^2_{p_x}+p(1-p)} \quad \text{.....................(1)}$$

where:
n= Sample volume
N= Total population of the central districts of Izmir province (2,647,337)
p= 0.5 was taken.
σ^2_{px} = Variance of the ratio.

The p value was set to 0.50 to determine the maximum sample size. The number of surveys conducted in the districts was calculated based on the population density of these districts. With a 90% confidence interval and a 10% margin of error, the sample size was determined to be 178.

Five-point Likert scales were employed in the questions aimed at measuring the consumption and purchasing behaviours of consumers towards bee products. Arithmetic mean and percentage calculations were utilized in data analysis. Statistical tests were performed to assess whether there were differences in the consumption and purchasing behaviours of consumers towards bee products before and after the onset of COVID. Comparison analyses were conducted using with Wilcoxon related two-sample test. This test is employed to compare the perspectives of a specific nonparametric group on two related but distinct topics or practices [8].

RESULTS AND DISCUSSIONS

Socio - Demographic Characteristics of Consumers

In this section of the study, we present the demographic characteristics of the consumers who participated in the survey. The average age of the respondents is 39. Of the survey participants, 39.3% were women, and 60.7% were men. On average, the surveyed consumers have 14 years of education, with 79.8% holding university degrees. Additionally, 87.1% of the interviewed consumers are currently employed (Table 1).

Table 1. Socio-demographic characteristics of the surveyed consumers

Variables	Categories	Number of People	%
Age (Average age: 39)	18-25	19	10.7
	26-35	38	21.3
	36-45	73	41.0
	46-55	35	19.7
	56-65	11	6.2
	65 and above	2	1.1
Gender	Woman	70	39.3
	Male	108	60.7
Education Status (Average duration of education: 14 years)	12	21	11.8
	14	8	4.5
	16	142	79.8
	>16	7	3.9
Employment Status	Employee	155	87.1
	Not working	13	7.1
	Retired	10	5.6
Total Monthly Income (Average Income: 887.73 USD*/month)	<443.86 $ / month	4	2.2
	443.86-835.51 $/month	23	12.9
	835.51-1,253.26 $/month	56	31.5
	>1,253.26 $/month	95	53.4
Occupational groups of consumers	Tradesmen	23	12.9
	Officer	109	61.2
	Private sector	30	16.9
	Student	8	4.5
	Retired	5	2.8
	Not working	3	1.7
Number of individuals living in the household (person)	One	32	18.0
	Two	26	14.6
	Three	56	31.5
	Four	51	28.7
	Five	12	6.7
	Six	1	0.6
Number of children living in the household	I have no children	75	42.1
	A child	60	33.7
	Two children	36	20.2
	Three children	6	3.4
	Five children	1	0.5
Distribution of people responsible for shopping in the household	Mother/ Woman	68	38.2
	Father/Male	77	43.3
	Child	1	0.5
	Other	32	18.0
Ownership status of consumers' residence	Own house	88	49.4
	Kira	90	50.6
Household ownership of automobiles	There is	122	68.5
	No	56	31.5
Total household food expenditure (USD*/month)	<104.44	8	4.5
	104.44-208.88	40	22.5
	208.88-313.32	48	27.0
	313.32-417.75	36	20.2
	417.75-522.19	33	18.5
	>522.19	13	7.3

Source: Own calculation.
*1 USD equals to 19.15 TRY in March 2023.

Regarding income, 53.4% of the surveyed consumers reported an average monthly income of $1,253, with an overall average income of approximately $888. Occupationally, 61.2% were civil servants, 16.9% worked in the private sector, 12.9% were artisans, 4.5% were students and 2.8% were retired.

Approximately 31.5% of the surveyed consumers reported having three members in their households. Furthermore, it was found that 42.1% of the consumers were childless. Gender distribution among the participants revealed that 43.3% identified as Father/Male, and 38.2% as Mother/Female.

In terms of housing, 50.6% of the consumers identified as tenants,while 49.4% stated that they owned the house they lived in. Vehicle ownership was reported by 68.5% of the respondents, while 31.5% did not have a car belonging to the household.

Concerning monthly budget allocation, 27% of the consumers allocated a monthly budget of $208.88-$313.32 USD for food expenditures, and 7.3% allocated a budget of $522.19 and above (Table 1).

Consumers' Behaviour towards the Consumption and Purchase of Bee Products

Table 2 presents the reasons for consumption among surveyed consumers both before and after the onset of COVID-19.

Table 2. Reasons for consumption of bee products by surveyed consumers

Reasons for consumption	Pre COVID-19		Post COVID-19	
	Number	**%**	**Number**	**%**
Immunization	91	51.1	141	79.2
High antioxidant content	82	46.1	123	69.1
Recommended by experts	70	39.3	120	67.4
High nutritional value	116	65.2	109	61.2
No additives	99	55.6	95	53.4
Being delicious	138	77.5	70	39.3
Habit	115	64.6	58	32.6
Can be stored for a long time	117	65.7	54	30.3
Loved by family members	119	66.9	48	27.0
Satisfying / satiating	113	63.5	45	25.3

Source: Own calculation.

*Since consumers gave more than one reason, the total percentage exceeds 100.

The percentage of consumers citing "Immunization" as a reason for consumption increasedsignificantly from 51.1% to 79.2% after the pandemic. Similarly, theproportion of consumers acknowledging "High antioxidant content" as a motivating factor rose from 46.1% to 69.1%; and the rate of consumers who agreed with the statement "Recommended by experts" increased from 39.3% to 67.4%. Conversely, it was observed that reasons such as "Does not contain additives", "Tasty", "Habit", "Can be stored for a long time", "Loved by family members" and "Satisfying/filling" witnessed a decreased in prevalence after the COVID-19 period (Table 2).

Table 3 outlines the buying preferencesof consumers for bee products. It was discerned that surveyed consumers predominantly opt to purchase bee products from supermarkets, with a frequency of 2-3 times a month, earning a score of 5.54. Following supermarkets in popularity are producers, cooperative sales stores, internet platforms and organic sales stores. Notably, wholesalers were identified as the least frequented option for purchasing bee products (Table 3).

Table 3. Thepurchasing frequency of bee products by surveyed consumers from specific points of sale

Points of sale	Purchase frequency
Supermarket	5.54
Manufacturer	5.46
Cooperative sales outlets	5.43
Online	5.34
Stores selling organic products	5.30
Grocery Store	4.78
Market	4.57
Wholesaler	4.18

Source: Own calculation.

*1: 1 time per year or less 2: Once every 6 months 3: 1-2 times in 3 months 4: Once a month 5: 2-3 times a month 6: At least 1 time per week

According to the survey results, consumers effectively conveyed their expectations fromcompanies producing and packaging bee products, with an average of 4.52 for the criterion of "quality”. Following closely, is the expectation for products "not containing additives" with an average of 4.46. In contrast, the expectationfor "different packaging designs" was rated at the lowest, with an average of 2.84, among the factors considered in the survey(Table 4).

Table 4. Surveyed consumers' expectations from companies producing and packaging bee products.

Why?	Mean
Quality	4.52
No additives	4.46
Production under hygienic conditions	4.44
No foreign objects in the packages	4.33
Accessible Price	4.17
Increased product diversity	3.50
Different packaging designs	2.84

Source: Own calculation.
Note: 1:Ineffective 2:Less Effective 3:Moderately Effective 4:Highly Effective 5:Very Effective

To assess consumers' attitudes *towards the consumption of bee products, a five-point Likert scale was employed*. The results indicate a strong agreement with the statement "I pay attention to consume natural and organic bee products." with an average rating of 4.47. Following closely,the statement "I care about the conditions under which the producer obtains the product" secured the second position with a mean score of 4.39. Consumers also expressed agreement with the following statements, "Consumption of bee products is very important for my health.", "I care about the quality, appearance and class of bee products," and "The city where the product is produced is important for me." (Table 5).

Table 5. Attitudes of surveyed consumers towards consumption of bee products

Attitude	*Mean*
I take care to consume natural and organic bee products	4.47
I care about the conditions under which the producer obtains the product.	4.39
Consumption of bee products is very important for my health.	4.38
I care about the quality, appearance and class of bee products.	4.29
I care about the taste of bee products.	4.27
Eating bee products makes me happy.	4.15
The use of sugar in the production of bee products is important to me.	4.12
I always try to buy the best bee products at the best price.	4.11
I shop at places that sell bee products, where I get expert advice.	4.07
The city where the product is produced is important to me.	3.86
A product of a famous brand influences my purchase of bee products.	3.58
I prefer to buy bee products openly rather than in jars.	2.88

Source: Own calculation.
Note: 1:Strongly Disagree 2:Disagree 3:Undecided 4:Agree 5:Strongly Agree

Analysis of Differences in Consumers' Consumption and Purchase Behaviours of Bee Products Before and After COVID-19

Table 6 provides insights into the factors considered by consumers when purchasing bee products before and after the pandemic. Before the pandemic, consumers emphasized the importance of "good quality" when buying bee products with an average of 4.50, and this emphasis increased to 4.54 after the pandemic. Additionally, the factor "not containing additives" received a mean of 4.40 before the pandemic, rising to 4.48 after the pandemic.Similarly, the importance attributed to the "production and expiration date" increased from a mean of 4.25 before the pandemicto 4.34 after pandemic. Consumers' attention to the organic nature of bee produces scored a mean of 4.21 before the pandemic, increasing to 4.34 after the pandemic.

Table 6. Consumers' reasons for purchasing bee products before and after COVID-19

Reason	**Pre COVID-19 Mean**	**Post COVID-19 Mean**
Quality	4.50	4.54
No additives**	4.40	4.48
Production and expiration date**	4.25	4.34
Being organic**	4.21	4.34
Price***	4.3	4.19
Which region it comes from***	3.98	4.12
Advice from close friends*	3.83	3.92
Appearance	3.79	3.86
Packaged***	3.66	3.79
Discounted*	3.58	3.67
Brand*	3.46	3.55
To be promoted***	3.34	3.48
Packaging material*	3.19	3.26
Ads***	2.77	2.93

Source: Own calculation.
Note: 1:Ineffective 2:Less Effective 3:Moderately Effective 4:Highly Effective 5:Very Effective
According to Wilcoxon test, there is a difference at ***$p<0.01$, **$p<0.05$ and $p<0.1$ levels.

Comparatively, consumer consistently prioritize purchasing quality products, emphasizing factors such asabsence of additives, production and expiration dates, and organic certification. Notably, thesignificance consumers place on advertisements when purchasing bee products was rated the lowest at 2.77 before the pandemic. However, this increased slightly to an average of 2.93 after the pandemic.

According to the Wilcoxon test results, there is a statistically significant increase in consumers' sensitivity to bee products not containing additives, production and expiration dates, being organic, price, region of origin, recommendations from close contacts, packaging, discounts, brand, promotions, packaging material, and advertisements after COVID-19 (Table 6).

As per the Turkish Food Codex Honey Communiqué (TGK), honey is defined as "the natural product of plant nectars, secretions of the living parts of plants or secretions of plant-sucking insects living on the living parts of plants, which the honeybee, after collecting them, modifies by combining them with specific substances, reduces the water content and matures by storing them in the honeycomb" [18].Pollen, a microscopic unit with a diameter of 6 to 200 micrometres[13], along with nectar, constitutesessential components of honeybee nutrition. In developed countries, pollen bee products, rich in nutrients for human consumption, are availablein various forms such as tablets, granules, liquids, and candies, thanks to the use of pollen traps at beehive entrances.

Perga, also known as bee bread, is a highly nutritious substance created by worker bees. They mix collected pollen with nectar and special enzymes, pack the mixture into honeycombs, and preserve it. Bee bread differs from pollen containing higher levels of vitamin K, reduced sugars, and digestive enzymes. Both bee pollen and bee bread are rich sources of polyunsaturated fatty acids essential for human nutrition [10].

Propolis, semi-solid at room temperature and varying in colour based on its source, is formed by the worker bees through biochemical modification of resinous substances and plant secretions[14]. Widely used in cosmetic,pharmaceutical, and apitherapy centres, propolis exhibits antibacterial properties and contains various chemical substances [17].

Beeswax, secreted by worker bees at 12-18 days of age from wax glands in their abdominal segments, is essential for constructing storage compartments in hives for honey and pollen for brood rearing [15].

Royal jelly, secreted byyoung worker bees after digesting flower powder and nectar, is a homogeneous substance with a runny and pasty consistency, containing carbohydrates, proteins and vitamins [15].

Bee venom is a pungent-smelling, bitter-tasting, yellowish substance formed in the venom bag of bees. It dries and crystallizes quickly in contact with liquid air and is injected through the stinger when the bee stings [4].

Apilarnil is the 3–7-day larval stage of drone larvae, occurring before the honeycomb eye closes. With a yellow-grey colour and an astringent taste, its complex composition islike royal jelly [20].

The survey results indicate a slight increase in the frequency of consumer purchases of pollen, perga (bee bread), propolis, beeswax, royal jelly, bee venom, and apilarnil. Notably, flower honey and pine honey, being relatively more affordable, witnessed aconsiderable increase. The average consumption of flower honey "at least once a week" rose from 4.40 before the pandemic to 4.79 after, while in pine honey, this average increased from 3.04 to 4.06 after the pandemic. Moreover, the average frequency of propolis "2-3 times a month" increased from 1.87 before the pandemic to 2.53 after, and in pollenthe rate of those purchasing "2-3 times a month" rose from 1.95 before the pandemic to 2.55 after the pandemic (Table 7).

Table 7. Consumers' frequency of purchasing bee products before and after the pandemic

Products	Pre COVID-19 Mean	Post COVID-19 Mean
Honey (Flower)***	4.40	4.79
Honey (Pine)	3.04	4.06
Polen***	1.95	2.55
Propolis***	1.87	2.53
Beeswax**	1.45	1.83
Royal Jelly	1.49	1.77
Perga (Bee Bread)	1.37	1.58
Bee Venom	1.26	1.52
Apilarnil	1.29	1.51

Source: Own calculation.

Note: 1: 1 time per year or less 2: 1 time in 6 months 3: 1-2 times in 3 months 4: 1 time per month 5: 2-3 times per month 6: At least 1 time per week

According to Wilcoxon test, there is a difference at ***p<0.01, **p<0.05 and p<0.1 levels.

The study results show a significant increase ($p<0.01$) in consumers purchasing flower honey, pine honey, pollen, propolis, beeswax, and royal jelly after the COVID-19 pandemic.This suggests that the shift in consumers priorities due to the pandemic has influenced their purchasing behaviour.

Table 8 illustrates the price range of bee products purchased by consumers both before and after the pandemic. Prior to the pandemic, consumers acquired flower honey at an average price of 1.49 and pine honey at an average price of 1.50.Following the pandemic,these averages increased to 2.55 for flower honey and 2.57 for pine honey.

In the case beeswax, consumers who boughtitfor an average of 2.03 before the pandemic found themselves purchasingitat an average of 2.78 after the pandemic. Similarly, the average price of pollen, which was 2.00 before the pandemic, rose to 2.95 after, while the average of bee venom, increased from 2.44to 3.04.Apilarnil, previouslypriced at 2.51, saw an average increase to 3.09, and Perga (bee bread), which stood at 2.30 before the pandemic, experienced an average rise to 3.14.

Propolis climbed from an average of 2.22 to 3.23 before the pandemic, and royal jelly increased from 2.31 to 3.29 after the pandemic. Comparing all the products in the table before and after the pandemic, it becomes evident that purchase prices have increased significantly (Table 8; $p<0.01$).

Various sectors experienced demand shocks due to measures taken within the scope of COVID-19 and the prevailing uncertainty.Logistical challenges and reduced access to raw materialsfurther contributed to negative supply shocks. The convergence of these demand shocks and supply constraints resulted in economic contractions, diminished production volumes in specific sectors, and price hikes in certain product categories. The surge in demand for medical supplies,pharmaceuticals, vitamins, cleaning tools; disinfectants, colognes, etc. as well as food and beverage products during the pandemic is a clear indication of this trend[2]. The increasing consumer demand for bee products during this period, coupled with inflation, has contributed to notable price increases in bee products (Table 8).

Table 8. Price range of consumers' purchase of bee products before and after the pandemic

Products	Pre COVID-19 Mean	Post COVID-19
Royal Jelly***	2.31	3.29
Propolis***	2.22	3.23
Perga***	2.30	3.14
Apilarnil**	2.51	3.09
Bee Venom	2.44	3.09
Polen***	2.00	2.95
Wax***	2.03	2.78
Honey (Pine)	1.50	2.57
Honey (Flower)***	1.49	2.55

Source: Own calculation.

Note: 1: 90 TL and below 2: 91-150 TL 3: 151-250 TL 4: 251-400 TL 5: 401-750 TL 6: 751-1200 TL 7: 1201-2000 TL 8: 2000 TL and above

According to Wilcoxon test, there is a difference at ***$p<0.01$, **$p<0.05$ and $p<0.1$ levels.

CONCLUSIONS

Honey is considered the most valuable food available to man [5]. When analysing the purchase prices of bee products, it was determined that consumers bought flower honey at an average price of 1.49 and pine honey at an average price of 1.50 before the pandemic. Upon comparing purchases of pollen, bee bread, propolis, beeswax, royal jelly, bee venom, and apilarnil by consumers before and after the pandemic, it was found that product prices had increased. Implementing occasional promotions on bee products with higher prices could prove effective in boosting consumer purchases and consumption.

Participants in the survey demonstrated that beforethe pandemic, the frequency of bee product purchaseswas at most once a month, with the least frequent purchase occurring once a year or even less. After the pandemic, there was a notable increase in the purchase frequency, with at least once a week being the most common. Flower honey and pine honey remained the most frequently purchased bee products before and after the pandemic. There was a noticeable surge in the purchase of propolis and pollen post-pandemic. Products like bee venom, perga, and apilarnil did not show a significant increase, likely due to their higher prices. The affordability of flower honey and pine honey was identified as the reason behind their high purchase frequency. The least consumed bee products included perga, beeswax, apilarnil, and bee venom.

Survey participants who frequently purchased bee products at least once a week predominantly chose supermarkets as their preferred shopping destination, followed by producers, cooperative sales stores, internet retailers, organic product stores, grocery stores, and markets.

Consumers consistently prioritize quality and additive-free nature from companies producing and packaging bee products, both before and after the pandemic. The reason for consumers avoiding market purchases is the open selling environment. Online sales, however, are not influenced by diverse package designs. Brand names emphasizing quality andadditive-free characteristics are considered more effective than package designs.

Consumers also give significant importance to expert opinions. It appears that as the income level rise, consumption of higher-priced bee products increases. Accessible pricing, with an average rate of 4.03 was identifies as another crucial factor in consumers' preferences, likely attributed to decreased purchasing power due to the economic crisis. Offering bee products in smaller, more affordable packages could address this concern.

In the analysis of consumers' attitudes towards bee products consumption, the highest-rated statement is "I pay attention to consume natural and organic bee products" with an average rate of 4.47. Consumers also express importance in the conditions of obtaining the product from the producer, health benefits, and the overall quality, appearance, and class of bee products, respectively. Consumers tend to avoid open purchases of bee products, favouring sealed jars.Since the early days of the COVID-19 pandemic in our country, natural immune-supporting products like bee products have garnered intense interest. While thesustainability of bees and bee products in agriculture has always been important, public attention heightened during the pandemic. The value of honey and bee products as nature's miraculous food became more apparent, reflecting positively in sales. If natural and economic conditions remain favourable, the upward trend in the sector is expected to continue.According to the survey results, consumers now demand high-quality and additive-free bee products post-pandemic. Considering this consumer sensitivity, thereis likely to be a sustained demand for bee products in the market.

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ASPECTS REGARDING THE IMPACT OF POLLUTION ON THE HEALTH OF THE INHABITANTS OF WESTERN REGION, ROMANIA

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Abstract

The present work aims to present aspects related to the main sources of environmental pollution that exist in the Western Region, as well as the impact of pollution on the health of the inhabitants, in order to ensure a healthy living environment for all the inhabitants of the region. Industrial activities located in this delimited area, sometimes very close or even in human settlements, lead to the appearance of intense sources of environmental pollution with effects on the health of the inhabitants. The short- and medium-term effects of air pollution are detrimental to human health and harm ecosystems and the economy. Long-term pollution affects the environment through: the effect of greenhouse gases, the destruction of the ozone layer, the presence of heavy metals, dust and suspended particles. The greenhouse gases specified in one of the annexes to the Kyoto Protocol are: carbon dioxide, methane, nitrous oxide. Heavy metals (mercury, cadmium, lead) are now well ahead of well-known pollutants such as carbon dioxide and sulfur and are predicted to be considered more dangerous than nuclear and solid waste. Heavy metal contamination is associated with their widespread use in industrial production, coupled with poor cleaning systems, as a result of which heavy metals enter the environment. Among all pollutants, suspended particles, nitrogen oxides, especially nitrogen dioxide, and ozone pose the highest risk to human health. Air pollution is potentially the most serious short- and medium-term health problem. Polluted air is the most difficult to avoid, and its effects penetrate everywhere and harm the health of the population. The Western Region has numerous sources of pollution such as the steel industry, the electricity and thermal energy production industry, the construction materials industry and the extractive industry.

Key words**:** *Western Region, pollution, heavy metals, disease, gas emissions*

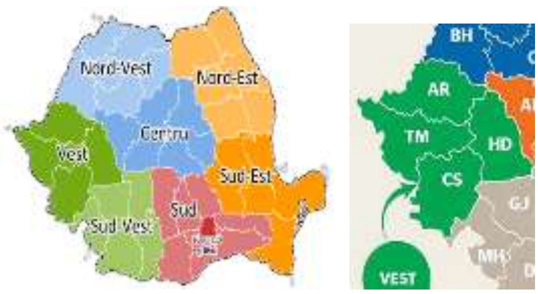
INTRODUCTION

This region analyzed in this study is situated in the Western part of Romania. Due to its location, the region has a strategic position in Europe, being the main gateway to Romania from Hungary and Serbia.

The Western Region analysed in this paper consists of the following counties: Arad, Timis, Caras-Severin and Hunedoara Map 1 [23].

To assess the level of air pollution at the local level, we analysed several pollutant emissions and were thus able to identify the air quality. [18]

At the Western Region level, there are air quality monitoring stations in each county, distributed as follows: Arad-4, Caras-Severin-4, Hunedoara-21, and Timis-4 [11].



Map 1. Location of the analyzed region
Sourse: Personal processing after https://www.google.com/search?q=regiunea+de+vest [23].

Map 2. The situation of suspended particles in the region
Sourse: Personal processing after https://www.google.com/search?q=regiunea+de+vest [23].

Suspended particles are a complex mixture of very small particles and liquid droplets. Larger particles are generally filtered out of the nose and throat and do not cause problems. Particles smaller than about 10 micrometres, called PM_{10}, and particles smaller than 2.5 micrometres ($PM_{2.5}$) can enter the respiratory tract and deep into the lungs and cause health problems [1], [7].
The situation of the suspended particles inthe studied region is shown in Map 2.
Hunedoara County has the largest share of regional CO_2 and N_2O emissions - 47.2% for CO_2 and 56.7% for N_2O; for CH_4, Timiș County has the highest contribution with 61.5%. The contribution of the energy sector to greenhouse gas emissions is significant, with 4.7% of total CO_2 emissions coming from this sector [9], [22].
In this context, the present work analyzes the main sources of environmental pollution existing in the Western Region, as well as the impact of pollution on the health of the population, in order to ensure a healthy living environment for all the inhabitants of the region.

MATERIALS AND METHODS

In order to carry out the study proposed in this article, we studied and analysed the information available in specialised databases. In addition to studying the literature, we also consulted works specifically dedicated to this subject. To better understand the effects of pollution, we contacted people specialised in this field who have direct contact with the places affected by pollution in the region analysed.
These people explained the problems from their point of view. In addition to the experts, we also met with the local authorities [15], [19].
As a result of these discussions, we were able to analyse the pollution problem more accurately because they gave us up-to-date data. The national statistics also helped, because they are up-to-date.
In this way, we were able to centralise the obtained data, process it and present the pollution situation in both tabular and graphical form. Finally, we were able to present some important conclusions of the study [2].

RESULTS AND DISCUSSIONS

Pollution is a worrying phenomenon that affects us every day, and studies show that prolonged exposure to pollution can cause various serious diseases [8].
The WHO (World Health Organization) draws attention to the fact that pollution makes this global warming crisis, in reality, a crisis with health implications [4], [14].
Air pollution is represented by the presence of harmful gases in the air and suspended particles (PM).
Chronic or recurrent inflammation of the airways generated by long-term exposure to atmospheric pollutants and, even more so if associated with unhealthy habits such as smoking, lead to damage to the cells that cover our respiratory system [9].
The main greenhouse gases tracked in this paper are: carbon dioxide (CO_2), methane (CH_4) nitrogen dioxide (NO_2), sulphur dioxide (SO_2) ammonia (NH_3) and ozone (O_3), and the main heavy metals are: Mercury (Hg), Cadmium (Cd) and Lead (Pb) [13].
Toxic metals come from the combustion of coal, fuels, household waste, etc. and from certain industrial processes.
They are generally found in particulate form (except for mercury which is gaseous).
Metals accumulate in the body and cause short- and/or long-term toxic effects [9],[14].

The main greenhouse gas emissions at the level of the Western Development Region are presented by county in Table 1, respectively Figure 3 [12].

Table 1. The situation of greenhouse gas emissions

County	CO_2, t/year	CH_4, t/year	N_2O, t/year
Arad	2,884.62	38,133.92	1,278.92
Caraş Severin	2,603.38	25,195.11	209.53
Hunedoara	5,803.00	76,307.65	2,045.35
Timiş	998.67	223,172.24	72.04
Western Region	**12,289.67**	**362,808.92**	**3,605.84**

Sourse: Processing and centralization according to the data from the authorities, http://statistici.insse.ro and Regional Action Plan for Environment 2019-2023 [9], [13]

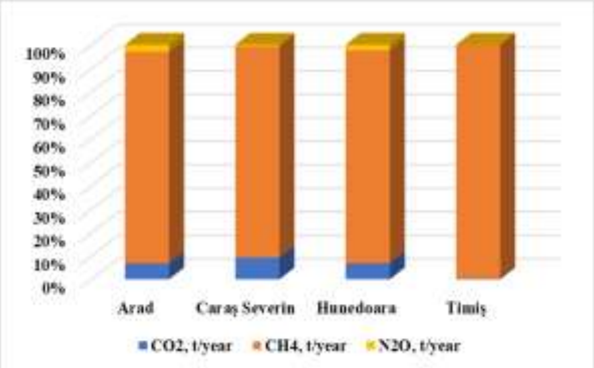


Fig. 3. The situation of greenhouse gas emissions
Sourse: Processing and centralization according to the data from the authorities, http://statistici.insse.ro and Regional Action Plan for Environment 2019-2023 [19], [13].

Carbon dioxide (CO_2) is a chemical compound resulting from the oxidation of carbon. On the other hand, it is a by-product in industrial processes such as the production of cement, steel, ammonia, methanol, ethylene, acetic acid, acrylic acid and other organic compounds. Carbon dioxide is essential for our survival because it is assimilated by plants in the process of photosynthesis, which in turn produce oxygen, which sustains life.

Carbon dioxide is an inert gas that can cause the elimination of oxygen (thus causing suffocation and death), it is a colorless gas, also present in the earth's atmosphere in a concentration of approximately 0.04% necessary to maintain the balance of the biosphere and one of the most important gases with an effect greenhouse [13], [14].

Methane (CH_4) is a greenhouse gas with a fairly large weight, contributing to the warming of the Earth's atmosphere. It is a colorless and odorless gas, soluble in organic solvents and insoluble in water.

Cooking with natural gas emits nitrogen dioxide, carbon monoxide, carbon dioxide and unburned methane that can linger indoors for hours after the stove is used. More than 700,000 children in the EU had asthma symptoms in the last year due to cooking with methane gas, and for adults, cooking with methane gas can have a negative impact on the brain, respiratory and nervous systems [13].

Nitrous oxide (N_2O), also known as laughing gas, is a dangerous chemical. It is a colorless gas with a sweet smell. N_2O is an oxidizer that can support combustion under certain conditions, but is stable at room temperature and has a mild anesthetic effect. and can make people laugh. In high concentrations it can cause suffocation [13].

From Figure 3 it can be seen that the emissions of CH_4 are considerably higher than those of CO_2 and N_2O in all counties of the western region, reaching the maximum value in Timiş county. As a result of the presence of certain pollutant emissions in the air, as a result of some chemical reactions, the pH of the air, precipitation and, sometimes, the soil changes [20].

Nitrogen dioxide (NO_2) is a chemical generated by engines, especially diesel engines. Exposure to it reduces resistance to infection and is associated with an increase in chronic respiratory diseases and premature aging of the lungs. For example, nitrogen dioxide pollution caused 49,000 premature deaths in the EU in 2020 [19], [1].

Sulphur dioxide (SO_2) is a colorless, bitter, non-flammable gas with a pungent odor that irritates the eyes and respiratory tract. Depending on the concentration and exposure period, sulphur dioxide has different effects on human health [10].

Exposure to a high concentration of sulphur dioxide over a short period of time can cause severe breathing difficulties. People with asthma, children, the elderly and people with chronic respiratory diseases are particularly affected [14].

Long-term exposure to a low concentration of sulfur dioxide can result in respiratory tract infections.

Ozone (O_3) is a highly oxidizing, highly reactive gas with a suffocating odor. It concentrates in the stratosphere and provides protection against life-damaging UV radiation. Ground level ozone causes respiratory irritation and eye irritation. High concentrations of ozone can cause reduced respiratory function.

Sulphur dioxide can potentiate the dangerous effects of ozone [10], [18].

Ammonia can be found in the air as a toxic gas with a pungent smell, liquid aerosols (NH_3) or solids (ammonium sulfate, ammonium chloride, etc.). Ammonia in relatively high concentrations is a strong irritant of the eyes and upper respiratory tract, the effect also depending on the salt formed. Due to its characteristic smell, it represents a discomfort factor [11].

Gas emissions with an acidifying effect from the studied region are highlighted both at the regional and county level in Table 2.

Table 2. Emissions of gases with acidifying effect

County	SO_2, t/year	NO_2, t/year	NH_3, t/year
Arad	13,715.32	9,999.09	4,624.97
Caraş Severin	19,857.78	3,884.71	5,951.73
Hunedoara	54,073.21	14,800.89	877.28
Timiş	3,973.56	1,380.56	9,295.63
Western Region	**91,619.87**	**30,065.25**	**20,749.61**

Sourse: Processing and centralization according to the data from the authorities, http://statistici.insse.ro and Regional Action Plan for Environment 2019-2023 [19], [13].

Analyzing Figure 4, it can be seen that the largest amounts of SO2 and NO2 came from Hunedoara County, while Timiş County had the lowest values for both gases.

Regarding NH3 emissions, they showed the highest values in Timiş county and the lowest in Hunedoara County.

It should be mentioned that the higher values of the concentrations recorded for the NH_3 indicator in Caraş-Severin County are not justified by the specifics of the economic activities in the area and it is assumed that they are of cross-border origin [17], [16].

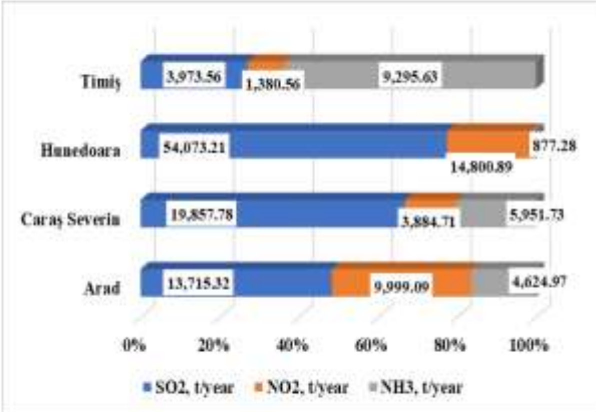


Fig. 4. Situation of gases with acidifying effect
Sourse: Processing and centralization according to the data from the authorities, http://statistici.insse.ro and Regional Action Plan for Environment 2019-2023 [19], [13].

If these chemical compounds appear in large quantities in the air, the pH of the precipitation decreases, they become acidic and become extremely harmful to the environment.

In the West Region, precipitation are collected in 37 sampling points. The lowest pH measured in the West Region was 4.9 and was recorded in Arad County. Emissions of heavy metals: mercury and cadmium come from various industrial processes and road traffic, for lead (Table 3)

Table 3. Heavy metal emissions

County	Mercury, kg/year	Cadmium, kg/year	Lead, kg/year
Arad	63.32	12.93	35,412.65
Caraş Severin	11.04	86.75	18,303.28
Hunedoara	407.36	411.22	7,546.49
Timiş	12.57	31.81	223.82
Western Region	**494.29**	**542.71**	**61,486.24**

Sourse: Processing and centralization according to the data from the authorities, http://statistici.insse.ro and Regional Action Plan for Environment 2019-2023 [19], [13].

In case of exposure to high concentrations, they can affect the nervous system, kidney, liver and respiratory functions.

One of the most used and at the same time dangerous heavy metals is mercury. It is used in amalgam fillings, mercury in thermometers and even insecticides used to preserve grains, real sources of poisoning with mercury preparations. Unfortunately, mercury crosses the placental barrier and that is why doctors in many countries call the attention of pregnant women to completely avoid tuna, considered to be one of the most contaminated fish with mercury. We are born without cadmium in the body because cadmium does not cross the placental barrier. At humans, cadmium accumulates predominantly in the kidneys and in smaller amounts in the liver and other organs. Studies by American doctors have proven the link between cadmium accumulation and cardiovascular diseases [21].

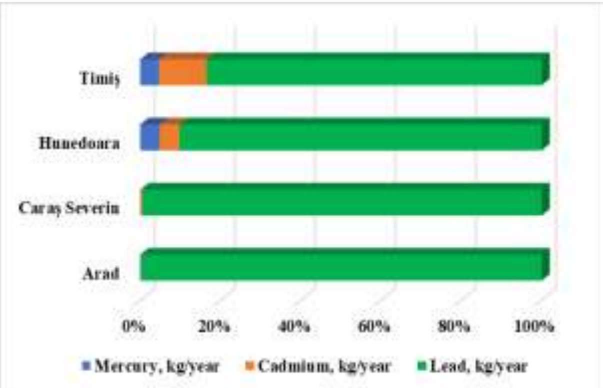


Fig. 5. The situation of heavy metals
Sourse: Processing and centralization according to the data from the authorities, http://statistici.insse.ro and Regional Action Plan for Environment 2019-2023 [19], [13].

Lead is one of man's old enemies. Since lead is present everywhere in nature and therefore also in many of the ingredients that make up our food, limit-admissible concentrations have been established for lead. Lead poisoning leads to the development of nephritis, the blocking of the activity of red blood cells and the disruption of the conductivity of nerve impulses. Sources of lead poisoning can be gasoline, foods and beverages stored in containers containing lead, or lead-containing paints [21].

To a large extent, mercury and, to a lesser extent, cadmium emissions also come from the waste treatment and storage activity. 82.4% of mercury emissions and 75.7% of cadmium emissions are found in Hunedoara County, while 57.6% of lead emissions come from Arad County. In the West Region there is a background pollution monitoring station, located in the Semenic mountain area, Caraş-Severin County (Figure 5) [20], [17].

Particulate matter is dust suspended in the air from the use of chemicals or the burning of fuels. For the indicators of suspended and sedimentable particles, frequent exceedances of the maximum admissible concentrations are recorded, which is not the case for the other pollutants [6].

The sources of atmospheric pollution with analyzed pollutants are:

- road traffic in all counties of the West Region, - steel and metallurgical industries (in Caraş-Severin and Hunedoara Counties)
- thermal power plants that use solid fuels (throughout the region)
- the cement industry (in Hunedoara County),
- household waste dumps (throughout the region)
- landfills for tailings (Caraş-Severin and Hunedoara Counties), etc. [9], [16].

In Table 4 we have presented data on the concentrations determined for suspended particles in the counties of the analyzed Region and the localities where the highest values are recorded.

Table 4. Concentrations determined for suspended powders

Specification				
County	**Arad**	**Caraş Severin**	**Hunedoara**	**Timiş**
City	Arad	Reşiţa	Chişcădaga	Timişoara
Annual average concentration, mg/mc	0.1897	0.1599	0.0688	0.0712
Maximum annual concentration, mg/mc	0.3000	0.3488	0.407	0.441
% of annual averages concentrations	200	232.5	271.3	294
Exceeded frequency, %	**89.91**	**44.12**	**14.53**	**7.51**

Sourse: Processing and centralization according to the data from the authorities, http://statistici.insse.ro and Regional Action Plan for Environment 2019-2023 [19], [13].

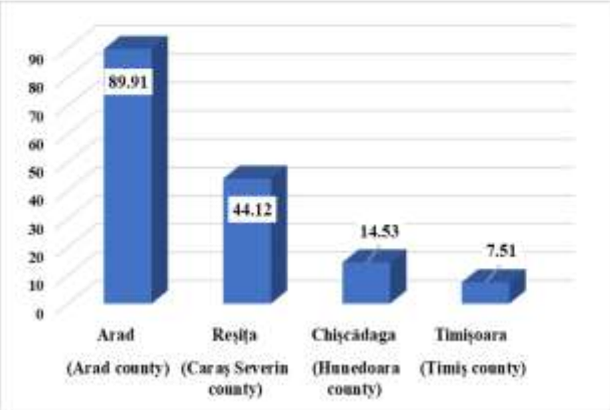


Fig. 6. Overtaking requency of suspension powders (%)
Sourse: Processed based on http://statistici.insse.ro, Regional Action Plan for Environment 2019-2023 [19], [13].

Figure 6 highlights the frequency of exceeding concentrations in percentage.
Table 4 also illustrates the fact that, although the highest average annual concentrations are recorded in the counties of Arad (0.1897mg/cm) and Caraş-Severin (0.1599mg/cm), the highest values of the maximum annual concentration were measured in Timiş County (0.441mg/cm) and Hunedoara (0.407mg/cm) [19], [18].
A comparison between the average annual concentration and the maximum annual concentration of the counties in the studied area can be seen in Figure 9.

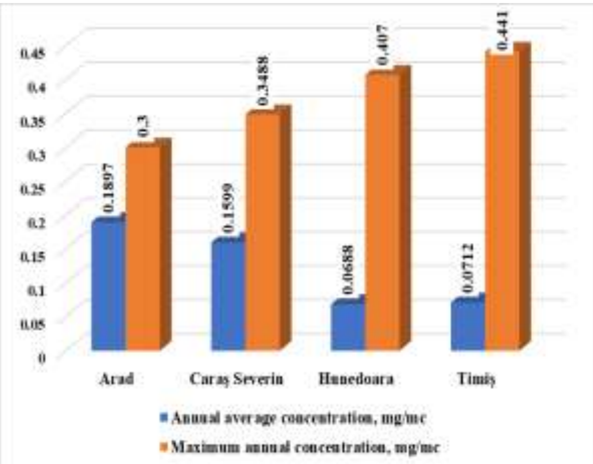


Fig. 7. Annual average concentration and annual maximum concentration (mg/mc) in Western Region
Sourse: Processing and centralization according to the data from the authorities, http://statistici.insse.ro and Regional Action Plan for Environment 2019-2023 [19], [13].

There are 26 large combustion plants in the West Region. The amount of gas emitted by them is shown in Table 5.

Table 5. The quantity of gases emitted by large combustion installations

County	Sulphur dioxide, t	Nitrogen oxides, t	Powders, t
Arad	105.551	643.279	358.411
Caraş Severin	16.401	209.221	3.117
Hunedoara	38,449.833	10,850.330	11,257.851
Timiş	2,333.122	956.703	120.051
Western Region	**40,904.907**	**12,659.533**	**11,739.430**

Sourse: Processing and centralization according to the data from the authorities, http://statistici.insse.ro and Regional Action Plan for Environment 2019-2023 [19], [13].

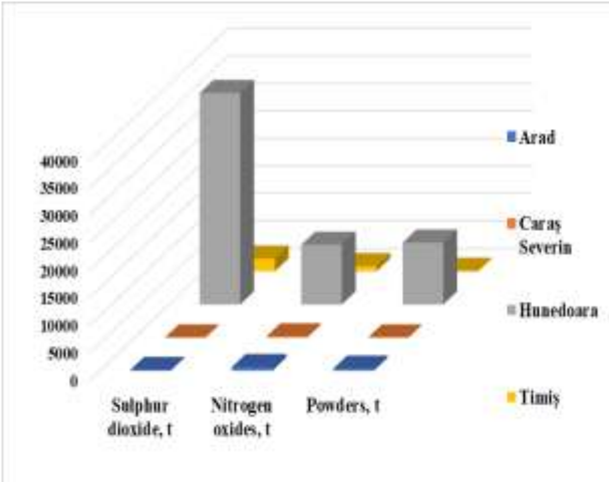


Fig. 8. The quantity of gases emitted by large combustion installations
Sourse: Processing and centralization according to the data from the authorities, http://statistici.insse.ro and Regional Action Plan for Environment 2019-2023 [19], [13].

Hunedoara County [3] has the main share of emissions from large combustion plants: 94% for SO_2, 85.7% for NO_2 and 95.9% for dust, values that can be observed in Table 5, respectively Figure 8.
Caraş-Severin County records the lower values for sulfur dioxide, nitrogen oxides and dusts.
Table 6 highlights the evolution of the number of illnesses by disease class in our country starting from 1992 until 2021.
To better highlight the evolution of these illnesses over time, at the national level, we have created Figure 9 below.

Table 6. Number of illnesses, by disease classes at the national level

	1992	2000	2010	2018	2019	2021
Tumors	45	40,689	68,349	96,996	108,141	85,552
Diseases of the circulatory system	413	678,398	884,666	816,231	872,278	788,682
Respiratory diseases	6,798	6,749,240	6,870,819	5,138,297	4,938,596	4,127,675
Congenital malformations, deformities and abnormalities	3	6,896	6,733	9,963	12,025	9,960
TOTAL	**7,259**	**7,475,223**	**7,830,567**	**6,061,487**	**5,931,040**	**5,011,869**

Sourse: Processing of the authors according to the received data and after http://statistici.insse.ro [13].

The lungs are permanently affected by the existing atmospheric pollution, that's why out of the total number of existing diseases at the national level of 5,011,869, the largest number is owned by respiratory diseases - 4,127. 675 [1], [5] (Table 6).

Statistics from Romania show that, annually, 10,770 Romanians are killed by bronchopulmonary cancer, this disease occupying the first place in the hierarchy of types of cancer in Romania.

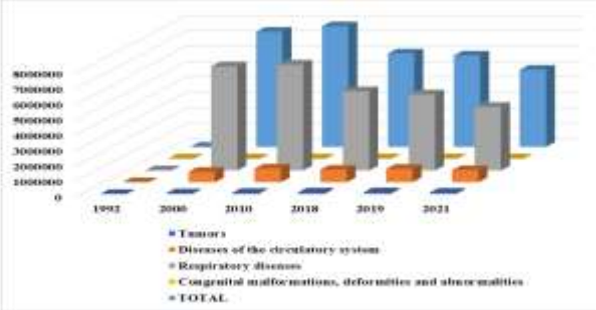


Fig. 9. Number of illnesses, by disease classes at national level

Sourse: Processing of the authors according to the received data and after http://statistici.insse.ro [13].

It is worrying that most of the patients who lost their lives after diagnosis came from Hunedoara County, from localities with major industrial pollution: Hunedoara and Simeria [1].

Based on the analyzed data, we managed to centralize the situation of deaths caused by pollution in the studied area, a situation presented in detail in Table 7.

Table 7. The situation of deaths in the analyzed region caused by pollution

Specification		1990	2000	2010	2018	2019	2021
Tuberculosis	**Western Region**	184	248	152	91	136	93
	Arad	49	55	26	26	25	20
	Caras-Severin	35	48	48	16	25	20
	Hunedoara	34	41	39	14	41	14
	Timis	66	104	39	35	45	39
Tumors	**Western Region**	3,543	4,056	4,665	4,691	4,689	4,696
	Arad	1,099	1,143	1,200	1,067	1,044	1,079
	Caras-Severin	599	643	689	739	685	700
	Hunedoara	750	912	1,168	1,235	1,250	1,235
	Timis	1,095	1,358	1,608	1,650	1,710	1,682
Diseases of the circulatory system	**Western Region**	15,949	15,989	14,579	12,874	12,771	14,220
	Arad	4,571	4,342	3,662	3,360	3,240	3,567
	Caras-Severin	3,142	2,937	2,755	2,439	2,343	2,651
	Hunedoara	3,372	3,811	3,383	3,511	3,443	3,936
	Timis	4,864	4,899	4,779	3,564	3,745	40,66
Respiratory diseases	**Western Region**	2,001	977	1,244	1,704	1,690	4,001
	Arad	501	205	422	452	508	1099
	Caras-Severin	460	254	138	221	241	621
	Hunedoara	401	268	385	354	340	1,087
	Timis	639	250	299	677	601	1,194
Congenital malformations, deformities and abnormalities	**Western Region**	141	72	54	25	15	15
	Arad	25	8	13	5	7	5
	Caras-Severin	24	16	9	-	2	2
	Hunedoara	38	21	13	5	1	4
	Timis	54	27	19	15	5	4
TOTAL	**Western Region**	**25,944**	**24,626**	**24,064**	**23,718**	**23,497**	**27,375**
	Arad	**7,250**	**6,559**	**6,133**	**5,903**	**5,872**	**6,926**
	Caras-Severin	**4,941**	**4,514**	**4,294**	**4,174**	**4,014**	**4,703**
	Hunedoara	**5,665**	**5,964**	**5,784**	**5,934**	**5,885**	**7,093**
	Timis	**8,088**	**7,589**	**7,853**	**7,707**	**7,726**	**8,653**

Sourse: Processing of the authors according to the received data and after http://statistici.insse.ro [13].

As can be seen from Figure 10, the evolution of the death situation was presented between 1990-2021, both at the level of the region and at the level of the region's component counties.

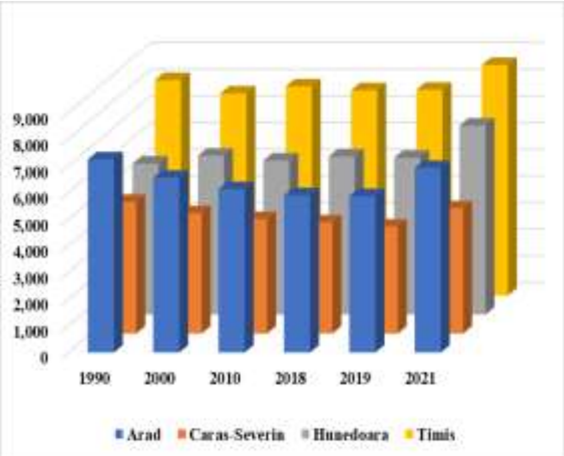


Fig. 10. The situation of deaths in the counties of the analyzed region caused by pollution (total)
Source: Processing of the authors according to the received data and after http://statistici.insse.ro [13].

Having the number of inhabitants of the region and the registered deaths, we managed to present the percentage of deaths from the number of inhabitants of the analyzed region for the years 2019 and 2021. Figure 10 highlights the deaths registered at the level of the area, in the period 1990-2021. [17], [3].
The counties of the region do not have an approximately equal number of inhabitants. The closest numerically are the counties of Arad and Hunedoara, as shown in the Table below. Caraş-Severin County has the fewest inhabitants, while Timiş is the most populated county in the region. The population of Timiş County is more than double that of Caraş-Severin County according to the centralized data in the table.

Tabel 8. Percentage of deaths registered in the analyzed region in 2019 and 2021

	Number of persons		Number of deaths		% deaths of total inhabitants	
	2019	2021	2019	2021	2019	2021
West region	**2,000,653**	**1,982,659**	**23,497**	**27,375**	**1.17**	**1.38**
Arad	470,558	466,820	5,872	6,926	1.24	1.48
Caraş-Serverin	317,265	310,073	4,014	4,703	1.26	1.51
Hunedoara	455,939	445,141	5,885	7,093	1.29	1.59
Timiș	756,891	760,625	7,726	8,653	1.02	1.13

Sourse: Processing of the authors according to the received data and after http://statistici.insse.ro [13].

In the analyzed years, a decrease in the number of inhabitants is observed in each county, but also in the entire region. Although the population has decreased, the same cannot be said about deaths caused by pollution. As shown in Table 8, the number of deaths caused by pollution increased in the analyzed years.
Both at the level of the region and at the level of the counties, an increase in the percentage of deaths among residents due to pollution is observed in the analyzed years.

CONCLUSIONS

In connection with greenhouse gas emissions, the county most affected by their effects is Hunedoara, followed by Arad, Caraş Severin and Timiş. Among the greenhouse gases mentioned in the paper, the one that most affects all counties in the region is methane.
Heavy metal emissions are also problematic in the study area. Lead emissions have very high values in the counties of Arad, Caras-Severin and Hunedoara. Mercury and cadmium emissions have low values in the counties of Arad, Caras-Severin and Timiş; only in Hunedoara do these two elements have high values. The frequency of exceeding the concentration determined by suspension powders registers high values in the counties of Arad and Caraş-Severin.
Another important category refers to the gases emitted by large combustion plants that affect Hunedoara County the most. Timiş County is affected to a very small extent by sulphur dioxide, on the other hand, Arad and Caras-Severin counties do not have problems with gases emitted by large combustion plants.
Even if the frequency of overtaking is the lowest at the sampling point in Timişoara (Timiş County), some maximum values were recorded here, the reason being the existence of heavy, particularly intense traffic, in the conditions of a damaged roadway, in an industrial area. Carbon dioxide, dust in suspension, nitrogen dioxide are atmospheric pollutants that can generate severe pathology of the respiratory tract. The greatest risk of developing bronchopulmonary cancer if there

is a long exposure to atmospheric pollutants is represented by active smokers and the elderly.

At the national level, the number of respiratory diseases registered huge increases from 1992 to 2010. After 2010, a visible decrease is observed at the country level from 6,870,819 cases to 4,127,676 cases, i.e. a decrease of 60.07% of respiratory diseases.

Respiratory diseases at the regional level doubled from 1990 to 2021, although the year 2000 saw a reduction in the occurrence of these diseases by about 50% compared to 1990. In the Western Region as a whole, the problems related to the registered cases of tuberculosis had a significant decrease after the year 2000. Tumors caused by pollution have increased considerably in the region from 1990 to 2021. Malformations and other medical problems recorded in the studied region were constant during the analyzed period.

Looking at deaths caused by pollution in the analyzed region, an increase of over 1,028 deaths in 2021 compared to 2019 can be observed in Hunedoara County. In Arad and Hunedoara counties, counties with numerically similar populations, the percentage of deaths caused by pollution increased from 2019 to 2021. In Arad County, an increase of 0.21% is recorded, and in Hunedoara County, an increase of 0.30%.

In Caraș-Severin County, the increase in deaths due to pollution increased by 0.25% in the analyzed period. The smallest increase in deaths can be observed in Timiș county, of only 0.11% in 2021 compared to 2019.

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COMPARATIVE INSIGHTS INTO LABOUR PRODUCTIVITY TRENDS IN THE EUROPEAN UNION'S AGRI-FOOD SECTOR

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Abstract

The agri-food sector stands as a fundamental pillar of the European Union's economic framework, essential for sustaining the region's population and playing a significant role in the overall economic health and stability of the EU. This study offers a comprehensive analysis of labor productivity trends in the EU's agri-food sector over the past decade, focusing on a comparative assessment between Romania and top-performing EU economies. Using data from Eurostat and national databases, we explore the dynamics of labor productivity, considering factors such as turnover, number of enterprises, and employment levels in the agri-food industry. The research reveals significant disparities in productivity growth, with countries like the Netherlands, Denmark, and Belgium showing high productivity levels, while Romania, despite a notable improvement, remains below the EU average. The study underscores the importance of strategic investments and policy interventions in boosting productivity and competitiveness in the agri-food sector across Europe.

Key words: *EU agri-food sector, labour productivity, economic performance, productivity trends*

INTRODUCTION

Over the last decade, the European Union's agri-food sector has experienced significant transformations due to various factors, ranging from technological advancements to policy reforms. This sector, vital for sustenance and economic stability, has seen diverse degrees of growth and productivity changes. One fundamental aspect underpinning these changes is nature's role in supporting life on Earth, providing essential resources like food, shelter, and clothing. However, the human population's rapid growth has started to strain these resources, especially regarding food demands [24]. Even that, a significant aspect of the agri-food sector is its capacity to produce large quantities of food, which brings forth its own set of challenges, particularly in managing this abundance. The food industry, along with agriculture, often struggles with effectively managing food production, leading to substantial waste. Issues within the supply chain, ranging from storage to distribution, contribute significantly to food waste, highlighting the need for more efficient management and sustainable practices in the sector [13].

These pressures have led to critical discussions on food security and the global population's ability to cope with hunger, a topic extensively covered in numerous studies [12]. Concurrently, the effects of global warming, such as increased air and ocean temperatures and melting snow and glaciers, have led to a rise in global sea levels, further impacting agricultural practices [6]. These environmental changes, coupled with the ever-increasing demand for sustainable and profitable agricultural practices, have transformed the global agricultural sector [21].

In this context, agriculture has become one of the most significant sources of pollution and greenhouse gas emissions, alongside sectors like transport and industry [10]. This environmental impact has brought to the

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forefront the need for sustainable production, especially as cereals, a major component of the world's basic food, have always held an important place in the global food economy [26].

The agricultural sector, facing limited resources, encounters significant challenges in crop cultivation [8]. Romania, with its favorable climate and fertile soil, is particularly conducive to cultivating oleaginous plants like sunflower and rapeseed [2]. Despite its agricultural potential, Romania still faces a range of risks and challenges in crop management, common to many countries but with certain unique aspects [5].

Before 2020, EU farmers enjoyed a relatively stable market, but recent events, including the COVID-19 pandemic and geopolitical tensions, notably the conflict between Russia and Ukraine, have dramatically altered market dynamics [3]. The creation of the EU single market aimed to stimulate and intensify trade exchanges, benefiting the entire community [19]. However, with current trends in production and consumption, there is a growing concern that future generations will face increased environmental challenges, including pollution, climate change, and extreme weather events [20].

Agriculture's role extends beyond just food production; it encompasses broader socioeconomic and environmental priorities [23]. This is evident in the diversity of European agriculture, reflected in farm sizes and the choice between conventional and ecological systems. Organic farms, for example, tend to be larger than traditional farms, reflecting a shift in agricultural paradigms [9, 22].

The EU's rural population is aging, the age structure is not harmonized and also training level shows a large gap versus the urban area [14].

In the EU, labour productivity in agriculture varies from a country to another [16] and the efficiency of its utilization as well [18].

In 2022, approximately 11% of Romania's population worked in agriculture, underscoring its vital role in the national economy [11].

Labour productivity in Romania's agriculture is very small compared to the level register in other EU countries [15, 18].

Labour force has a deep impact on agricultural production in Romania [27].

The increase of labour productivity in agriculture will have important implications on farming system [1, 28].

In the EU it is a large variation of labour productivity in agricultural enterprises among the member states as affirmed by [7].

Agricultural companies need to be financially supported to grow labour productivity [25].

In this context, the present resesarch offers a detailed examination of labor productivity trends in the European Union's agricultural and food sectors, with a special focus on Romania and a comparison with the EU's most successful countries in this area, is intended to offer an in-depth insight into these patterns.

This study is anticipated to reveal areas of growth, highlight the necessity for strategic investments, and identify possible strategies to improve productivity within the EU's agri-food sector.

This integrated text maintains the essence of each provided passage while creating a coherent narrative that logically connects the various aspects of the agri-food sector's challenges and transformations within the EU, with a special focus on Romania.

MATERIALS AND METHODS

This research utilizes a quantitative method to investigate labor productivity in the agricultural and food sectors of the European Union. It mainly draws data from Eurostat and various national statistical databases, ensuring a broad and thorough overview of the industry within the EU. The study concentrates particularly on companiesinvolved in food production.This encompasses a wide range of activities such as processing and preserving of meat and meat products, fish, crustaceans and molluscs, fruits and vegetables; production of vegetable and animal oils and fats; manufacturing of dairy products, grain mill products, starches and starch products; and the preparation of bakery and farinaceous products, condiments, tea, coffee, cocoa, as well as prepared animal feeds.

Key metrics analyzed encompass the turnover per person employed, the evolution of the number of enterprises, and employment figures in the agri-food industry from 2011 to 2020.

The comparative analysis focuses on the top 10 EU countries and Romania, with particular attention to annual growth rates, percentage changes over the decade, and the ratio of 2020 productivity to that of 2011. Additionally, the study examines the average productivity per employee, providing a broader perspective on the economic performance and trends within the sector.

A qualitative analysis complements the quantitative data, interpreting the economic strategies and market conditions that have influenced these trends. This approach ensures a multifaceted understanding of the variations in labour productivity across different EU nations, offering valuable insights for policymakers and stakeholders in the agri-food industry.

The methodology of this study is designed to capture the dynamics of labour productivity, thereby facilitating a comprehensive understanding of the sector's progress and challenges. It provides a robust framework for analyzing productivity trends and identifying key drivers of growth and efficiency in the agri-food sector across the European Union.

RESULTS AND DISCUSSIONS

Over the last decade, the agri-food industry within the European Union has displayed diverse dynamics in terms of the number of active enterprises. Analyzing the top 10 EU member countries, in France, the number of enterprises consistently declined from 57,446 in 2011 to 50,320 in 2020, which represents a decrease of 6,126 units or a reduction of approximately 10.7% (Figure 1).

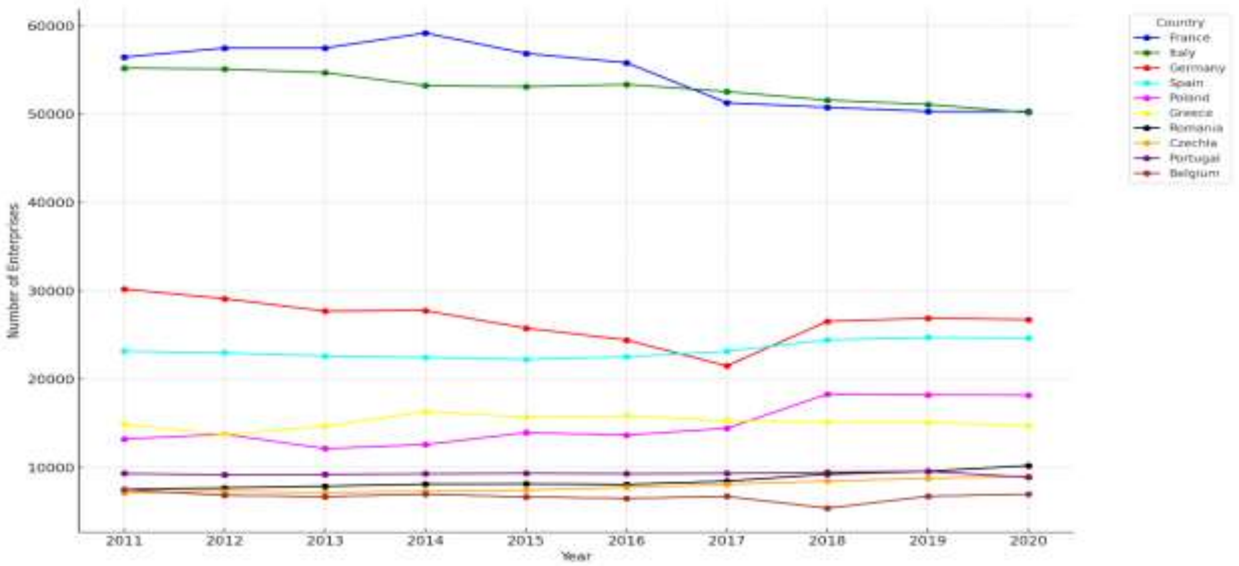

Fig. 1. Evolution of Agri-food industry enterprises in top 10 EU countries (2011-2020)
Source: Own representation based on data available on Eurostat, 2024 [4].

Italy showed a similar trend, with a decrease from 55,203 enterprises to 50,177 during the same period, signaling a reduction of 5,026 enterprises, which is a 9.1% decrease in percentage terms.

On the other hand, Germany experienced a different trajectory, with a decrease noted in the early stages of the decade, followed by a notable increase in 2018, and then stabilizing at 26,739 in 2020, down from 30,185 in 2011, indicating a total reduction of 3,446 enterprises, representing about 11.4%.

In Spain, a modest increase was observed from 23,165 to 24,654 enterprises, which is an increase of 1,489 units or 6.4%, suggesting a potentially more resilient market or an expansion of the agri-food sector.

Poland and Romania have shown remarkable progress, with Poland's figures rising from 13,219 to 18,162 and Romania's from 7,508 to 10,215. These represent growth rates of 37.4% and 36.1% respectively, signaling a strong expansion in the agri-food sector. Greece, after an initial increase, saw a slight decrease, reaching 14,760 in 2020 from 14,882 in 2011.

The Czech Republic and Portugal showed fluctuations over the decade but both countries ended the period with a net increase, thus demonstrating adaptability and progress in the sector. Belgium, however, recorded an overall decline (Fig. 1).

Looking at the turnover expressed in millions of euros of the first 10 EU member countriesover the years 2011-2020, we observe the following trends: Germany maintained its leading position throughout the analyzed period, with a steady increase in turnover, reaching a peak of 195,058.7 million euros in 2019, with a slight decrease in 2020. France also showed an upward trend, especially starting in 2017, reaching a turnover of 181,660.6 million euros in 2020, the largest increase among the 10 countries. Italy had a moderate increase over the years, except for a small decrease in 2020 compared to 2019. Spain also recorded sustainable growth, except for a decline between 2019 and 2020, despite impressive growth in the period 2016-2019. The Netherlands had a relatively constant growth, with small fluctuations, but a generally positive trend. Poland showed remarkable growth between 2016 and 2019, before a slight decrease in 2020. Belgium had fluctuations throughout the decade, but the turnover generally increased, with a notable decrease in 2018. Denmark showed steady growth throughout the period, without major fluctuations. Austria had an overall upward trend, with significant growth starting in 2017. Sweden had a more variable evolution, with a decrease between 2013 and 2015 and then a recovery and gradual growth until 2020 (Table 1).

Table 1. Turnover of the top 10 companies in the agri-food industry for the period 2011-2020, (millions of euros)

Country	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2020/ 2011**
Germany	160,297.8	166,787.9	172,858.2	171,065.5	166,844.5	170,544.1	183,270.0	185,172.5	195,058.7	195,020.4	121.66
France	143,800.4	151,804.3	154,703.1	156,836.6	153,639.7	150,330.9	178,558.9	179,886	181,212.4	181,660.6	126.33
Italy	106,497.3	106,833.9	111,302.7	111,423.8	113,226.8	113,661.2	117,954.9	119,783.3	122,543.5	122,052.8	114.61
Spain	85,752.3	86,482.0	87,257.5	89,515.5	92,676.6	95,075.7	101,577.6	105,514.3	111,215.1	109,442.2	127.63
Netherlands	58,184.2	60,217.0	64,428.1	63,932.9	65,616.7	68,472.2	70,772.7	70,651.1	70,506.3	72,894.9	125.28
Poland	42,368.8	46,626.3	47,519.5	48,124.5	47,954.0	49,199.3	55,090.7	59,744.0	63,090.0	60,587.2	143.00
Belgium	38,150.6	39,219.9	41,069.9	40,628.4	40,838.4	41,932.0	44,692.9	39,893.2	41,846.8	42,589.2	111.63
Denmark	20,859.0	22,616.5	24,297.6	24,349.2	24,615.7	24,480.6	25,764.3	25,984.7	26,258.9	27,013.9	129.51
Austria	14,444.6	15,273.8	16,398.7	16,647.9	16,592.8	16,708.9	17,761.1	19,512.8	19,896.1	19,640.5	135.97
Sweden	16,140.7	16,886.1	17,454.4	16,354.5	16,201.7	16,735.0	17,197.8	16,709.4	16,465.0	17,238.0	106.80

Source: Eurostat, 2024 [4].

In a retrospective look over the last decade, the agri-food industry has shown a variety of economic trajectories among EU member nations. Germany recorded solid growth, consolidating its position as an economic powerhouse with an increase of over 21%. France surprised with its economic dynamics, highlighting a growth of over 26%, attributed to a combination of innovation and expansion in the sector. Italy and Spain followed upward trends, with Spain recording the highest growth of nearly 28%, and the Netherlands also followed a positive course, with growth of over 25% (Figure 2).

Poland stands out particularly with the highest growth of 43%, a sign of remarkable economic development in this sector. On the other hand, Belgium had more tempered growth, reflecting a more stable market. Denmark and Austria also showed impressive increases, with Austria recording nearly 36%, resulting in a positive and sustainable development. Sweden, although with the most modest growth, maintained a steady growth trajectory, with a more tranquil evolution.

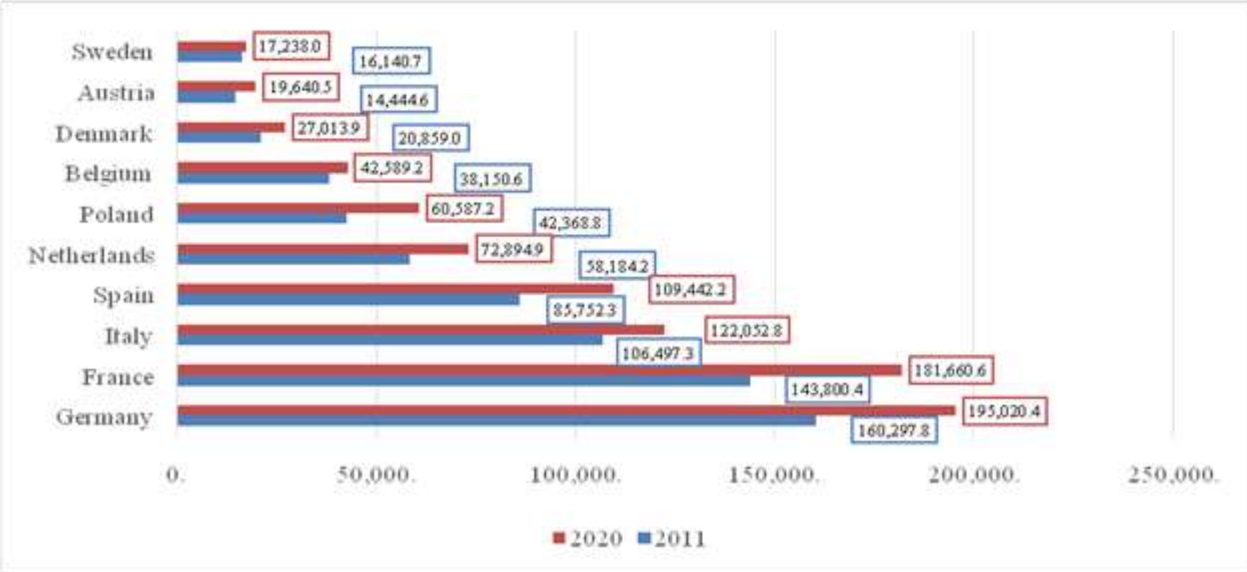

Fig. 2. Turnover of the top 10 companies in the agri-food industry for 2011 and 2020, (millions of euros)
Source: Own representation based on data available on Eurostat, 2024 [4].

These patterns clearly indicate notable transformations in Europe's agri-food sector, where certain countries are rapidly advancing while others expand at a steadier rate. This reflects the variety of economic approaches and the adaptability to shifts in market dynamics across different European nations (Fig. 2).

The number of employees in the EU agri-food industry remained relatively constant in the early years, with a slight decrease between 2011 and 2015. After 2015, a significant increase is observed, reaching 4,000,000 employees in 2018 and maintaining this level in 2020. This indicates a general expansion of the sector in the second half of the decade.

Germany experienced steady growth in the number of employees, except for a minor decrease between 2013 and 2014. In 2020, Germany accounted for 21.02% of the total EU employees in this sector, being an industry leader.France had moderate fluctuations, but overall, an upward trend, representing 16.07% of the total EU employees in 2020. The greatest growth is observed after 2015.

Poland showed steady growth, except for a slight decrease between 2019 and 2020, accounting for 10.24% of the EU workforce in this sector.Spain also experienced overall growth, contributing 9.62% to the EU workforce in this sector in 2020. The largest increase occurred between 2015 and 2020.Italy had a moderate and steady growth, representing 8.85% of the total EU employees in 2020.

In the case of Romania, a general stability in the number of employees is observed, with a slight decrease towards the end of the decade, representing 3.9% of the total EU employees in this sector. Romania thus occupies a modest position within the EU agri-food industry, having a smaller role compared to larger economies. The potential for development and growth in this sector remains an important aspect for the future of the agri-food industry in Romania.

The Netherlands, Greece, Hungary, Belgium showed moderate and steady growth throughout the decade, with minor variations from year to year.

Hence, the EU's agri-food industry has generally displayed an upward trend in employment numbers, with certain countries witnessing more substantial rises than others, indicative of the sector's expansion. Germany and France emerge as prominent leaders in this industry, whereas nations such as Poland and Spain are experiencing rapid and noteworthy growth (Table 3, Figure 3).

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Table 3. Evolution of the number of employees in the agri-food industry during 2011-2020

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2020%
UE 27	3,500,000	3,500,000	3,463,329	3,490,000	3,460,000	3,627,162	3,710,843	4,000,000	3,945,120	4,000,000	100.00
Germany	772,615	772,021	768,584	752,314	754,218	796,175	786,044	874,611	877,557	840,974	21.02
France	532,454	534,063	528,674	543,423	488,785	555,307	601,796	605,403	613,499	642,759	16.07
Poland	369,925	372,424	364,370	371,863	373,783	382,340	386,005	420,040	423,484	409,453	10.24
Spain	303,747	299,234	290,957	292,631	300,534	323,660	338,151	360,545	380,634	384,927	9.62
Italy	306,282	309,977	309,545	309,064	312,026	323,634	336,992	342,428	350,955	353,997	8.85
Romania	164,440	163,005	162,703	161,881	160,363	160,121	161,824	163,171	160,719	155,908	3.90
Netherlands	113,926	114,994	115,088	115,398	117,235	118,845	120,593	122,440	127,827	126,135	3.15
Greece	66,755	70,146	69,316	82,446	83,592	90,813	94,611	109,162	108,668	105,937	2.65
Hungary	86,314	87,364	87,032	87,952	91,074	90,008	89,951	95,147	91,593	91,647	2.29
Belgium	78,704	77,909	78,412	77,436	77,848	79,417	81,364	84,673	88,220	87,053	2.18

Source: Eurostat, 2024 [4].

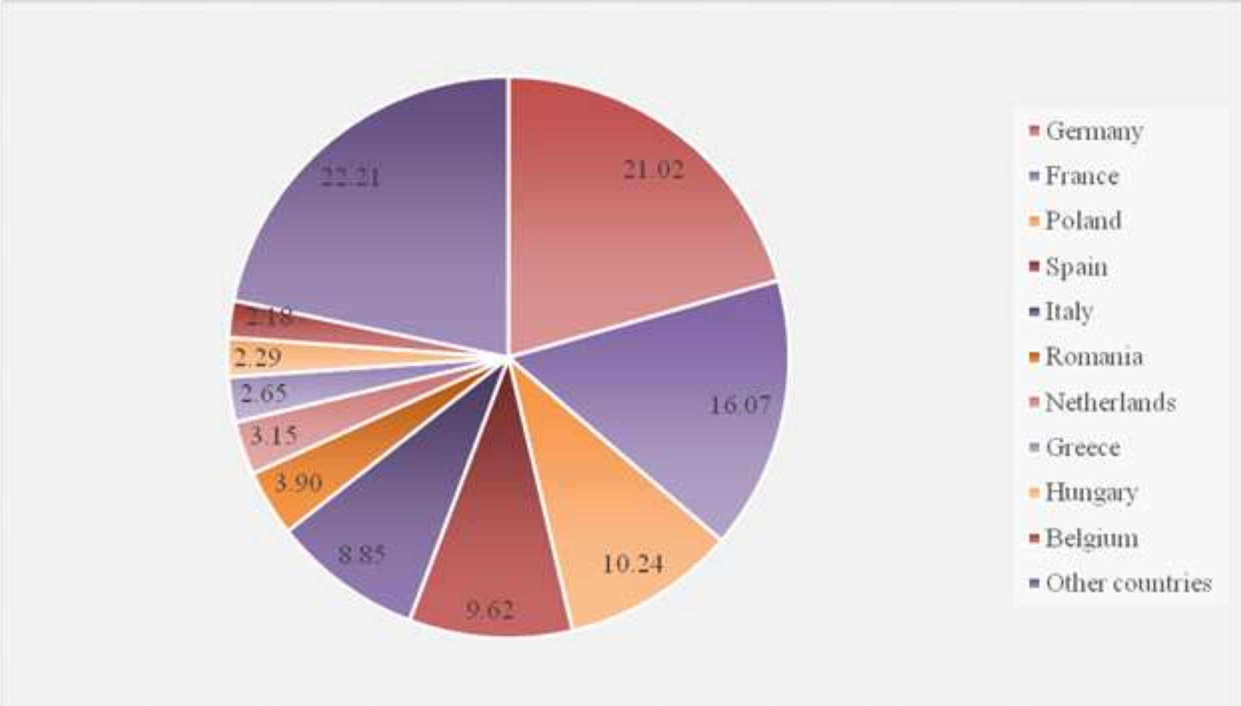

Fig. 3. Evolution of the number of employees in the agri-food industry for 2020 (%)
Source: Own representation based on data available on Eurostat, 2024 [4].

In terms of the evolution of the average number of employees in the agri-food industry for the top 10 countries, as well as Romania's position in comparison to these and its development relative to the EU average, all in the context of Malta's exclusion due to lack of data, the following observations can be made: Luxembourg, Denmark, and Germany have consistently remained in the top three for the number of employees throughout the decade, demonstrating a dynamic and resilient labour market in the agri-food sector.

Finland recorded a significant increase in 2020, while Ireland showed steady growth over the decade, culminating in a figure at the end of the period almost identical to that of 2011.

On the other hand, Poland experienced fluctuations, but a general decrease was observed towards the end of the decade. Austria and Hungary maintained relatively stable employee numbers, with a slight upward trend in Austria.

Lithuania experienced a notable decline in its workforce across the analyzed period, while the Netherlands saw a steady decrease in its average number of employees throughout the decade (Table 4).

Romania, not featuring in the top 10 at any time during the decade, also observed a gradual reduction in the average number of employees in its agri-food industry, dropping from 22.1 in 2011 to 15.4 in 2020.

Table 4. Top 10 EU countries by average employment, 2011-2020

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Luxembourg	33.0	35.8	37.7	37.8	40.2	42.8	42.2	43.8	45.5	44.9
Denmark	40.5	40.9	39.9	39.5	38.3	35.9	36.5	37.7	38.5	40.5
Germany	27.1	28.0	28.8	28.3	30.6	33.7	37.9	34.3	33.9	32.7
Finland	20.6	21.0	21.6	22.1	21.0	22.0	22.2	22.4	22.9	30.0
Ireland	28.6	27.8	26.9	27.4	27.6	27.7	26.2	28.0	29.8	29.9
Poland	29.3	28.4	31.3	30.8	28.2	29.2	28.0	23.8	24.1	23.4
Austria	19.7	20.6	20.7	21.0	21.1	21.5	21.8	23.0	22.8	22.7
Hungary	20.0	20.2	20.4	20.2	20.6	20.1	20.2	21.8	21.3	21.2
Lithuania	32.0	28.2	27.8	25.9	25.3	23.8	24.7	23.4	23.4	20.9
Netherlands	27.6	26.3	22.6	22.6	21.7	21.3	21.2	20.5	20.4	19.3
EU27	14.5	14.5	14.4	14.3	14.3	15.0	15.7	15.8	15.9	15.9

Source: Eurostat, 2024 [4].

This declining trend places Romania in a less favorable position relative to countries with the highest employee counts in the industry, ranking it 16th.The EU27 average shows slight fluctuations but generally an upward trend towards the end of the decade, increasing from 14.5 in 2011 to 15.9 in 2020. Romania's figures are above the EU27 average at the beginning but fall below this average starting in 2018 (Table 4, Figure 4).

Fig. 4. Top 10 EU countries by average employment, 2020
Source: Own representation based on data available on Eurostat, 2024 [4].

Analyzing the labour productivity per employee, measured in thousands of euros, for the top ten EU member countries over the selected decade, it was found that throughout this decade, the Netherlands consistently led the ranking in labour productivity per employee, starting with an impressive productivity of 492.0 thousand euros in 2011 and increasing to 557.8 thousand euros in 2020. Denmark followed a similar upward trajectory, with an increase from 346.2 thousand euros to 491.7 thousand euros over the analyzed period. Belgium showed growth until 2017, followed by a slight fluctuation, but ended the decade with a value of 453.5 thousand euros per employee, thus demonstrating an ability to maintain high productivity despite economic challenges.

Conversely, Ireland experienced a significant decline after a peak in 2012 of 650.8 thousand euros, dropping to 417.6 thousand euros in 2020. Among other top-performing nations are Sweden, Italy, France, Spain, Finland, and Austria, each displaying varying levels of productivity, but generally maintaining a stable or slightly increasing trend over the decade.

Romania, on the other hand, started from a much lower base, with a productivity of 50.6 thousand euros in 2011, growing slowly but steadily to 68.5 thousand euros in 2020. Although this growth is a positive sign, indicating an improvement in efficiency and value-added generated by the agri-food sector, Romania remains below the EU27 average and far behind the countries with the highest productivity.

Regarding the EU27 average, it increased from 211 thousand euros in 2011 to 233 thousand euros in 2020, signaling a modest but consistent rise in productivity across the union. This overall upward trend of the EU could be attributed to technological advancements, improvement in business practices, and an increasingly skilled workforce (Table 5).

The comparative analysis of these data illustrates a diversified economic landscape in the EU, where some countries have managed to maximize labour productivity in the agri-food sector, while others, such as Romania, although improving, still have much to do to align with European standards. This underscores the importance of investment in innovation, technology, and human capital development to increase productivity and competitiveness.

Table 5. Turnover per person employed between 2011-2020, thousand euro

Rank	Country	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2020 % EU	2020 / 2011
1	**Netherlands**	492.0	504.4	539.2	533.9	538.1	554.5	564.1	555.0	532.0	557.8	239.60	113.37
2	**Denmark**	346.2	379.1	418.7	420.0	440.3	461.4	481.8	470.1	489.6	491.7	211.21	142.03
3	**Belgium**	445.6	460.0	479.6	477.6	480.2	484.5	502.6	444.4	443.1	453.5	194.80	101.77
4	**Ireland**	590.0	650.8	586.0	557.1	540.8	495.3	500.3	445	390.2	417.6	179.38	70.78
5	**Sweden**	271.7	292.3	305.2	291.8	283.9	289.0	299.0	288.1	285.1	313.4	134.62	115.35
6	**Italy**	268.6	271.1	283.0	286.5	289.3	282.8	285.4	287.3	289.0	287.8	123.63	107.15
7	**France**	256.7	270.6	279.3	275.7	300.6	260.9	288.5	288.1	287.6	275.8	118.47	107.44
8	**Spain**	269.6	276.0	281.7	289.7	293.0	281.4	287.9	279.4	280.6	272.8	117.18	101.19
9	**Finland**	267.0	280.1	280.7	275.5	267.4	266.4	257.9	262.1	265.2	263.7	113.25	98.75
10	**Austria**	210.7	217.2	228.9	225.7	221.7	221.8	230.7	244.7	246.5	245.3	105.37	116.42
26	**Romania**	50.6	51.8	55.2	55.3	59.2	58.9	60.9	62.7	66.8	68.5	29.42	135.38
	EU 27 average	211	220	229	228	230	223	236	234	231.6	233	100.00	110.33

Source: Eurostat, 2024 [4].

CONCLUSIONS

The past decade has witnessed a period of significant evolution within the EU's agri-food sector. This era has been characterized by a complex interplay of environmental, technological, and economic forces, reshaping the landscape of agricultural production and labour productivity across the Union.

Amidst the backdrop of these changes, environmental concerns, particularly those related to global warming, have emerged as critical drivers. The agricultural sector, while vital for feeding the growing global population, faces the dual challenge of mitigating its environmental impact and adapting to the changing climate. The increase in temperatures, melting glaciers, and rising sea levels underscore the urgency of transitioning towards more sustainable farming practices.

In terms of labour productivity, the study reveals a tapestry of varying performances across the EU. While some nations exhibit high levels of productivity, reflecting advanced agricultural practices and efficient use of resources, others, like Romania, though improving, still lag behind. The journey of Romania, with its unique agricultural strengths and challenges, exemplifies the diverse economic trajectories within the EU. Despite its potential, Romania grapples with challenges in crop management, market dynamics, and environmental sustainability, necessitating focused efforts to enhance productivity.

The creation of the EU single market has been a significant economic milestone, fostering trade and growth within the community. In recent years, external factors like the COVID-19 pandemic and geopolitical conflicts have significantly reshaped the agriculture and trade landscape. These events have brought new challenges and complexities, highlighting the importance of resilience and adaptability in agricultural and economic strategies.Looking to the future, it's clear that the agri-food sector in the EU, and particularly in Romania, stands at a crossroads. Embracing sustainable practices, investing in innovation and human capital, and adopting new technologies like the metaverse will be crucial in navigating the challenges ahead. The sector's future success will hinge on its ability to integrate environmental priorities with economic goals, reflecting a broader commitment to sustainability and resilience.

In summary, while the EU agri-food sector faces an array of challenges, it is also poised for transformative growth. For Romania, this represents an opportunity to leverage its unique advantages while embracing change and innovation. As the sector moves forward, it will increasingly reflect the broader socioeconomic and environmental priorities of our times, signaling a new era of sustainable, efficient, and integrated agriculture within the EU.

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EMPLOYMENT TRENDS IN EUROPEAN UNION'S MEAT PROCESSING COMPANIES: A TEN-YEAR PERSPECTIVE, 2011-2020

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Abstract

The study provides an in-depth analysis of employment trends within the European Union's meat processing industry over a ten-year period, from 2011 to 2020. It specifically focuses on companies across various employee size categories, emphasizing Romania's position within these dynamics. The research employs comprehensive data from Eurostat, assessing changes in the labour force across different company sizes and countries. The study uncovers notable variances in labour force evolution, reflecting the distinct impacts of economic conditions, industry-specific factors, and regulatory frameworks in each nation. Germany exhibited a significant rise in its labour force in larger companies, while Spain showed the highest growth rate, more than doubling its labour force in this sector. Contrarily, Poland experienced a minor decrease, illustrating a different trend. Italy and Romania both marked considerable growths, with Romania demonstrating notable progress, particularly in larger companies. These findings highlight the multifaceted nature of labour dynamics in the EU meat processing industry, influenced by a complex interplay of market demand, technological advancements, and economic policies. The study underscores the sector's essential role in the EU's economy and the need for adaptable labour force strategies in response to changing industry landscapes.

Key words: *meat processing industry, labour force dynamics, employment trends, industry evolution*

INTRODUCTION

Climate change is at the forefront of European decision-making, significantly influencing both natural and human systems [10]. This has spurred a global focus on developing solutions for climate change adaptation, disaster risk reduction, and sustainable practices, with a special emphasis on circular economy models and societal impacts [5]. In the field of agriculture, an essential component for global food security, there's a marked shift occurring within the European Union (EU) [11, 18]. Farmers, who are central to this sector, are facing the challenges of rising input costs, the use of fertilizers and pesticides and circular economy [8, 18]. These costs are partly attributed to the EU's dependency on countries like Russia, Ukraine, and Belarus, which, in 2021, supplied a significant portion of the fertilizers used in the region [3].

The EU has traditionally focused on conventional agriculture, aimed at maximizing profits and labor efficiency [17]. However, this approach is being reassessed due to its environmental impacts and questions about its long-term sustainability [14]. In response, there's a noticeable movement towards organic farming, which not only signals a shift to more environmentally friendly practices but also holds the promise of feeding Europe until 2050 and supporting grain exports to other countries. Organic agriculture could provide healthier food products [7, 13, 14].

In this evolving landscape, the role of processing companies becomes critically important. These companies, pivotal in transforming raw agricultural products into finished goods, form an integral part of the food supply chain. Their business turnover and employment rates are significant indicators of the sector's health and impact on the economy. Romania, in this context, is noteworthy. Its agricultural sector, dominated by small and semi-subsistence farms, is complemented by a network of processing companies [15]. These businesses are essential in adding value to agricultural products, thereby boosting the sector's overall profitability. The turnover of these companies provides insights into the health of the agricultural economy, where high turnovers indicate robust demand and efficient processing capabilities, while lower figures might signal market challenges or inefficiencies.

The employment aspect in the processing sector is equally vital, especially in economies like Romania, where small-scale farming prevails [20]. Processing companies in these regions often become key employers, offering stable jobs, and contributing to the economic stability of rural areas. This is particularly important in a landscape where farming alone might not provide sufficient economic support for local communities [9].

Additionally, the environmental footprint of these processing companies is increasingly scrutinized, aligning with the broader EU focus on sustainable practices. The push towards sustainability encompasses not just how food is grown, but also how it is processed and brought to market, as processing methods can significantly impact the carbon footprint of food products.

In conclusion, as the EU and particularly Romania navigate the challenges of sustainable agriculture, the role of processing companies, their contribution to business turnover, and the employment they provide are key factors in shaping a resilient, economically viable, and environmentally conscious agricultural sector [16]. Cooperatives have provided access to factors of production, technology, or markets for farmers and growers [6]. These elements intertwine with consumer demands, market dynamics, and environmental considerations, offering a comprehensive view of the agricultural landscape in the EU [12].

The EU meat processing industry is facing challenges in terms of the reduction of livestock, high input costs, and product quality [19].

In this context, this study aimed to offer an in-depth analysis of employment trends within the European Union's meat processing industry in teh period 2011 to 2020, emphasizing various employee size categories of the companies and especially in Romania.

MATERIALS AND METHODS

The study utilizes comprehensive employment data from Eurostat, focusing on the meat processing industry in the European Union. Data were collected for companies of various sizes, specifically those with 0-9, 10-19, 20-49, 50-249, and over 250 employees. The time frame of analysis spanned from 2011 to 2020.

A quantitative approach was adopted to evaluate the labor force numbers annually. Comparative analysis techniques were employed to discern trends and changes in labor force sizes across different countries within the EU. Special attention was given to the growth or decline rates of these numbers, to understand the underlying patterns and influences in each member state, with a particular emphasis on Romania’s position in these dynamics.

The study's methodology allowed for a comprehensive overview of the labor force trends and provided insights into the broader economic and regulatory impacts on the meat processing industry in the EU.

RESULTS AND DISCUSSIONS

In the context of this study, we aim to analyze the numerical evolution of companies in the meat processing and meat product sector within the European Union, with a particular focus on the top five member countries in terms of the number of these entities, as well as Romania's position in this context. The time interval targeted is the decade from 2011 to 2020.

We observe that the total number of companies in the EU27 has decreased from

37,700 in 2011 to 33,364 in 2020, representing a reduction of 11.50%. This general trend of reduction could be attributed to the consolidation processes within the industry, possibly reflecting both mergers and acquisitions, as well as a potential restructuring following changes in regulations or market demand.

Analyzing each of the top five countries individually, Germany, being at the top of the ranking, shows a reduction of 17.91% in the number of companies, suggesting a concentration of production in the hands of a smaller number of larger entities. On the other hand, France shows an even more pronounced decrease of 30.70%, one of the most significant declines among the countries analyzed.

In contrast, Poland exhibits an increase of 16.12% in the number of companies, contrary to the general trend observed in the EU. This phenomenon indicates an expansion of the sector in this country stimulated by a favorable economic environment and a diversification of business strategies.

Romania's case is interesting, ranked seventh, where an increase of 15.27% in the number of companies is noted, suggesting a positive dynamic of the sector in the national context, potentially influenced by internal economic factors and a growing market (Table 1).

Table 1. Top 5 European countries in meat and meat product processing companies and Romania's position, 2011-2020

No	Country	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2020/2011	Share
	EU 27	37,700	38,114	37,000	37,000	38,211	35,000	32,671	34,066	33,885	33,364	88.50%	100.00
1	*Germany*	11,295	11,120	10,225	9,440	10,206	8,925	7,409	9,445	9,518	9,272	82.09%	27.79
2	*France*	6,540	7,299	7,970	8,425	8,399	6,392	5,466	5,108	4,749	4,532	69.30%	13.58
3	*Spain*	4,062	3,910	3,297	3,455	3,657	3,714	3,661	3,500	3,503	3,459	85.16%	10.37
4	*Italy*	3,601	3,555	3,500	3,458	3,463	3,421	3,182	3,132	3,162	3,185	88.45%	9.55
5	*Poland*	2,692	2,787	2,448	2,486	2,730	2,684	2,788	3,246	3,172	3,126	116.12%	9.37
7	*Romania*	773	777	793	817	801	800	814	839	834	891	115.27%	2.67

Source: Eurostat, 2024 [4].

The impact of the pandemic has been particularly acute in the business sector, leading to a downturn in company performance. In Romania, the aftermath of the 2008-2011 financial crisis saw a significant increase in corporate debt levels, from 65% to 76%, which in turn led to a spike in insolvencies. However, subsequent economic growth has helped to reduce the number of insolvency cases.

At a broader European level, the analysis of insolvency trends reveals some interesting patterns. While there was an expectation of a significant increase in insolvencies in 2020 due to the global economic shock, the actual outcome was a 12% decrease. This discrepancy can be attributed to massive state interventions, which prevented more than 35% of potential insolvencies globally. This trend was especially pronounced in Western Europe, where government interventions averted roughly half of the expected insolvencies[1].

The Eurozone experienced a 6.8% GDP contraction in 2020, but with various countries implementing different measures to combat the economic impact of the pandemic, the recovery has been uneven. For instance, countries like France, Belgium, Italy, and Spain enacted laws in 2020 that temporarily froze bankruptcy proceedings or declared bankruptcies inadmissible. These measures led to a sharp decrease in insolvencies for the year[2].

In the meat processing sector, most companies are small and medium-sized enterprises (SMEs), which have been particularly affected by these economic shifts. The European Regional Development Fund (ERDF) 2014-2020 aimed to enhance the competitiveness of these SMEs, a goal that seems to have been reflected in their upward trend. The case of Germany is notable, where a large share of meat processing companies are also SMEs. The German three-pillar banking system, characterized by fragmentation and the presence of small local creditors, plays a significant role in this sector. This structure has likely influenced the high proportion of SMEs in the industry.

In summary, the European insolvency landscape, particularly in the wake of the pandemic, illustrates the delicate balance between economic pressures and state interventions. The meat processing industry, dominated by SMEs, has been significantly impacted by these broader economic trends.

Table no. 2 presents a detailed overview of the small-scale meat processing industry in Europe, focusing on the top five countries and Romania over a decade. These top five countries collectively hold 68.29% of all European companies with 0-9 employees in this sector. Except for Poland, each of these countries has experienced declines since 2011, particularly after 2017 due to the swine fever crisis. Romania, in the sixth position, comprises 2.62% of the total European sector.

Out of 33,364 European meat processing companies, a significant 66.64% are micro-enterprises, underscoring the prominence of small businesses in the industry (Table 2).

Table 2. Top 5 European countries by meat processing companies with 0-9 employees and Romania's position

No		2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2020/2011	Share
	EU 27	24,907	24,476	25,357	25,752	25,627	22,723	21,922	21,959	22,590	22,235	89.27%	100.00
1	*Germany*	6,145	6,669	5,941	5,811	5,477	3,976	3,722	4,366	5,405	5,116	83.25%	23.01
2	*France*	5,502	6,046	6,770	6,919	6,771	5,091	4,531	4,157	3,782	3,531	64.18%	15.88
3	*Spain*	2,684	2,625	2,086	2,371	2,437	2,487	2,379	2,354	2,292	2,320	86.44%	10.43
4	*Italy*	2,538	2,504	2,470	2,450	2,461	2,388	2,213	2,162	2,174	2,214	87.23%	9.96
5	*Poland*	1,617	1,726	1,428	1,466	1,761	1,726	1,876	2,093	2,027	2,004	123.93%	9.01
6	*Romania*	387	395	425	452	449	454	463	490	514	583	150.65%	2.62

Source: Eurostat, 2024 [5].

These data highlights the critical role these companies play in the European meat processing industry landscape, reflecting the challenges and shifts they have encountered over the years, including economic shifts and health crises like swine fever.

It's clear that Table 3 shows an overall decline in the number of companies with 10-19 employees within the EU27, with a decrease from 6,813 in 2011 to 5,278 in 2020, which is a 77.47% change over the period. Germany leads with the highest number of such companies, despite a decrease to 64.38% of its 2011 figures. The table also highlights that, in contrast to Romanian companies with 0-9 employees, which saw an increase, those with 10-19 employees experienced a decrease in 2020 compared to 2011 by 22.8%.

For Romania, the table indicates a decrease in the number of companies with 10-19 employees, holding a 1.61% share of the EU market in this category by 2020.

Table 3. Top 5 European countries by meat processing companies with 10-19 employees and Romania's position

No	Country	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2020/2011	Share
	EU27	6,813	6,195	5,874	5,229	6,397	6,337	4,983	6,100	5,223	5,278	77.47%	100.00
1	*Germany*	3,933	3,224	3,048	2,389	3,488	3,525	2,295	3,404	2,409	2,532	64.38%	47.97
2	*Italy*	546	539	535	527	503	539	500	495	507	490	89.74%	9.28
3	*Spain*	592	556	507	416	454	464	526	430	480	467	78.89%	8.85
4	*France*	347	495	495	577	621	527	416	429	441	460	132.56%	8.72
5	*Poland*	281	288	270	288	266	250	230	391	387	412	146.62%	7.81
8	*Romania*	110	100	102	95	97	98	106	111	92	85	77.27%	1.61

Source: Eurostat, 2024 [4].

This trend of decrease is consistent with the broader EU trend, except for France and Poland, which show an increase in the number of companies compared to 2011, with France growing to 132.56% and Poland to 146.62% of their 2011 figures (Table 3).

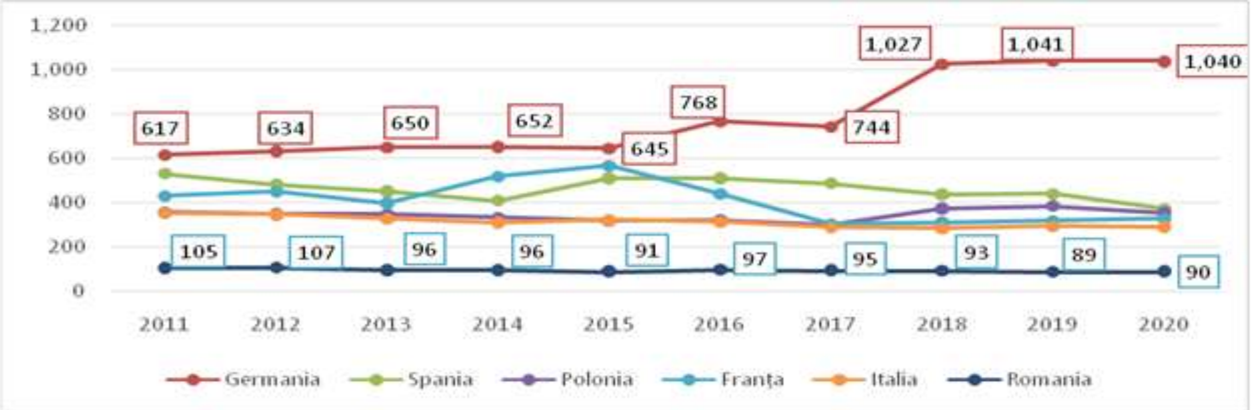

Fig. 1. Top 5 European countries by meat processing companies with 20-49 employees and Romania's position
Source: Own representation based on data available on Eurostat, 2024.

Germany's trend line shows a remarkable upward trajectory, particularly from 2016 onwards, reaching its peak in 2019 with 1,041 companies, and maintaining nearly the same number in 2020 with 1,040 companies. This signifies a strong growth in medium-sized meat processing companies within Germany, dominating the industry compared to the other countries shown.

Spain, Poland, France, and Italy demonstrate relatively flat or slightly declining trends over the decade. Spain's numbers show a gradual decline overall, ending lower in 2020 than where they started in 2011. Poland's line remains stable with minor fluctuations, suggesting a consistent industry size throughout the years. France exhibits some variability with a significant drop between 2016 and 2018 but shows a slight recovery by 2020. Italy's number of companies declines consistently over the period, indicating a shrinkage in this sector of their meat processing industry. Romania's line, while starting the lowest, remains relatively flat, with a slight dip in the mid-decade and a small uptick in 2020. Although Romania has the fewest companies of this size among the countries represented, its industry shows resilience with little change over the years (Figure 1.).

Between 2011 and 2020, medium-sized meat processing companies in the EU experienced a decline, with Romania facing a notable decrease, ending with a 4.48% market share. Germany's minor drop contrasts with Italy and Spain's growth, suggesting varied industry health across the EU. Romania's medium-sized meat processing sector saw a significant reduction over a decade, diminishing to 68.94% of its presence in 2011 and holding a 4.48% share of the EU market by 2020 (Table 4).

Table 4. Top 5 European countries by meat processing companies with 50-249 employees and Romania's position

No		2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2020/2011	Share
	EU27	2,239	2,221	2,102	2,270	2,298	2,256	2,152	2,085	2,103	2,030	90.67%	100.00
1	*Germany*	509	503	496	499	503	556	542	540	563	486	95.48%	23.94
2	*Poland*	343	331	309	308	294	304	298	297	288	277	80.76%	13.65
3	*Spain*	218	209	213	210	212	208	219	220	225	233	106.88%	11.48
4	*Italy*	137	143	142	149	157	161	158	167	163	166	121.17%	8.18
5	*France*	225	244	238	323	347	264	173	168	163	165	73.33%	8.13
6	*Romania*	132	132	124	129	121	107	106	102	96	91	68.94%	4.48

Source: Eurostat, 2024 [4].

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The EU27 has experienced a general increase in the number of large meat processing companies, which suggests a trend of growth and consolidation within the industry at a larger operational scale.

Germany, as the leader, has shown a substantial increase in its number of large companies, although not the largest in terms of percentage growth, it still holds the most significant share within the EU (Figure 2).

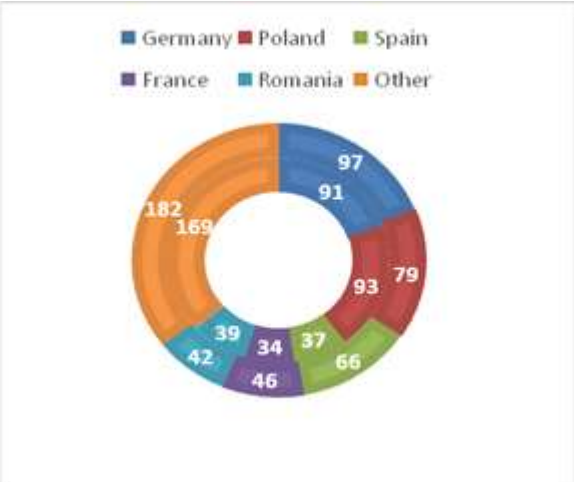

Fig. 2. Top 5 European countries by meat processing companies over 250 employees and Romania's position
Source: Own representation based on data available on Eurostat, 2024 [4].

Poland's decrease in the number of large companies indicates a possible shift, due to economic pressures or internal restructuring within its meat processing industry. Spain stands out with the highest percentage increase among the top five countries, indicating an aggressive expansion or favorable market conditions that have supported the growth of larger companies in the sector. France also demonstrates a considerable increase, although not as pronounced as Spain's.

Romania, while having the smallest share among the mentioned countries, shows an increase in the number of large companies, reflecting potential growth within its large-scale meat processing sector.

The data regarding the turnover of companies operating in the meat processing industry indicates a positive trend in the revenue of meat processing companies within the EU between 2011 and 2020, highlighting overall growth in this sector. Germany, positioned at the forefront, exhibits an increase in revenue, reflecting a robust industry. France, while trailing Germany, also displays revenue growth. Spain, notably, has seen the most significant percentage increase in meat processing revenue, suggesting expansive industry development.

Italy demonstrates a healthy rise in revenue figures, while Poland's substantial growth could signal an increase in production and export activity. Romania, placed 13th, has a smaller share of EU revenue but shows potential for growth within the meat processing industry.

Fig. 3. Turnover of the companies operating in the meat processing industry in 2020
Source: Own representation based on data available on Eurostat, 2024 [4].

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In the fiscal landscape of 2020, the revenue performance of the meat processing sector in the EU illustrates resilience and growth, despite the global challenges presented during the year. Germany not only retained its lead but also grew its revenue, reinforcing its status as an industry powerhouse. France and Italy also registered increases, with France’s revenue indicating steady growth and Italy displaying resilience in the sector.

Spain stands out with remarkable revenue growth in 2020, the most significant among the top five nations, possibly indicative of strategic industry advancements or a successful navigation of market conditions.

Poland, while also growing, did not match the percentage increase of Spain, but the positive change in revenue suggests robust sector health and competitiveness.

Romania, though holding a minor share within the EU's revenue for meat processing companies, also experienced an uptick in 2020. The growth, while modest, reflects an industry that is managing to hold its ground and exhibits potential for future development amidst larger European counterparts.

The data presented in Figure no. 5tracks the turnover of meat processing businesses with 0-9 employees across the top five European countries and Romania, measured in millions of Euros from 2011 to 2020.

Overall, the EU27 witnessed a significant decline in turnover by 56.37% during this period, indicating the sector was heavily impacted, with the trade sector being the most affected. Despite a decrease in the number of small businesses in Germany, there was a substantial 72% increase in turnover, which underscores Germany's dominant market position with a 37.87% share.

France’s trend is notably downward during this decade. The year 2011 stands out, with a subsequent decrease of 93.35% in turnover by 2020, showing significant fluctuation in the sector.

Poland showcases a dramatic growth, over fivefold, which could reflect an impressive sectoral expansion or improvement in business performance.

Italy's figures hover around the same initial mark, with a turnover that slightly decreased by 14%, which may reflect relative stability in the market size of small meat processing companies.

Spain's turnover decreased by around 16%, whereas Romania showed an improvement, with an increase of approximately 105%, albeit starting from a much smaller base compared to the others.

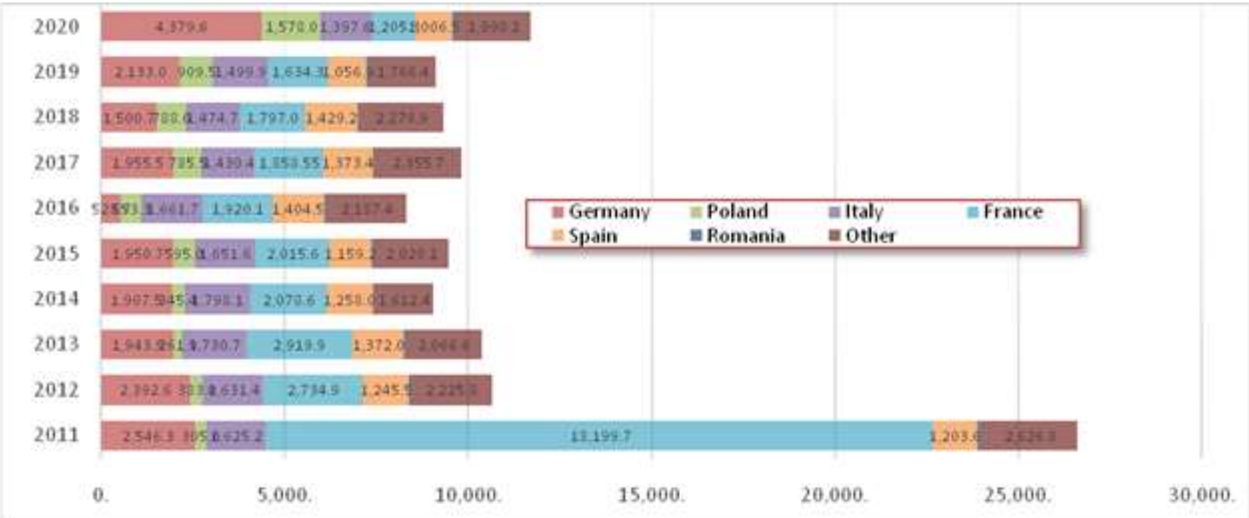

Fig. 4. Top 5 European countries by turnover of meat processing companies with 0-9 employees - million euros
Source: Own representation based on data available on Eurostat, 2024 [4].

The European meat processing industry's financial snapshot for companies with 10-19 employees reveal a diverse fiscal health across the continent in 2020. Germany, even after a significant decline in revenue since 2011, holds the majority market share. Italy defies the general downtrend by not only maintaining but increasing its turnover, hinting at strategic industry strengths or market gains.

On the other hand, France and Spain, alongside the collective EU market, have faced a downturn, with Spain's figures notably contracting. Poland emerges as the outlier with substantial fiscal growth.

Romania, despite a decrease in turnover, accounts for a minimal share of the EU market, underscoring a potential area for industry development and growth.

Table 5. Top 5 European countries by turnover of meat processing companies with 10-19 employees (million euros)

No	Country	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2020/ 2011	Share %
	EU27	11,741.9	11,122.7	10,623.4	9,808.3	11,030	10,779.1	11,286.8	9,975.3	9,375.9	8,910.0	75.88%	100
1	Germany	4,276.7	3,331.5	2,568.0	1,824.5	2,303.6	2,695.0	3,629.9	3,020.5	2,754.8	2,382.2	55.70%	26.74
2	Italy	1,696.2	2,092.2	2,095.0	2,363.6	2,421.0	2,526.5	2,324.6	2,162.1	2,136.0	1,958.1	115.44 %	21.98
3	Spain	1,596.1	1,253.6	1,223.9	1,139.0	1,740.8	1,399.6	1,615.0	1,051.4	999.8	1,044.8	65.46%	11.73
4	France	1,276.1	1,578.9	1,595.2	1,547.4	1,544.2	1,195.9	1,050.8	905.7	908.0	939.1	73.59%	10.54
5	Poland	468.8	498.2	510.8	528.1	497.1	451.3	470.3	764.0	738.5	781.5	166.70 %	8.77
14	Romania	81.9	87.9	149.5	144.4	110.7	92.5	128.9	126.6	115.6	62.4	76.19%	0.70

Source: Eurostat, 2024 [4]

The data reflects the growth in business revenue for meat processing companies with 20-49 employees in the year 2020 compared to the base year 2011.

Germany leads the growth at 139.69%, indicating a vigorous expansion in the revenue of medium-sized companies in the meat processing industry over this period. Italy is also notable, with an increase of 130.85%, showing significant development in the industry.

Spain, while lower, still shows an increase of 68.07%, which might indicate a positive trend in revenue growth, albeit at a more moderate pace compared to Germany and Italy.

France's growth is at 54.41%, suggesting a more gradual increase in the revenue of its medium-sized meat processing companies, possibly reflecting different market dynamics or economic factors.

Poland exhibits a robust increase of 110.97%, which is indicative of a strong expansion in the sector's revenue within this company size range.

Romania, although lower in the ranking, demonstrates a notable increase of 118.12%, indicating that its medium-sized meat processing sector has seen substantial revenue growth, surpassing the average EU growth rate.

This data collectively points to a general upward trend in the revenue of meat processing companies of this size in Europe, with varied growth rates highlighting the diverse economic health and development strategies of each nation's sector (Fig. 5).

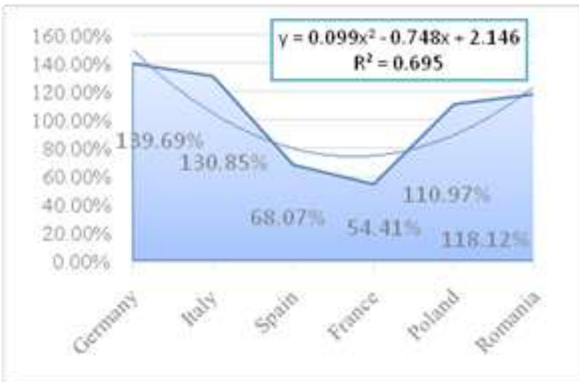

Fig. 5. The growth of turnover for meat processing companies with 20-49 employees in the year 2020 compared to the base year 2011

Source: Own representation based on data available on Eurostat, 2024 [4].

The R^2 value ranges from 0 to 1, where 0 indicates that the model does not explain any of the variability of the response data around its mean, and 1 indicates that the model explains all the variability of the response data around its mean. An R^2 value of 0.6953 in the context of our dataset indicates that about 69.53% of the variance in the business revenue of meat processing companies with 20-49 employees in the year 2020 relative to 2011 can be predicted by the model used to fit this data.

It implies a reasonably strong linear relationship between the years and the revenue changes.

While this is a significant proportion, it also means that there is another 30.47% of the variance that is not explained by the model. This unexplained variance could be due to other factors not included in the model, such as market conditions, management practices, technological advancements, regulatory changes, and broader economic trends that may have affected the meat processing industry differently in each country.

The growth percentages for Germany, Italy, Poland, and Romania suggest that, for these countries, the meat processing sector for companies with 20-49 employees has generally fared well over the period, growing beyond the levels seen in 2011. On the other hand, the relatively lower percentages for Spain and France suggest a more modest growth or more significant challenges faced by these countries in this sector during the same period.

Initially leading with €15,452.4 million, Germany's turnover declined to €9,209.6 million by 2020, indicating significant market changes affecting its meat processing industry. Contrary to Germany, Italy's sector showed growth, starting at €6,215.3 million and rising to €8,139.2 million. Spain's turnover reduced from €6,752.7 million to €5,507.9 million, while Poland's turnover grew from €3,719.1 million to €5,021.7 million, reflecting distinct market dynamics in these countries. Starting from a lower base of €910.5 million, Romania demonstrated considerable growth, with turnover increasing to €1,186.6 million.

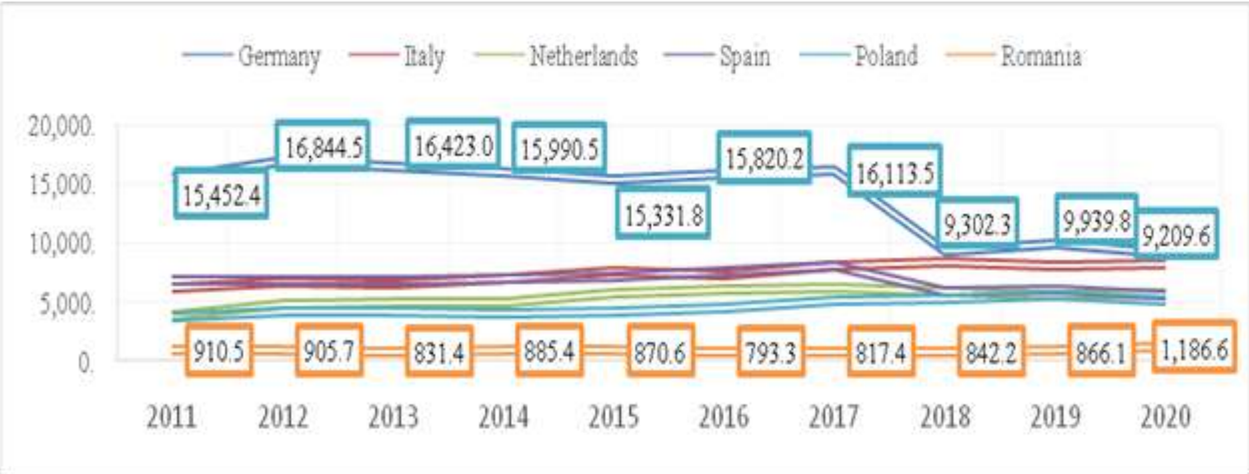

Fig. 6. The growth of turnover for meat processing companies with 50-249 employees (million euros)
Source: Own representation based on data available on Eurostat, 2024 [4].

The decade-long overview of turnover for meat processing companies with over 250 employees reveals shifting economic landscapes within the EU's sector. From the start of the period in 2011 to the end in 2020, there's been a discernible change in the financial throughput of these companies, indicating broader industry trends, market adaptations, and shifts in consumer demand and production efficiency across member states.

The EU27's turnover saw a notable increase, indicating a healthy sector with growing demand or improved productivity.

Germany, from €19,347 million in 2011, sustained its lead, witnessing a growth in turnover to €34,736.3 million by 2020.

France showed an extraordinary increase, multiplying its turnover to €29,296.9 million.

Spain's turnover grew to €20,739.3 million, nearly tripling, an indication of substantial expansion within its meat processing industry with more than 250 employees. Italy's turnover had less fluctuation, ending at €9,753.9 million, while Poland observed a rise to €8,971.2 million, demonstrating their industry's resilience and growth. Romania, positioned at 14th in the ranking, despite a smaller overall share, displayed a significant increase in turnover to €1,946.7 million, a positive indicator of its industry's growth trajectory, proportionally outpacing some larger economies (Table 6).

Table 6. Top 5 European countries by turnover of meat processing companies over 250 employees (million euros)

No	Country	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2020/ 2011	Share %
	EU27	70,714.6	88,765.1	93,678.7	95,056.4	94,138.8	94,813.1	113,853.8	132,270.9	138,552.5	137,560.0	194.53%	100.00
1	Germany	19,347.0	20,700.3	21,636.1	21,592.9	21,530.9	21,972.5	23,870.2	32,560.2	35,216.7	34,736.3	179.54%	25.25
2	France	5,277.6	18,962.6	19,185.9	19,753.0	19,520.9	19,349.9	29,904.3	30,214.4	27,457.1	29,296.9	555.12%	21.30
3	Spain	7,304.4	7,799.5	9,090.0	9,462.6	9,440.2	10,077.9	11,177.7	16,511.4	20,471.5	20,739.3	283.93%	15.08
4	Italy	8,215.6	8,206.2	8,625.0	7,784.5	7,846.6	6,744.1	8,843.0	9,251.5	9,791.3	9,753.9	118.72%	7.09
5	Poland	6,655.2	7,627.2	8,114.5	8,430.6	8,741.9	8,905.8	10,027.3	11,073.6	11,892.7	8,971.2	134.80%	6.52
6	Romania	1,294.0	1,438.0	1,564.9	1,472.1	1,613.7	1,733.7	1,909.0	2,042.6	1,908.8	1,946.7	150.44%	1.42

Source: Eurostat, 2024 [4].

The data on employment within the meat processing industry serves as a valuable barometer for understanding economic vitality and labor market dynamics within the broader agri-food sector in the European Union.

Given that, Germany consistently leads the rank in employment numbers within the industry, peaking in 2019 with approximately 227,762 workers.

Fig. 7. Ranking of the first 5 countries according to the number of employed people and Romania's position
Source: Own representation based on data available on Eurostat, 2024 [4].

France and Poland exhibit similar employment figures, with slight annual fluctuations but generally maintaining a steady labor force. Spain shows a notable upward trend in employment, starting from 83,277 employees in 2011 and rising to 114,120 by 2020.

Italy also follows a growth pattern, albeit starting from a lower base compared to Spain, with employee numbers gradually increasing

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from just over 59,100 in 2011 to 66,420 in 2020.

Romania, ranked sixth, displays a slightly different trend with a marginal decrease in employment numbers, starting from 43,193 employees in 2011 to 42,153 in 2020, suggesting either improvements in operational efficiencies or other market dynamics impacting employment.

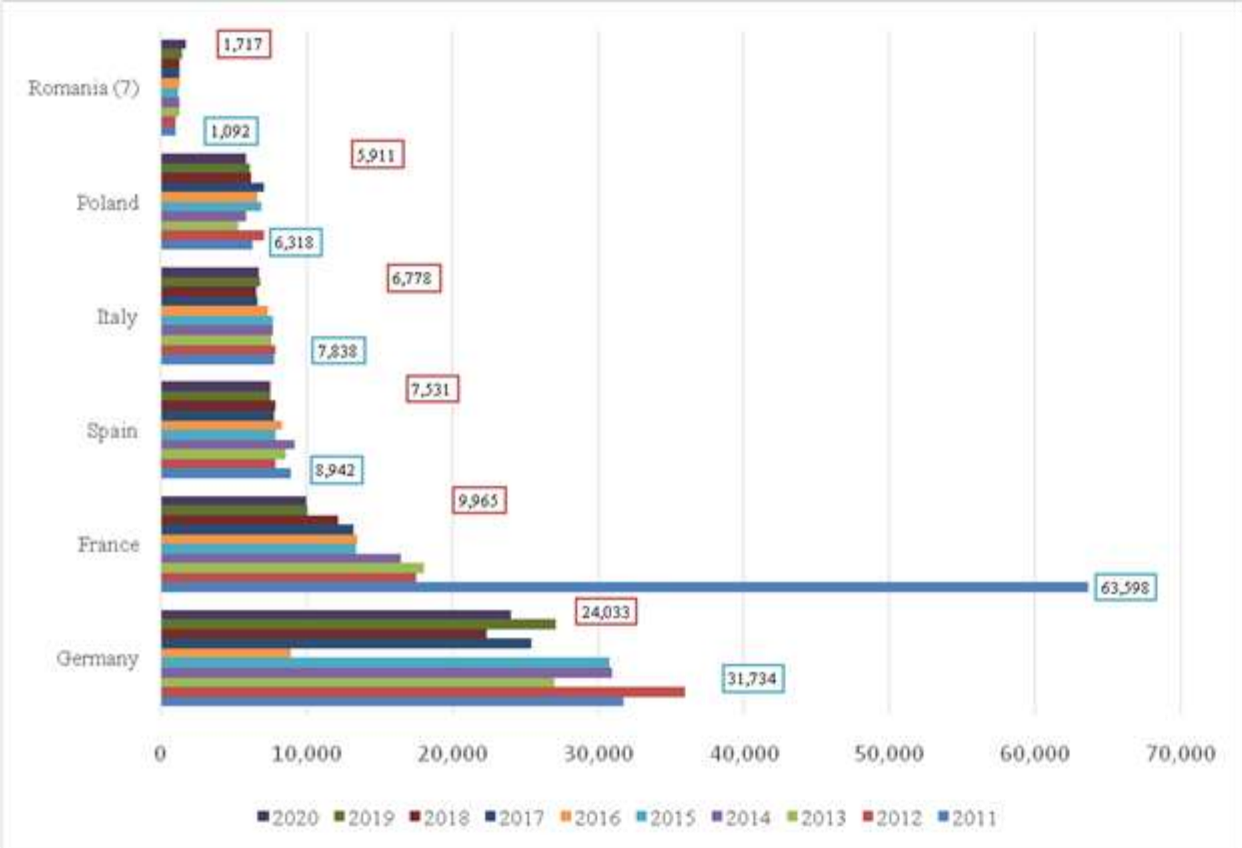

Fig. 8. Ranking of top European countries by number of employees in meat processing industry: companies with 0-9 employees and Romania's position
Source: Own representation based on data available on Eurostat, 2024 [4].

In the ranking of European countries by the number of employees in the meat processing industry for companies with 0-9 employees, Germany leads, although it saw a decrease from 31,734 employees in 2011 to 24,033 in 2020. France, starting with 63,598 in 2011, experienced a significant drop to 9,965 by 2020. Both Spain and Italy have smaller numbers of employees in this sector, with Poland following a similar pattern. Romania, at 7th place, increased from 1,092 employees in 2011 to 1,717 in 2020, showing growth in this employment category (Figure 8).

From 2011 to 2020, there's a notable shift in the labor force of the meat processing sector within five top European countries plus Romania which is on seventh place for businesses with 10-19 employees. Germany's labor force has decreased to 71.30% of its initial size. Contrastingly, France saw an increase to 116.17%, and Poland's labor force grew significantly to 142.64%. Italy and Spain experienced moderate reductions to 89.17% and 84.21%, respectively. Romania's labor force witnessed a decline to 75.49% of its 2011 figure. These figures underscore the varying trends in industry employment across these nations (Figure 9).

The ranking of European countries based on the number of employees in meat processing companies with 20-49 employees shows Germany with a notable decrease from 2011 to 2020, yet it maintains the highest numbers.

Spain and Poland both experience a reduction in their labor force in this category, with Poland rebounding slightly towards the end of

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the decade. France shows fluctuations, ultimately reducing its numbers. Italy also sees a slight decrease over the years. Romania, ranking eighth, has a relatively stable number of employees, with a slight decrease by 2020.

Fig. 9. Evolution of the number of employees in meat processing companies with 10-19 employees and Romania's position (2020/2011)
Source: Own representation based on data available on Eurostat, 2024 [4]

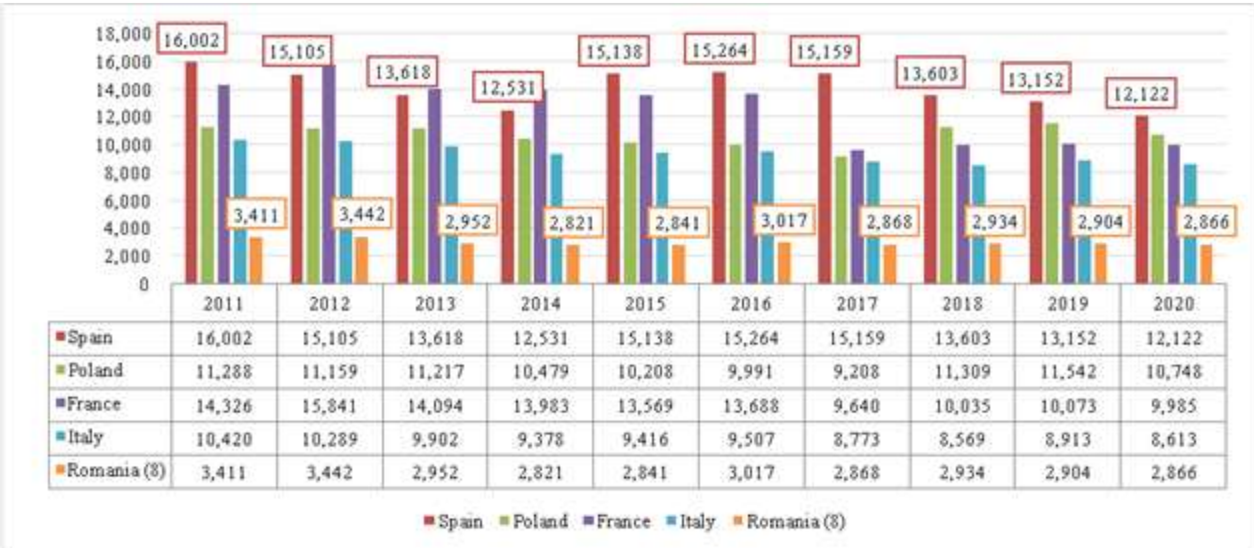

Fig. 10. Evolution of the number of employees in meat processing companies with 20-49 employees and Romania's position
Source: Own representation based on data available on Eurostat, 2024 [4].

In 2011, Germany's labor force in meat processing companies with 50-249 employees was at 52,976, decreasing to 49,530 by 2020. Poland also experienced a reduction, from 36,025 employees in 2011 to 30,395 in 2020. Romania, ranking fifth, saw a decline from 15,693 employees in 2011 to 10,707 in 2020, reflecting a contraction in the labor force within this sector over the decade.

In the meat processing industry of the EU, the labor force in larger companies saw mixed changes from 2011 to 2020. Germany experienced a significant increase in its laborforce, and Spain's more than doubled, marking the highest growth. Italy and Romania also demonstrated substantial increases, with Romania ranking fourth.

Table 7. Evolution of the number of employees in meat processing companies over250 employees

No	Country	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2020/ 2011
1	*Poland*	60,622	61,298	63,431	65,853	65,446	64,583	65,597	68,268	70,118	58,744	96.90
2	*Germany*	43,205	43,306	42,690	42,606	44,226	50,551	55,097	78,747	78,009	74,402	172.21
3	*Spain*	28,949	29,482	31,662	35,603	35,632	39,036	42,807	55,549	60,665	64,276	222.03
4	*Romania*	21,471	23,870	25,312	23,865	23,780	25,267	25,335	26,516	25,683	25,711	119.75
5	*Italy*	20,761	18,793	19,028	18,767	19,039	20,072	24,063	26,627	27,253	28,580	137.66

Source: Eurostat, 2024 [4].

Conversely, Poland observed a slight decrease. The labor force growth rates - Germany at 172.21%, Spain at 222.03%, Italy at 137.66%, Poland at 142.64%, and Romania at 119.75% - reflect varied industrial strategies and market conditions across the EU (Table 7).

CONCLUSIONS

This study, utilizing extensive employment data from Eurostat, offers a thorough analysis of the meat processing industry in the European Union, a very important sector to the EU's economy for its significant contribution to employment, food production, and overall economic vitality. Data spanning from 2011 to 2020 across a spectrum of company sizes, from micro-sized firms with 0-9 employees to large-scale enterprises with over 250 employees, were examined.

The analysis, through a quantitative approach, assessed the annual changes in the labor force, employing comparative techniques to uncover trends and variations in labor sizes across different EU nations. This allowed for an in-depth understanding of the dynamic labor landscape, noting significant growths and declines, and shedding light on the factors influencing these changes, with a special focus on Romania.

Importantly, the study underscores the meat processing industry's role in the EU's economic framework. The companies within this sector not only provide substantial employment opportunities but also significantly contribute to the EU's food security and trade balance. By examining the labor trends, the research highlights the industry's adaptability and responsiveness to economic and regulatory changes, indicating its resilience and strategic importance in the EU market. This comprehensive view offers valuable insights for policymakers, industry stakeholders, and researchers, emphasizing the need for continued support and development of this vital sector.

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STUDY ON THE WORLDWIDE PORK MARKET FOR THE PERIOD 2015-2021

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Abstract

The present research captured a series of aspects related to the global pork market, focusing, above all, on the 2015-2021 interval. The main indicators that had to be analysed are: worldwide pig herds, worldwide pork production, global pork consumption, worldwide imports and exports of pork. Regarding pork, it was found that it is part of the food consumption model for part of the world's population, because it presents several characteristics agreed by consumers. The statistical data that were presented and analyzed in the study were provided by the FAOSTAT website. In order to better capture the evolution of the worldwide pork market, numerous specialized materials were consulted. In 2021, Asia achieved 52.4% of the production share of pig meat with the bone, fresh or chilled obtained worldwide. The top three pork consuming countries in 2021 were: Korea (31.6 kg/inhabitant); Vietnam (25.9 kg/inhabitant) and Chile (25.0 kg/inhabitant).

Key words: *pork, pig herds, pork consumption, pork imports and exports*

INTRODUCTION

At the global level, meat production represents an important element in terms of ensuring food security, especially in the conditions of population growth. It is necessary to mention the fact that the world's population consumes various types of meat [14]. According to data provided by the Organization for Economic Cooperation and Development (OECD), pork is in second place in the world's meat consumption list, after poultry, although for a long-time pork was the most consumed meat. Along with the development of human society, essential changes have been observed regarding the structure of food consumption at the global level. In this sense, it is necessary to mention the fact that a significant part of consumers have started to consume, on the one hand, more pork, and on the other hand, to give up other foods, in favor of pork [6, 10, 11]. In the view of specialists, pork is an important source of food because it contains: proteins; selenium; vitamin B; fats and thiamine. For these reasons, pork is part of the category of products preferred and often purchased by consumers [9, 15]. Worldwide, the health crisis has impacted the global pork market, causing numerous changes. In this context, economic analysts highlighted the fact that, during the mentioned period, the volume of sales of products obtained based on pork decreased. [2, 12, 13].

In perspective, an increase in the global pork market is estimated. A number of factors have been identified that will be the basis for the growth of the pork market. Among them, the most significant are: increasing demand for pork; increasing incomes for certain segments of the population; innovative production methods in correlation with the new requirements regarding sustainability [6, 18].

The upward trend expected in the future by specialists for the pork market will be accompanied by numerous challenges aimed at the sustainability of production. It is important to mention a series of problems, such as: greenhouse gas emissions produced by pig farms; the emissions related to the production of fodder, respectively to the use of the associated lands; interruption of the supply chain due to certain crises etc. [18].

Photo 1. Pork
Source: [7].

MATERIALS AND METHODS

The paper presents a series of aspects related to the pork market worldwide, for the period 2015-2021. In order to carry out this study, it was necessary to analyze the main indicators such as: worldwide pig herds; worldwide pork production; global pork consumption; worldwide pork imports and exports. The statistical data that formed the basis of the study were obtained from the FAOSTAT website, as well as from other sources. The results of the study were presented graphically and tabularly.

RESULTS AND DISCUSSIONS

According to the studies carried out regarding the biological qualities, the conclusion was reached that pigs represent a species that is massively involved in meeting the meat needs of the world's population. According to official statistical data, it was found that pigs provide 30% of the total meat consumed worldwide [7]. During the analyzed period, a series of changes were noticed at the global level that directly and indirectly influenced the degree of satisfaction of the population's consumption demand. In this context, it was necessary to specify the fact that the sector of raising and selling pork had to face a series of challenges. The first indicator analyzed in the present study is represented by the pig herds registered worldwide. From the data presented, it is easy to see that, between 2015-2019, pig herds worldwide were in decline. This situation was due to the appearance and spread of the African swine fever. Starting with 2020, the numbers started to grow. The lowest pig herd recorded worldwide was in 2019 (838.4 million heads), and the largest was in 2015 (992.1 million heads). In the year 2021, the number of pigs highlighted worldwide decreased by 1.7% compared to the year 2015 (Fig. 1).

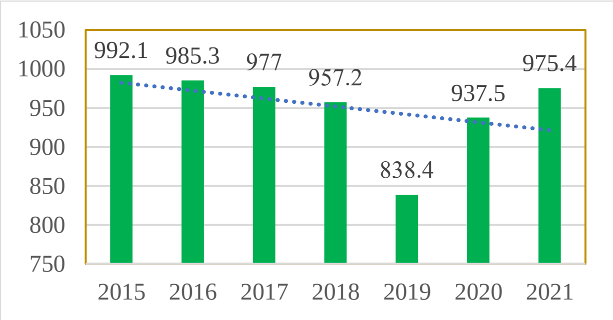

Fig. 1. Pig herds worldwide, in the period 2015-2021 (millions of heads)
Source: [3].

Globally, in the period 2015-2021, pork production recorded changes from one period to another. From the statistical data presented, it can be seen that the lowest pork production was recorded in 2020 (108,341 thousand tons), and the highest production was 120,095 thousand tons (2021). Pork production recorded worldwide increased in 2021, by 1.47% compared to 2015 (Fig. 2) [17].

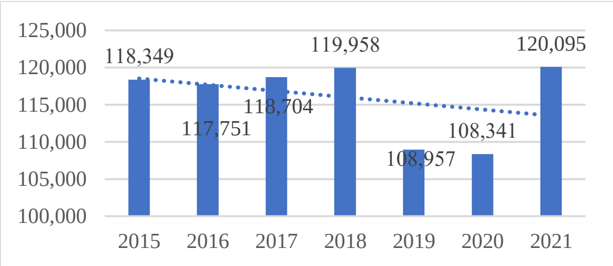

Fig. 2. Pork production worldwide, in the period 2015-2021 (thousands of tons)
Source: Own processing based on FAOSTAT 2024 data [4].

In this context, it is necessary to specify that the production of pork obtained worldwide has registered several changes mainly due to: pig herds; African swine fever; the 2020-2021 health crisis; the price of fodder, as well as prices for pork worldwide.

At the regional level, in 2021, Asia was the largest producer of pig meat with the bone, fresh or chilled, achieving 52.4% of the production obtained worldwide.

Table 1. of meat of pig with the bone, fresh or chilled, in 2021

Nr. crt.	Region	Production in absolute value (tons)	% of world production
1.	Asia	63,071,327.03	52.4
2.	Europe	30,788,805.18	25.6
3.	Americas	23,916,954.92	19.9
4.	Africa	2,014,684.64	1.7
5.	Oceania	580,355.25	0.5

Source: [3].

In 2021, Oceania obtained the lowest production of pig meat with the bone, fresh or chilled, making only 0.5% of the production recorded worldwide and 0.9% of the production obtained by Asia.

In 2021, according to statistical data published by Faostat, the three largest producers of fresh or chilled pork registered worldwide are: China (52,959,300 tons); USA (12,559,837 tons) and Spain (5,180,060 tons) [4].

China has become the largest producer of pork because, here, special emphasis has been placed on the development of pig farms in accordance with the real market requirements.

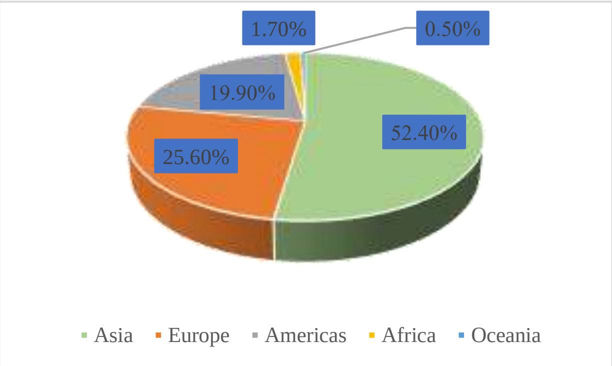

Fig. 3. Production share for pig meat with the bone, fresh or chilled at regional level, in 2021
Source: Own design based on FAOSTAT database 2023 [3].

During the analyzed period, China registered a significant economic growth, which determined the increase in the demand for pork at the national level. In this context, the farmers promptly responded to the market, focusing especially on increasing pork production. In order to achieve the proposed objective, farmers in China have adopted the most efficient production methods [5, 16].

The total consumption of pork worldwide, in the period 2015-2021, recorded a series of changes from one year to the next. The most significant consumption was highlighted in 2018 (117,474 thousand tons), and the lowest was 104,421 thousand tons (2020).

Worldwide pork consumption decreased in 2021, by 4.22%, compared to 2015 (Fig. 4).

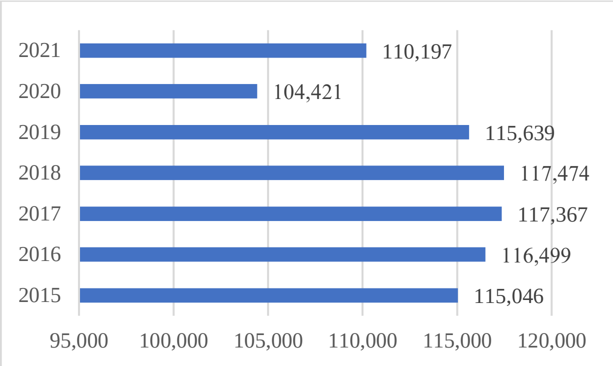

Fig. 4. Total pork consumption worldwide, in the period 2015-2021 (thousands of tons)
Source: Own processing based on FAOSTAT 2024 data [4].

Regarding the annual consumption of pork meat per inhabitant worldwide, it was found that it registered a series of changes during the analyzed period. The lowest consumption of pork per inhabitant worldwide was in 2020 (13.36 kg/capita). This reduced consumption also coincided with the health crisis manifested worldwide when, on the one hand, the supply chain recorded a series of interruptions, and on the other hand, the incomes of the population decreased. The highest consumption per inhabitant was recorded in 2016 (15.45 kilograms/capita). In 2021, the annual consumption of pork per inhabitant recorded worldwide decreased by 9.46%, compared to 2015 (Fig.5).

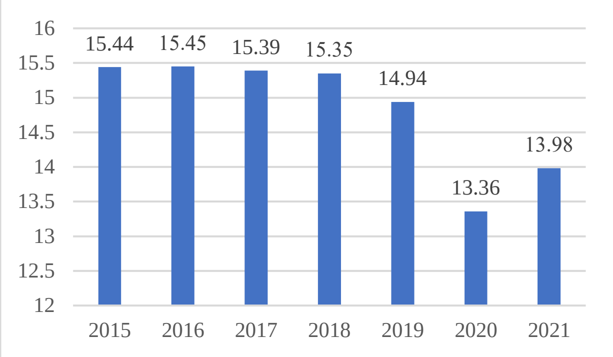

Fig. 5. Pork consumption per inhabitant worldwide, in the period 2015-2021 (kg/ capita)
Source: Own processing based on FAOSTAT 2024 data [4].

In 2021, the most significant per capita consumption of pork was recorded in Korea (31.6 kg/capita). The following four places in the ranking of pork consumption per inhabitant recorded worldwide were occupied by: Viet Nam - 25.9 kg/capita, Chile -25.0 kg/capita, United States -23.9 kg/capita, China 23.7 kg/capita.

According to estimates for the year 2029, the top 5 biggest consumers of pork per inhabitant will be made up of the following countries: Viet Nam (32.7 kg/capita); Korea (32.3 kg/capita); China (31.1 kg/capita); Chile (26.8 kg/capita) and the United States (23.8 kg/capita) [8].

In the period 2015-2021, quantitative imports of pig meat with the bone, fresh or chilled pork suffered a series of variations. Quantitative imports increased from 5,541,973.15 tons (2015) to 6,145,050.68 tons (2017). In 2018, quantitative imports decreased compared to 2017, reaching 6,126,142.94 tons. Starting with the year 2019, the imports of pig meat with the bone, fresh or chilled, followed an upward trend until the year 2021. The highest quantitative imports were in the year 2021 (7,832,860.35 tons). According to the statistical data published in 2021, quantitative imports increased by 41.33%, compared to 2015 (Fig. 6).

Worldwide, according to the data provided by Faostat, in 2021, the 5 largest importers for the "Pig meat with the bone, fresh or chilled" category were: China (2,511,999.33 tons); Italy (807,370.40 tons); Mexico (772,599.89 tons); Germany (635,332.30 tons); and Poland (518,061.40 tons) [4] (Fig. 7).

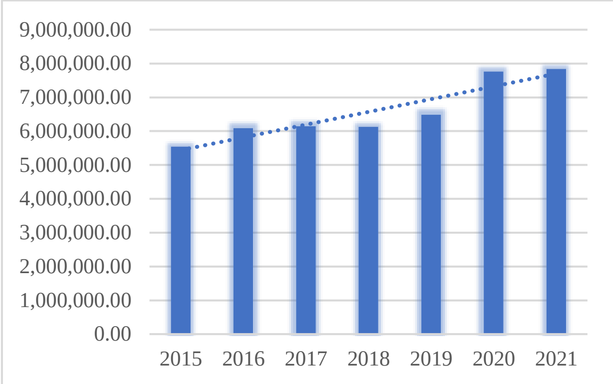

Fig. 6. Quantitative imports of pig meat with the bone, fresh or chilled worldwide, in the period 2015-2021 (tons)
Source: Own graphics based on data taken from Faostat, 2024 [4].

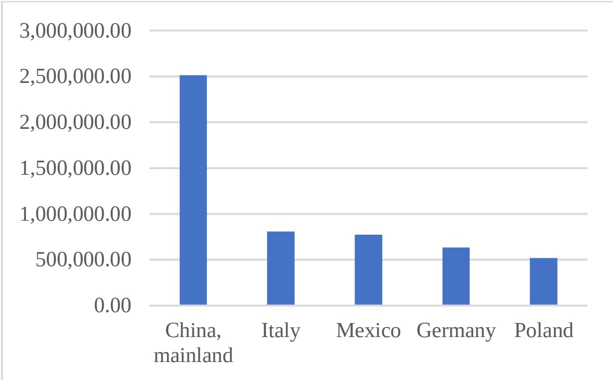

Fig. 7. Ranking of the 5 largest registered importers worldwide for the category "Pig meat with the bone, fresh or chilled" in 2021 (tons)
Source: Own graphics based on data taken from Faostat, 2024 [4].

In the period 2015-2021, quantitative exports of pig meat with the bone, fresh or chilled pork registered changes. The most significant quantitative exports were highlighted in 2021 (7,274,504.34 tons). At the opposite pole, there were the lowest quantitative exports of 5,899,590.57 tons (2015) [4].

In 2021, quantitative exports of pig meat with the bone, fresh or chilled pork increased by 23.30%, compared to 2015 (Fig. 8).

According to the data provided by FAOSTAT for the year 2021, the largest exporters registered worldwide for the category "Pig meat with the bone, fresh or chilled" were: Spain (1,314,515.13 tons); Germany (845,674.37 tons); Denmark (835,673.14 tons); Netherlands (Kingdom of the)

(805,271.67 tons) and United States of America (786,372.25 tons) [1, 4] (Fig. 9).

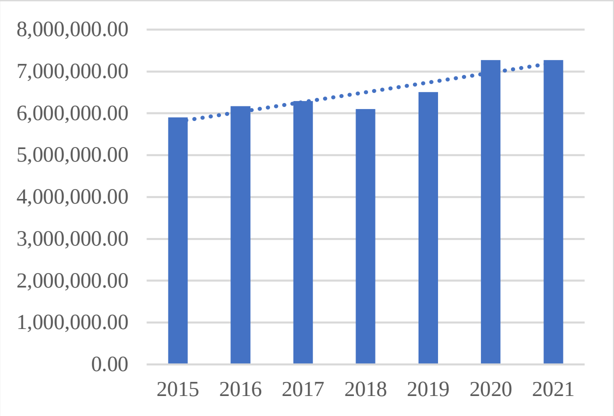

Fig. 8. Quantitative exports of pig meat with the bone, fresh or chilled worldwide, in the period 2015-2021 (tons)
Source: Own graphics based on data taken from Faostat, 2024 [4].

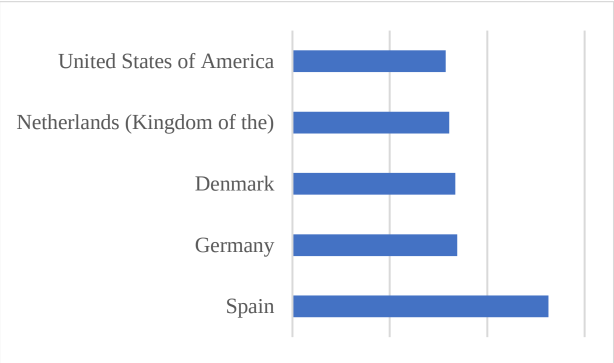

Fig. 9. Ranking of the 5 largest registered exporters worldwide for the category "Pig meat with the bone, fresh or chilled" in 2021 (tons)
Source: Own graphics based on data taken from Faostat, 2024 [4].

From the previously presented data, it can be easily established that the first four registered exporters of pig meat with the bone, fresh or chilled pork are part of the European Union. This situation shows us a high development potential for the future in terms of the pork production and marketing sector.

CONCLUSIONS

According to the analysis of the specific indicators of the worldwide pork market for the period 2015-2021, the following results were obtained:
-In 2015, the largest herd of pigs was registered, of 992.1 million heads;
-In 2021, the most significant pork production was achieved, of 120,095 thousand tons;
-Worldwide pork production increased by 1.47%, in 2021, compared to 2015;
-Asia, in 2021, occupied the first position in the continental ranking, regarding the production of pig meat with the bone, fresh or chilled, because it obtained 52.4% of the production achieved at the global level;
-In 2021, China was the largest producer of fresh or chilled pork, recording a production of 52,959,300 tons;
-In 2018, the most substantial pork consumption was recorded, of 117,474 thousand tons;
-In 2016, worldwide, the highest consumption of pork per inhabitant was highlighted, at 15.45 kilograms/capita;
-Korea, stood out in 2021, with the highest consumption of pork per inhabitant, with 31.6 kilograms/capita;
-In 2021, worldwide, the most significant quantitative imports of pig meat with the bone, fresh or chilled pork, of 7,832,860.35 tons were recorded;
-China, in 2021 the largest importer of meat in the "Pig meat with the bone, fresh or chilled" category;
-Worldwide, the largest quantitative exports of pig meat with the bone, fresh or chilled pork, were 7,274,504.34 tons (2021);
-Spain, in 2021, was the largest meat exporter in the "Pig meat with the bone, fresh or chilled" category, with 1,314,515.13 tons;
In the future, the specialists in the field expect an increase in the demand for pork worldwide, simultaneously with the increase in the requirements regarding the sustainability of the production.

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A STATISTICAL OVERVIEW ON THE PRODUCTS CERTIFIED WITH NATIONAL AND INTERNATIONAL QUALITY SCHEMES IN ROMANIA'S 8 DEVELOPMENT REGIONS

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Abstract

Romania is organized with all the 41 counties into 8 development regions. Some regions have an important representation for quality schemes and products that enrich the cultural and gastronomic heritage of the area. Among the 4,857 certified products at national level, the highest share belongs to mountain products, an aspect which consolidates the national and not necessarily international representativeness. The purpose of the paper is to analyse the status of agri-food products with national recognition and products with international recognition regarding the attestation of quality schemes. The Pearson correlation coefficient and the linear and polynomial regression functions (2nd, 3rd and 4th degree) were used to analyze the relationship between the number of certified products and the number agricultural holdings. The data are collected from national and European registers (e-Ambrosia). For the certified products, the data were extracted for the period 2005-2023, and regarding agricultural holdings, 2002-2020 was analyzed. The results pointed out that there is no direct relationship between agricultural holdings and the number of certified products and that the center and northwest regions are the ones that best represent Romania in terms of agro-food products with gastronomic value and certified quality.

Key words: *quality schemes, agricultural holdings, Romania, agri-food products, gastronomic heritage*

INTRODUCTION

Since 1998, Romania has been organized into 8 development regions: North-East Region, South-East Region, South-Muntenia Region, South-West Oltenia Region, West Region, North-West Region, Center Region and Bucharest-Ilfov Region. These being the means by which the regional development policy is implemented [1].

Map 1. Romania's 8 development regions
Source: [2], [19].

The Ministry of Agriculture and Rural Development promotes food products registered in various national and European quality schemes [12].

The national representativeness is consolidated through the 4,857 certified products - mountain products have the largest share. The certified products with Protected geographical indication, Protected designation of origin and Traditional specialities guaranteed having a very low share in Romania, 0.3% of the total certified products. This aspect is due to the fact that international quality schemes involve much more rigid and complex attestation conditions. Certification costs are high in terms of samples for analysis reports and annual fees charged by certification bodies.

Many consumers in developed countries of the European Union and part of consumers in Romania give a great importance to food

quality that they intend to purchase and consume [17].
Through national or European quality systems for agricultural and food products, consumers receive assurance about the quality and characteristics of the products or the production process; these aspects of the voluntary certification represent an added value for the certified products [18].
In this context, the purpose of the paper is to analyse the status of agri-food products with national recognition and products with international recognition regarding the attestation of quality schemes.

MATERIALS AND METHODS

The analysis perspective will involve organization by region (i.e. the 8 development regions of Romania).
During the documentation and research process, information collected from the public registers provided by the Ministry of Agriculture and Rural Development was used for analysis. Databases from the archive of the National Institute of Statistics (NIS) were also analyzed. The reference year is 2020, being the last update valid at the time of the research. The documents and NIS databases are updated even though the data from the last 3 years are not provided (2021 , 2022 and 2023) because this kind of massive nationwide data collection involves an impressive logistics and the data do not fluctuate wildly from year to year.
General data and provisional data were collected by development regions and counties such as: number of agricultural holdings with legal personality and number of agricultural holdings without legal personality and agricultural holdings with used agricultural area and livestock. The time horizon under which the data were analyzed was 2002-2020 (assuming only the years 2002, 2005, 2007, 2010, 2013, 2016, 2020).
The information used in writing this paper were collected from the EU databases (e-Ambrosia and the EU geographical indications register) [3],[4],[5], for products with protected geographical indication, products with protected designation of origin and products with guaranteed traditional specialty.
All data from the national documents provided by MARD are collected until June 2023. Regarding traditional products, data were collected for a period of 18 years (2005-2023) through the National Register of Traditional Products (NRTP) [9]. Also analyzed were the National Register of Mountain Products (NRMP) between 2017-2023 [8],[10] and the National Register of Products Certified According to Consecrated Recipes (NRPCP) during the period 2014-2023 [7],[11].
In this paper the correlation method was used by applying the Pearson coefficient, the linear function and the polynomial function of the 2nd, 3rd and 4th degree. The purpose of using this method is to highlight and exemplify the relationship between certified products and agricultural holdings.
This research presents the status of the of products certified by national and international quality schemes in the state of Romania between 2005-July 2023 in correlation with the number of agricultural holdings between the years 2002-2020.
The research based on the data analysis involved the brief evaluation of the basic documents in the process of authorizing a product to a quality scheme, either national or international, and also the collection of information found in official documents, regulations, laws, registers, announcements, both nationally and internationally. The data interpretation was done for the period 2005-2023.

RESULTS AND DISCUSSIONS

Romania has 4,857 products certified through quality schemes; being poorly represented at the level of the European Union (13 certified products), but having a much greater recognition at the level of national quality schemes with 755 products certified as a traditional product, 58 products obtained from established recipes and 4,044 mountain products. Also, in the field of wines and spirits, Romania stands out with 62 products certified with Geographical Indication.

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Romania is characterized by its gastronomic heritage of national products, and much less of international ones.

Regarding the accreditation process, the waiting time is also an important element to mention. Generally, at the national level it takes from a few days to a month until a product is actually mentioned into the National Registers. While internationally, in order to register a product

Table 1. Status of products with national recognition and products with international recognition - by county

Crt. No.	County	Traditional products	Products with consecrated recipes	Mountain products	Total number of national products	Protected geographical indication	Protected designation of origin	Traditional speciality guaranteed	Total number of international products
1	Alba	49	0	122	171	0	0	0	0
2	Arad	7	0	3	10	1	0	0	1
3	Argeș	47	0	63	110	1	0	0	1
4	Bacău	4	0	190	194	0	0	0	0
5	Bihor	8	0	25	33	0	0	0	0
6	Bistrița Năsăud	32	10	622	664	0	0	0	0
7	Botoșani	26	9	x*	35	1	0	0	1
8	Brașov	173	0	107	280	1	0	0	1
9	Brăila	0	0	x*	0	0	0	0	0
10	București	19	0	x*	19	0	0	0	0
11	Buzău	33	0	21	54	1	0	0	1
12	Caraș-Severin	12	0	179	191	0	0	0	0
13	Călărași	0	0	x*	0	0	0	0	0
14	Cluj	15	1	215	231	0	0	0	0
15	Constanța	1	0	X	1	0	0	0	0
16	Covasna	23	0	459	482	0	0	0	0
17	Dâmbovița	5	0	17	22	0	0	0	0
18	Dolj	3	1	x*	4	0	0	0	0
19	Galați	14	3	x*	17	0	0	0	0
20	Giurgiu	1	0	x*	1	0	0	0	0
21	Gorj	9	0	162	171	0	0	0	0
22	Harghita	2	0	249	251	0	0	0	0
23	Hunedoara	10	0	188	198	0	0	0	0
24	Ialomița	0	0	x*	0	0	0	0	0
25	Iași	23	0	x*	23	0	0	0	0
26	Ilfov	4	2	x*	6	0	0	0	0
27	Maramureș	58	1	295	354	0	0	0	0
28	Mehedinți	3	0	8	11	0	0	0	0
29	Mureș	3	2	77	82	0	1	0	1
30	Neamț	29	0	167	196	0	0	0	0
31	Olt	3	0	x*	3	0	0	0	0
32	Prahova	6	0	44	50	0	0	0	0
33	Sălaj	15	0	0	15	0	0	0	0
34	Satu Mare	28	0	110	138	0	0	0	0
35	Sibiu	17	18	159	194	2	0	0	2
36	Suceava	23	0	162	185	0	0	0	0
37	Teleorman	0	0	x*	0	0	0	0	0
38	Timiș	4	1	3	8	0	0	0	0
39	Tulcea	21	0	x*	21	3	0	2	5
40	Vâlcea	22	10	345	377	0	0	0	0
41	Vaslui	3	0	x*	3	0	0	0	0
42	Vrancea	0	0	52	52	0	0	0	0
Total number of products		**755**	**58**	**4,044**	**4,857**	**10**	**1**	**2**	**13**

*x=County that is not in the mountain area according to the List of Territorial Administrative Units in the mountain area - the delimited area according to the National Rural Development Program 2014 – 2020 [6]

Source: Own calculation based on the data from [3],[4],[5],[6],[7],[8],[9],[10],[11],[12].

According to the data extracted from the previously mentioned national registers and from the e-Ambrosia database, the Register of traditional specialties guaranteed and the European Union Register of products with geographical indication, it is observed that the first 5 places in the ranking of counties with the most certified products are occupied by Brașov, Maramureș, Alba, Argeș and Buzău for traditional products and Harghita, Maramureș, Vâlcea, Covasna and Bistrița-Năsăud for mountain products. The top 5 counties do not coincide or overlap a specific county. We cannot mention that there is an uniformity, on the contrary, the categories of products and quality schemes differ from one area to another, mainly due to the specifics of the respective county. Among the 8 development regions of Romania, two of them have a representative character: the Center Region and the North West Region account for a large part of the certified food products (2,899 products out of a national total of 4,870). Out of a total of 42 counties (41 counties + Bucharest Municipality), the mountain area is represented by 64% of the counties at national level.

Bistrita-Năsăud County leads the list of mountain products at the national level with an impressive advantage: 622 certified products from 2017 to mid-2023. The next county in the ranking is Covasna with 459 mountain products. It is concluded that in the period 2017-2023, 4,044 products were registered at national level. Sălaj is the only county located in the mountainous area, but which does not yet have any certified product. Arad, Timiș, Mehedinți and Dâmbovița are the counties with the fewest mountain products in the whole country.

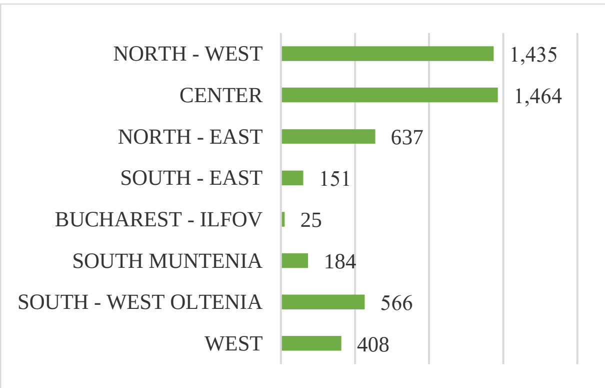

Fig. 1. Status of certified products by regions
Source: Own calculation based on the data from Table. 1.

There are counties that have no certified products at all, but analyzing by region, the situation balances out – each region having at least 150 products (except Bucharest-Ilfov with 25 products).

The Southwest Oltenia region consists of the counties: Dolj, Gorj, Mehedinți, Olt and Vâlcea. It presents 556 certified products (40 traditional products, 11 products obtained from established recipes and 515 mountain products). These 5 counties represent 12% of the total of 4,857 certified products at national level.

Map 2. The location of Valcea county on the Romanian map
Source: [20].

Vâlcea County is the most representative in terms of certifying products with added value and proven quality. From the whole region, Vâlcea has a large part of certified products: 377 products, being also important in the mountainous region for its specific products.

Valcea has a predominantly mountainous relief in the Northern part and is named as a historical county with tourist attractions in the area of resorts and monasteries.

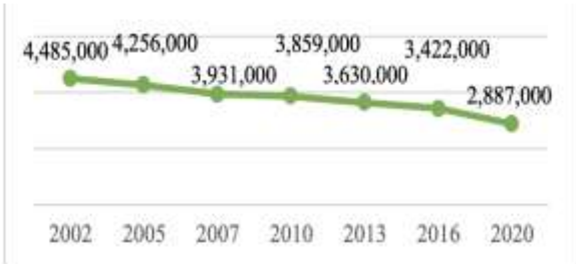

Fig. 2. Status of agricultural holdings in Romania
Source: Own calculation based on the data from [13], [14].

According to the data provided by the National Institute of Statistics and analyzing according to the category they belong to, at the end of 2022 there were 25,394 agricultural holdings with legal personality and 2,861,673 holdings without legal personality. The latter including: individual agricultural holding, PFA (authorized person), II (individual enterprise) and IF (family enterprise). Agricultural holdings with legal personality represent slightly less than 1% of the total holdings.

In 2002, there were almost 4.5 million agricultural holdings in total in Romania. Since then, their number is constantly decreasing resulting in 2,887,067 agricultural holdings in 2020.

Table 2. Status of agricultural holdings with used agricultural area and livestock

Development region	Total number of agricultural holdings	Agricultural holdings with used agricultural area and livestock	Agricultural holdings only with used agricultural area	Agricultural holdings only with livestock
NORTHWEST	443,059	228,699	212,564	1,793
CENTER	318,475	165,062	149,033	4,380
NORTH - EAST	592,998	397,513	190,118	5,366
SOUTH EAST	324,061	205,304	112,041	6,712
BUCHAREST - ILFOV	17,234	7,907	8,977	350
SOUTH MUNTENIA	521,961	313,340	192,398	16,219
SOUTH-WEST OLTENIA	466,512	331,624	126,254	8,634
WEST	202,767	123,219	77,443	2,104
TOTAL	**2,887,067**	**1,772,668**	**1,068,828**	**45,558**

Source: Own calculation based on the data from [13], [14].

Romania is at the top of the EU-28 ranking with 33.61% of agricultural holdings. Also important to mention are Poland (13.18%), Italy (9.31%) and Spain (8.9%). These 4 states represent an impressive number of farms - 7,034 million, which is 64.8% of the total number of agricultural holdings in the EU-28 [15, 16].

Agricultural holdings with livestock were taken into account, as well as those with agricultural land, because the certified product categories are complex (meat products, milk products, vegetable or fruit products, beverages, bakery and pastry products).

The statistical-mathematical method involves correlations between various variables relevant to the research topic. In the present case, the variables being the number of agricultural holdings with and without legal personality and the number of products certified with national and international quality schemes.

The correlation method was used applying the Pearson coefficient, the linear function, and the polynomial function (of the 2nd, 3rd and 4th degree) using the data collected from Table 2.

The Pearson coefficient value of 0.2935 (Table 3) assumes that there is a weak correlation between the number of agricultural holdings and number of certified products, because it is a very large number of farms and a small number of certified products.

The analysis method results in a positive but weak correlation as the values of coefficients (Table 3) falls between -0.5 and -0.25 and between 0.25 and 0.5.

The interpretation of the positive correlation coefficient assumes that when one variable changes, the other variable changes in the same direction.

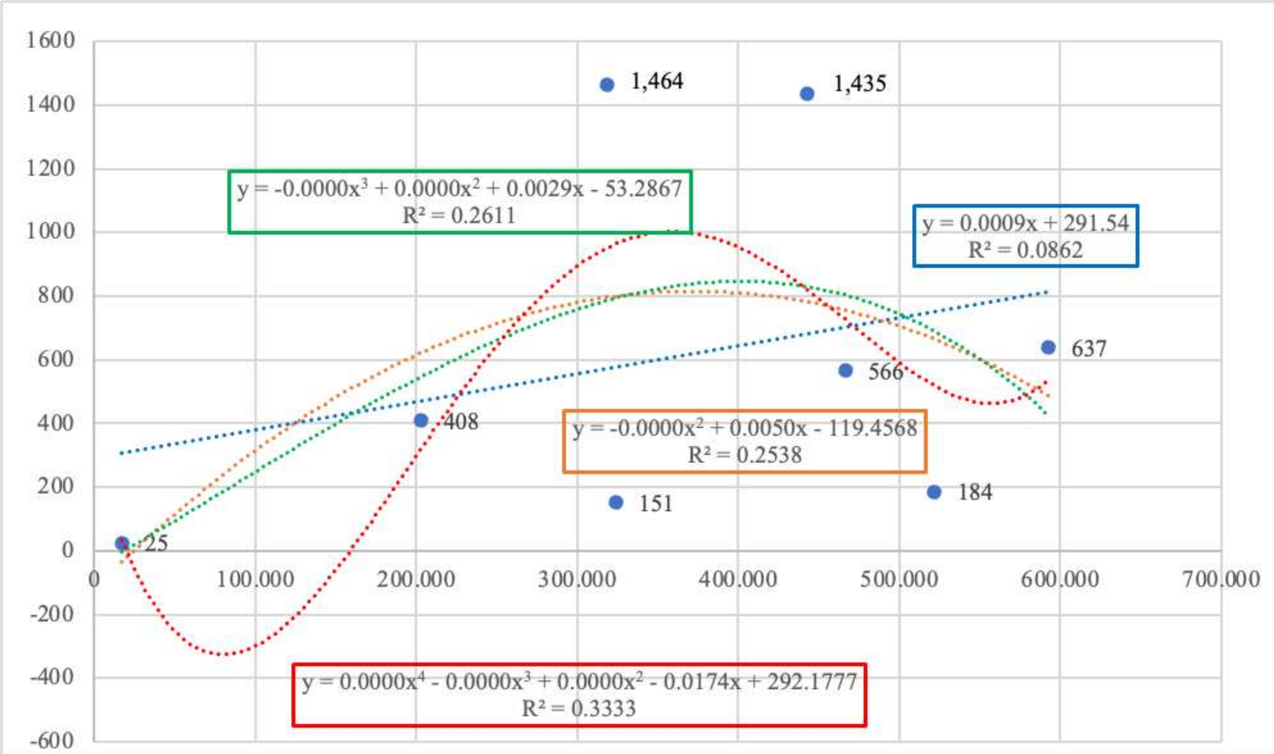

Fig. 3. Corellation between agricultural holdings and number of certified products
Source: Own calculation based on the data from Table 2.

Table 3. Correlation variables

Correlation variables	r	R^2	R^2	R^2	R^2
Agricultural holdings/ Certified products	Pearson coefficient	Linear function	Polynomial function (2nd degree)	Polynomial function (3rd degree)	Polynomial function (4th degree)
	0.2935	0.0862	0.2538	0.2611	0.3333

Source: Own calculation based on the data from Fig. 3.

The values of the variables assume a direct influence, but, if the values are closer to 0, this suggests that the number of certified products is not necessarily influenced by the number of holdings, implying other factors in the analysis.

CONCLUSIONS

The poor representation of internationally certified products in Romania is mainly due to the demanding quality requirements for the whole production process. Other elements that do not make it easy to certify products with international schemes are the complexity and costs regarding the initial certification. International certification requires much more effort and attention from the producer. In the case of products with national recognition, the certification process is easier and takes less time. Certainly, in the case of international schemes, the producer needs a consultant to be able to facilitate the fulfilment of the attestation procedures.

Most of the products certified by quality schemes in Romania have representative elements from the mountain area. A number of 4,044 mountain products are certified until July 2023.

The mountainous area in Romania is represented by 64% of the counties. The Carpathian Mountains are located in the Czech Republic, Slovakia, Poland, Hungary, Ukraine, Romania and Serbia and are part of the great central mountain system of Europe. The largest share is located in Romania - 51% of the Carpathian Mountains (91 mountains).

In 2002, there were almost 4.5 million agricultural holdings in total in Romania.

Since then, their number is constantly decreasing, reaching 2,887,060 in 2022.

Applying the Pearson coefficient for the variables number of agricultural holdings and number of traditional products, a direct and positive correlation results. However, as it approaches 0, there is no predominant relationship. The correlation is not very strong, implying other important factors. In fact, the degree of correlation is weak towards zero correlation.

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OVERCOMING ADMINISTRATIVE OBSTACLES IN FINANCING CROATIAN FARMERS AND ENTREPRENEURS: THE POLICY DIMENSION OF THE EUROPEAN UNION'S FUND ABSORPTION

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Abstract

The research aims to analyze the EU funding for agriculture as well as the administrative obstacles of the national public bodies in using these funds for Croatian family farms/entrepreneurship and the role of policymakers in increasing the efficiency of absorbing funds from this source. Administrative barriers that appear at the national level were analyzed, with an emphasis on those that arise in procedures when applying for EU fund competitions, the financial approval process, and the criteria and conditions of the competitions themselves. The data used in the empirical analysis included 284 respondents who were surveyed through a questionnaire. The respondents were private consultants working on the preparation and implementation of projects funded from EU funds and were surveyed based on their many years of experience. Consultants from all regions in Croatia were covered to ensure more reliable results. The results show that delays in the preparation of national strategic documents significantly affect the reduction of efficiency in the use of EU funds. The most significant impact on the reduction of efficiency in the absorption of funds from EU sources is due to unreliable publication plans, prolonged project application assessments, frequent changes to competition documentation, and competition misalignment with the possibilities and needs of potential applicants. In contrast, less influence comes from unclearly defined competition conditions and the way (model) competitions are announced. The research aims to assist national authorities and provide guidelines to reduce administrative barriers, making it easier to finance projects for companies, public institutions, and other potential applicants.

Key words*: *administrative challenges, EU funds, absorption, policy makers, family farms

INTRODUCTION

EU funds serve as a key driver for the development of both member states and countries in the process of negotiating EU accession. The aim of these funds is to reduce regional, national, and local disparities between different geographic areas and individuals. By providing equal opportunities for all individuals, companies, and organizations that can access non-repayable grants from EU funds, the EU seeks to balance development. One of the EU's major challenges is its agricultural policy, which needs to have clear development directions and to finance actual needs on the ground. The ultimate goal in this entire process is to facilitate access to these funds by financing the development projects of organizations and individuals. However, we are aware of the numerous obstacles at all levels in absorbing these resources.

In certain cases, political elites are not willing to decentralize the governance system and powers, leading to significant administrative barriers [44]. Digitalization is essential in reducing corruption and administrative constraints in public services, where structural changes and strategic planning play a key role [57]. The research by Schedler et al., 2019 shows that the main administrative barriers to the functioning of higher levels of public administration can be summarized as legal foundations, technical infrastructure, cost-benefit relationships, innovativeness, legitimacy, and policy coherence [46]. Public administration could take advantage of the possibilities offered by the new digital age, which would significantly ease communication and collaboration with target groups [45]. According to the research by Ng et al., 2022, one of the main factors affecting the reduction in public administration efficiency is technical challenges and public resistance to change [41].

Marcu et al., 2020 highlight that information, transparency, implementation, and relationship with beneficiaries are key factors that public administration needs to work on to utilize funds more effectively from EU sources [34]. The European Commission encourages significant simplification of administrative barriers and prioritizes the importance of overcoming gaps and overlaps between different EU fund instruments [29]. The 2017 study by Breznitz and Ornston indicates that Poland's innovation system is hindered by various challenges, including poor governance, limited collaboration, human capital constraints, and regulatory obstacles [7]. Considering the changes that have occurred in the United Kingdom and their exit from the EU, a sharp decline in the participation of small and medium-sized enterprises in EU projects has been observed. A stable framework for participation and clear rules from the EU is needed regarding the possibilities for third countries to participate in project funding [8]. After negotiations between countries and the European Council, the focus on rule-of-law requirements is primarily aimed at corruption associated with the use of funds, rather than on fundamental rule-of-law standards [15]. In their 2019 study, Pirvu et al. conclude that there needs to be a shift in cohesion policy. They recommend moving away from traditional investments in infrastructure and social aid for underdeveloped regions, and instead focusing on innovation as well as social and environmental strategies [43]. The 2021 research by Domorenok et al. indicates that a combination of knowledge-based, political, and financial resources can effectively contribute to the development of specialized administrative capabilities. These are essential for executing integrated policy frameworks, which are encouraged by international policy agendas without the need for a centralized control mechanism [18].

In the Republic of Croatia, the inefficiency of the public system is most linked to corruption. According to the Corruption Perceptions Index for the year 2022, the Croatia falls into category B, which means that it is doing very well in combating corruption (Transparency International, 2023). [53]. Croatia has made significant strides in reducing the avenues for corruption and limiting discretionary powers in public decision-making (OECD, 2023) [42]. Croatia is focusing on advancing digitalization in the public sector with the aim of establishing online processes and electronic services, as well as enhancing the efficiency of public administration (European Commission, 2022) [19]. Clientelism is deeply ingrained in nearly every aspect of Croatian society. It is particularly evident in public administration employment practices and in the country's territorial structure, which is divided in a way that serves the political agenda of the ruling elite [27]. In its National Reform Program, Croatia has identified one of the key challenges in attracting funds from EU sources, ranging from simplifying application procedures and project implementation to introducing an e-system for project applications (Government of Croatia, 2020) [20].

According to Iova et al., 2023, it is extremely important to invest efforts in the development of human resources and digitalization for the more effective utilization of EU funds [24].

The 2023 study by Manolache et al. demonstrates that the agricultural sector serves as a model for other domestic economic sectors in terms of European fund absorption, revealing a strong correlation between effective utilization of European Structural Funds and net national investments in agriculture [33]. In their 2023 study, Chiurciu and Văruțoiu emphasize the need to devise new funding programs for rural development, as existing ones do not cover all essential areas of development [10]. The 2022 study by Matei et al. demonstrates that European funding boosts the number of new farmers and increases agricultural entrepreneurial income, providing valuable insights for public decision-makers on the financial needs and economic significance of the agricultural sector [36]. Effective agricultural policy, when aligned with the appropriate utilization of resources, encourages investment, and helps to shrink the budget deficit [21].

The primary benefit of EU funds lies in their nature as non-repayable financial resources, contributing directly to the economic growth of a given country [56]. Effective management and strategic planning are the cornerstones of success; there's no room for political maneuvering and self-promotion in projects and development [49]. Charasz and Vogler (2021) emphasize the long-term effect of EU funds on both local and state capacities and suggest that these funds contribute to the reduction of bureaucracy [9]. Mugambi et al. (2021) point out that energy efficiency in spending is not evenly distributed across regions in Spain, and this is directly linked to the EU funding allocation criteria [39]. Attitudes towards EU institutions can potentially reduce the number of applications for EU-funded projects, although Crepaz and Hanegraaff (2022) argue that this influence is almost negligible [11]. Crescenzi et al. (2020) show that affection for the EU cannot be bought, exemplified by the UK's exit from the EU despite significant EU fund contributions to their development [12]. Crucitti et al. (2023) note that research should focus not only on the number of financial resources absorbed but also on how these resources are allocated [13]. In his study, Hagemann (2019) underscores the importance of capacities, stating that poor capacities severely impact the ability to absorb funds and reduce regional disparities [22]. In their research, Maleković et al. (2018) and Šostar et al. (2018) highlight the strong influence of EU funds on regional development in Croatia [32, 50]. The allocated funds have expedited the adaptation processes of institutions and individuals to European legislation and capacity-building, although there are visible administrative barriers that lead to partial funding losses. In the study by Bańkowski et al. (2022), administrative obstacles are also noted as a bottleneck in the absorption of EU funds [3]. The fact that more projects don't necessarily equate to higher economic growth for a specific region should be considered; it's crucial to properly allocate EU funds to areas that contribute most to growth [16].

Human resources are a vital asset for any country's success, particularly in the planning and execution of regional policies, focusing on EU funds [17, 55]. Studies by Lutringer (2023) and Van Wolleghem (2022) identify the barriers to the optimal absorption of EU fund resources, pointing to factors such as time, accounting mechanisms, administrative and financial capabilities, as well as the intrinsic nature of the funds themselves [30, 54]. Kersan-Škabić and Tijanić (2017) suggest that the key to effective fund absorption lies in investing in human capital, decentralization, investment frameworks, and infrastructure development [26]. Medve-Bálint and Šćepanović (2020) note that a significant portion of EU funds is absorbed by foreign companies, which then repatriate the capital [37]. Multiple studies have established a link between the quality of public administration and the capacity for absorbing EU-funded projects [6, 51]. Mendez and Bachtler (2022) argue that regional governance has no impact on the administrative efficiency of EU funds [38]. In contrast, Baschieri (2021) highlights how Poland's evolving approach to EU funds over time has been supported by institutional capacities and effective management, resulting in a high level of fund absorption [5]. According to a study by Jagódka and Snarske (2023), all regions in Poland have focused on human capital and innovation, significantly enhancing the effectiveness of EU funds [25]. Murzyn (2018) observes a notable increase in smart growth in Polish regions due to the utilization of EU funds [40]. Marcu et al. (2020) conducted a study in Romania, emphasizing initial capacity shortcomings when accessing EU funding due to a lack of expertise, though the situation improved over time [35]. This improvement was attributed to increased knowledge, experience, transparency, and advancements in information and communication systems. The rapid formation of a new region in Hungary in 2020 (Budapest and Pest County region) led to unforeseen changes that directly affected the absorption rates of EU funds

[47]. Moreover, the role of national governments is significant in the absorption of EU funds, with a focus on human resource investment and quality project development [4, 2].

According to Šostar (2021b), the capacities required for attracting and utilizing EU funds are divided into three categories: administrative, financial, and macroeconomic. The administrative capacity mainly involves both the system and individual stakeholders' ability to perform tasks related to EU fund management [48].

Țigănașu et al. (2018) show that high-quality institutional governance positively impacts the absorption rate of EU funds [52]. Aivazidou et al. (2020) suggest that less successful local governments should shift their strategic focus to strengthening administrative capacities rather than solely focusing on increasing fund absorption [1]. Given the limitations of capacities, Madeira et al. (2021) emphasizes the importance of following a smart specialization strategy [31].

Research by Darvas et al. (2019) explores the importance of curbing corruption within a country to facilitate easier access to EU funds and to ensure that these resources are allocated appropriately [14].

Lădaru and colleagues (2018) highlight disparities in the operational programs that issue calls for EU funding [28]. These disparities manifest as varying levels of efficiency in absorbing funds, suggesting flawed planning at higher levels, often misaligned with the actual needs on the ground.

Incaltarau and associates (2020) present an intriguing study that underscores the role of government in reducing corruption to improve the absorption of EU funds, which has a direct impact on the regional development of specific areas [23].

In this context, the aim of this research is to analyze the administrative limitations of national authorities (decision-makers) that restrict the utilization of EU funds in the agriculture and entrepreneurship sectors.

MATERIALS AND METHODS

In order to set up this research, seven key variables have been identified that limit and reduce efficiency in using these funds: delays in developing national strategic documents, unreliable tender publication plans, unclearly defined tender conditions, the manner of tender publication as a "continuously open call," lengthy evaluation of project applications, frequent changes to tender documentation, and misalignment of tenders with the capabilities and needs of potential applicants.

For the purposes of the research, hypotheses related to the identified variables have been set and presented in Table 1.

Table 1. Hypothesis of the study

H1	All administrative limitations equally affect the reduction of efficiency in using EU funds
H2	Delays in the development of national strategic documents significantly affect the reduction of efficiency in using EU funds
H3	Unreliable tender publication plans significantly affect the reduction of efficiency in using EU funds
H4	Unclearly defined tender conditions significantly affect the reduction of efficiency in using EU funds
H5	The manner of tender publication as a "continuously open call" significantly affects the reduction of efficiency in using EU funds
H6	Lengthy evaluation of project applications significantly affects the reduction of efficiency in using EU funds
H7	Frequent changes to tender documentation significantly affect the reduction of efficiency in using EU funds
H8	Misalignment of tenders with the capabilities and needs of potential applicants significantly affects the reduction of efficiency in using EU funds

Source: Author’s hypothesis.

Materials and methods used for accepting/rejecting the hypotheses were based on the study of existing data and scientific literature in the field of EU funds absorption and the limitations that occur in this process, as well as survey methods through a questionnaire. The questionnaire was conducted on 284 respondents. The respondents were private consultants who work on the preparation and implementation of projects funded by EU funds, and their attitudes were examined based on long-term

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experience. Consultants from all counties in Croatia were included to make the results more reliable, and they were selected randomly by researching websites of development agencies, entrepreneurial incubators, private consulting firms, and project departments of local and regional governments from all regions in Croatia.
The questionnaire was conducted in 2023 via the respondents' email. A total of 400 emails were sent out, and 284 respondents replied. The obtained results were analyzed, and the normality of the distribution was tested using the Kolmogorov-Smirnov and Shapiro-Wilk tests, as well as the Spearman correlation coefficient, to examine the relationships between the observed variables.

RESULTS AND DISCUSSIONS

In the analysis of the obtained data, we can see the results of the set hypotheses.
Looking at the data for the question regarding how delays in the development of national strategic documents by employees in public bodies responsible for the preparation and implementation of EU policies affect the reduction of efficiency in using EU funds, it can be observed that the arithmetic mean is 4.20, with a standard deviation of 1.01 (Table 2).

Table 2. Arithmetic mean and standard deviation of the posed questions

		N	%	$\bar{x}$	Sd
Delays in the development of national strategic documents by employees in public bodies responsible for the preparation and implementation of EU policies affect the reduction of efficiency in using EU funds	I completely disagree	7	2.5%		
	I disagree	21	7.4%		
	Neither disagree nor agree	18	6.3%		
	I agree	101	35.6%		
	I completely agree	137	48.2%		
	Total	284	100.0%	4.20	1.01
Unreliable tender publication plans affect the reduction of efficiency in using EU funds	I completely disagree	20	7.0%		
	I disagree	17	6.0%		
	Neither disagree nor agree	13	4.6%		
	I agree	89	31.3%		
	I completely agree	145	51.1%		
	Total	284	100.0%	4.13	1.19
Unclearly defined tender conditions affect the reduction of efficiency in using EU funds	I completely disagree	99	34.9%		
	I disagree	94	33.1%		
	Neither disagree nor agree	17	6.0%		
	I agree	43	15.1%		
	I completely agree	31	10.9%		
	Total	284	100.0%	2.34	1.37

Source: Author's own calculations based on the current research.

For the question about how unreliable tender publication plans affect the reduction of efficiency in using EU funds, the arithmetic mean is 4.13, with a standard deviation of 1.19.
For the question regarding how unclearly defined tender conditions affect the reduction of efficiency in using EU funds, the arithmetic mean is 2.34, with a standard deviation of 1.37 (Table 2).
Examining the data for the question regarding how published tenders in the form of "permanently open calls" affect the reduction of efficiency in using EU funds, it can be observed that the arithmetic mean is 2.22, with a standard deviation of 1.23. For the question about how the lengthy evaluation of project applications affects the reduction of efficiency in using EU funds, the arithmetic mean is 4.31, with a standard deviation of 0.96.
For the question regarding how frequent changes in tender documentation affect the reduction of efficiency in using EU funds, the arithmetic mean is 4.00, with a standard deviation of 1.24.
For the question about how the misalignment of tenders with the capabilities and needs of potential applicants affects the reduction of efficiency in using EU funds, the arithmetic mean is 4.20, with a standard deviation of 0.92 (Table 3).

Table 3. Arithmetic mean and standard deviation of the posed questions

		N	%	$\overline{x}$	Sd
Published tenders in the form of "permanently open calls" affect the reduction of efficiency in using EU funds	I completely disagree	105	37.0%		
	I disagree	87	30.6%		
	Neither disagree nor agree	27	9.5%		
	I agree	55	19.4%		
	I completely agree	10	3.5%		
	Total	284	100.0%	2.22	1.23
Lengthy evaluation of project applications affects the reduction of efficiency in using EU funds	I completely disagree	9	3.2%		
	I disagree	10	3.5%		
	Neither disagree nor agree	17	6.0%		
	I agree	97	34.2%		
	I completely agree	151	53.2%		
	Total	284	100.0%	4.31	.96
Frequent changes in tender documentation affect the reduction of efficiency in using EU funds	I completely disagree	24	8.5%		
	I disagree	20	7.0%		
	Neither disagree nor agree	13	4.6%		
	I agree	101	35.6%		
	I completely agree	126	44.4%		
	Total	284	100.0%	4.00	1.24
The misalignment of tenders with the capabilities and needs of potential applicants affects the reduction of efficiency in using EU funds	I completely disagree	8	2.8%		
	I disagree	11	3.9%		
	Neither disagree nor agree	17	6.0%		
	I agree	129	45.4%		
	I completely agree	119	41.9%		
	Total	284	100.0%	4.20	.92

Source: Author's own calculations based on the current research.

In the following, we present the testing of normality using the Kolmogorov-Smirnov and Shapiro-Wilk tests to determine how the observed factors in the study are distributed. Based on this, it will be decided whether parametric or non-parametric tests will be applied. From the provided significance levels in Table 4, it can be observed how the significance levels of the Kolmogorov-Smirnov and Shapiro-Wilk tests are distributed. Specifically, if the significance for a particular category is greater than 0.05 ($p>0.05$), it indicates a normal distribution. If the significance is less than 0.05, the distribution is different from normal. Since the significance level for all observed variables is not greater than 0.05, it can be said that the mentioned distributions do not follow a normal distribution in all observed categories.

Table 4. Testing the normality of distribution

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Delays in the development of national strategic documents by employees in public bodies responsible for the preparation and implementation of EU policies affect the reduction of efficiency in using EU funds	.268	284	.000	.748	284	.000
Unreliable tender publication plans affect the reduction of efficiency in using EU funds	.279	284	.000	.714	284	.000
Unclearly defined tender conditions affect the reduction of efficiency in using EU funds	.278	284	.000	.817	284	.000
Published tenders in the form of "permanently open calls" affect the reduction of efficiency in using EU funds	.246	284	.000	.827	284	.000
Lengthy evaluation of project applications affects the reduction of efficiency in using EU funds	.296	284	.000	.704	284	.000
Frequent changes in tender documentation affect the reduction of efficiency in using EU funds	.298	284	.000	.745	284	.000
The misalignment of tenders with the capabilities and needs of potential applicants affects the reduction of efficiency in using EU funds	.289	284	.000	.741	284	.000

a. Lilliefors Significance Correction

Source: Author's own calculations based on the current research.

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To better examine the relationships between the observed variables, Spearman's correlation coefficient was used. The value of this test ranges within the interval -1≤r≤+1, where a negative sign indicates negative (inverse) correlation, and a positive sign indicates positive correlation. The higher the value of Spearman's correlation coefficient, the stronger (more significant) the correlation between the variables. From Table 5, it can be observed that very weak correlations were recorded only between the question of delays in the development of national strategic documents by employees in public bodies responsible for the preparation and implementation of EU policies affecting the efficiency of using EU funds and frequent changes in tender documentation affecting the efficiency of using EU funds ($r=0.135$, $p<0.05$), and unreliable plans for publishing tenders affecting the efficiency of using EU funds and published tenders in the form of "permanently open calls" affecting the efficiency of using EU funds ($r=-0.118$, $p<0.05$).

Table 5. Spearman's correlation coefficient

		1	2	3	4	5	6	7
Delays in the development of national strategic documents by employees in public bodies responsible for the preparation and implementation of EU policies affect the reduction of efficiency in using EU funds	R	1.000	.057	.054	.038	-.010	**.135***	.050
	P	.	.342	.369	.522	.868	.023	.400
	N	284	284	284	284	284	284	284
Unreliable tender publication plans affect the reduction of efficiency in using EU funds	R	.057	1.000	.004	**-.118***	.072	.006	.051
	P	.342	.	.952	.046	.226	.914	.391
	N	284	284	284	284	284	284	284
Unclearly defined tender conditions affect the reduction of efficiency in using EU funds	R	.054	.004	1.000	-.010	.075	-.026	.029
	P	.369	.952	.	.863	.209	.667	.624
	N	284	284	284	284	284	284	284
Published tenders in the form of "permanently open calls" affect the reduction of efficiency in using EU funds	R	.038	-.118*	-.010	1.000	.018	.072	-.005
	P	.522	.046	.863	.	.761	.226	.940
	N	284	284	284	284	284	284	284
Lengthy evaluation of project applications affects the reduction of efficiency in using EU funds	R	-.010	.072	.075	.018	1.000	-.042	.114
	P	.868	.226	.209	.761	.	.480	.055
	N	284	284	284	284	284	284	284
Frequent changes in tender documentation affect the reduction of efficiency in using EU funds	R	.135*	.006	-.026	.072	-.042	1.000	-.017
	P	.023	.914	.667	.226	.480	.	.775
	N	284	284	284	284	284	284	284
The misalignment of tenders with the capabilities and needs of potential applicants affects the reduction of efficiency in using EU funds	R	.050	.051	.029	-.005	.114	-.017	1.000
	P	.400	.391	.624	.940	.055	.775	.
	N	284	284	284	284	284	284	284

*. Correlation is significant at the 0.05 level (2-tailed).
Source: Author's own calculations based on the current research.

Even though the research results do not show a significant relationship between variables, the analysis of the survey questionnaire in Tables 2 and 3 indicates that certain variables have a direct impact on the application and absorption of EU fund resources. Based on this, hypotheses H1: All administrative limitations equally affect the reduction of efficiency in using EU funds; H4: Unclearly defined tender conditions significantly affect the reduction of efficiency in using EU funds; and H5: The manner of tender publication as a "continuously open call" significantly affects the reduction of efficiency in using EU funds, are **REJECTED** and are not supported by the obtained results. Furthermore, hypotheses H2: Delays in the development of national strategic documents significantly affect the reduction of efficiency in using EU funds; H3: Unreliable tender publication plans significantly affect the reduction of efficiency in using EU funds; H6: Lengthy evaluation of project applications significantly affects the reduction of efficiency in using EU funds; H7: Frequent changes to tender documentation significantly affect the reduction of efficiency in using EU funds; and H8: Misalignment of tenders with the capabilities and needs of potential applicants significantly affects the reduction of efficiency in using EU funds, are

ACCEPTED and have an impact on the project applications by potential applicants, in the sense that they agree that these variables limit them.

CONCLUSIONS

EU funds are one of the main drivers of regional development and the reduction of inequalities between and within countries. Non-repayable financial resources from the European Union finance development projects in the fields of agriculture, entrepreneurship, and tourism with the aim of stimulating economic activities, macroeconomic and microeconomic stability, as well as tangible benefits for public and private organizations and individuals. Opportunities for various competitions encompass the possibility of financing projects according to the actual needs and development priorities of each country. Like every system has its administrative limitations, it is evident that in the Republic of Croatia there are various obstacles that limit the absorption and use of EU funds, thereby directly affecting the rural and regional development of a particular region.

The set hypotheses, to a greater or lesser extent, prove the stated claims, but they do not have an equal impact on the absorption of EU funds and an individual's decision to apply for a project. A greater impact is evident in the delays in the adoption of strategic documents at higher levels, which limits the public sector in project applications. Furthermore, the announcement of calls for funding of certain projects is not in line with the annual plan of the body publishing the call. This leads to financial and timing planning issues for the applicants. If a project application does occur, the long time it takes for the project to be evaluated, approved, and contracted is demotivating. The project becomes outdated after a prolonged period due to daily changes in technology development and progress. It should also be noted that there's a visible issue with frequent changes to the call documentation. Specifically, during the period when the call is open for applicants, the tender documentation and conditions are known to change several times, leading to project planning problems. Project applicants often apply for a project, and afterward, the documentation and conditions change. There is often also a problem of mismatch between the actual needs on the ground and what is considered an acceptable investment in a project.

Alternatively, the documentation or project application system is too complicated, deterring potential applicants.

We can conclude that there are many administrative challenges in financing projects from EU funds in the Republic of Croatia.

State authorities should take into account the conclusions of this study and simplify the entire project application system to facilitate potential applicants in realizing their projects.

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ECONOMIC SUSTAINABILITY OF PRODUCTION OF PLUM AND CHERRY ON FAMILY HOLDINGS IN THE REPUBLIC OF SERBIA

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Abstract

The production of plum and cherry, as stone fruit species, occupy a significant place in the plant agricultural activity of the Republic of Serbia. In this paper, on the basis of data from selected family holdings in the southern part of Serbia, the production results and evaluation of the economic justification of these two fruit species were investigated. Data collected through a survey were used for the research, and the economic evaluation was performed using static calculative methods. The most important economic indicators determined were: cost price, net profit (average amount), accumulativeness expressed through the rate and time period of investment capital. When producing plums, the average annual financial result is from 503,490 RSD/ha to 594,340 RSD/ha. The analysis determined that by investing RSD 100/ha in production of plum, 40 RSD is accumulated, and the average annual net profit is 425,313 RSD/ha. From the average amounts of net profit, investments made in raising plum trees plantations (1,080,000 RSD/ha) can be recovered during the third year of its exploitation. Although the yield of cherry per unit area is lower compared to the yield of plum, better economic results in the amount of 535,800 RSD/ha to 682,920 RSD/ha are achieved due to a much more favorable selling price per unit measure. For every RSD 100 invested in cherry production, 48 RSD of accumulation is achieved. The average net profit amounts to 492,099 RSD/ha, and the investments made in raising plantations of cherry trees (1,020,000 RSD/ha) can be recovered in the third year of its exploitation. In recent years, cherry have been very profitable fruit species in Serbia, due to the high demand and favorable selling price. With permanent education of fruit producers, as well as with various support measures at the state and local level, it is possible to contribute to the improvement of the existing business and improve the profitability of plums and cherry production.

Key words**:** *production of plum and cherry, family holdings, economic results*

INTRODUCTION

The production of stone fruit is very widespread in the world, because it has characteristics that are suitable for processing [2]. Fruit growing is an important branch of agriculture in the Republic of Serbia. Areas under fruit plantations account for 5.2% of the total agricultural areas in Serbia [13]. In the world, from the total area under plum plantations, the largest share is in Asia 78.62%, followed by Europe 16.05%, America 3.08%, Africa 2.12% and Oceania 0.13% [1]. Serbia is one of the leading countries in the world in plum production. The production of plums is realized on small, fragmented and neglected plots where it is not possible to implement productive agro-technical measures with the use of mechanization. According to the average annual production of 440.91 thousand tons, Serbia ranks third in the world, with a 3.77% share in the total world production of plum. The first and second places are occupied by China and Romania. However, despite the significant production volumes of plums in Serbia, the average yields per unit area are at a low level and are only around 5.35 t/ha according to the Food and Agriculture Organization (FAO) [1], i.e. 6.49 t/ha according to the database Statistical Office of the Republic of Serbia (SORS) [13].

Plum has been cultivated in the Republic of Serbia for centuries due to a number of advantages: it is relatively easy to reproduce, it germinate quickly and it thrive in hilly and mountainous areas [7]. It is grown in the area of western Serbia, Šumadija and part of southern Serbia around Prokuplje [14]. Over 50 types of products are obtained by processing plums. From it, brandy known as šljivovica is obtained as one of the traditional Serbian products [7]. One of the most important factors in the successful production of fruit is the correct selection of the variety [8]. The leading varieties of plum in Serbia are: Čačanska lepotica, Stanli, Čačanska rodna, Valjevka and Požegača. Protection of fruit trees plantations is the main factor in preserving yield from increased air humidity and moderate temperature [15]. In countries with developed fruit trees growing, associations of producers regularly monitor the state of fruit production in their country, in the surrounding area, as well as in the most important competing countries, and in this way plan the structure of production by types of fruit trees, as well as within the species, represented varieties [10], [11]. In the costs of plum production, the calculation procedure determined that material costs (fertilizer, protective agents, fuel, etc.) account for the largest share, about 45%, followed by labor costs, from 35 to 37%, and other costs, from 18 to 20% [11].

Cherry is one of the oldest fruit species. According to calculative procedures, in the structure of the total costs of cherry production, the largest share is material costs, about 45%, followed by labor costs, about 36%, and other costs, about 19%. Realized production results, dynamics and structure of costs in the process of fruit production are influenced by a number of factors such as, for example location of production, terrain configuration, type of soil, type of fruit culture, level of production technology, etc. [10], [12]. The leading cherry varieties for production plantations are: burlat, stella, van, stark hardy giant and binge [4], [9], [5], [6]. The orchards of plum and cherry trees represent long-term investments. That is why it is important to consider the important factors for their successful exploitation before raising them. Mistakes made during planting cannot be corrected later. In order to make a successful investment, one should try to avoid or possibly mitigate potential risks when planning and designing orchards [10, 12].

Based on data on the production of plums and cherries on selected family holdingss in the southern part of the Republic of Serbia, the subject of this research is the focus on the situation on the ground and determining the indicators of the economic justification of growing these two fruit species. The main goal of the research is to identify problems, find opportunities and propose solutions for improving the key organizational, technological and economic factors for the improvement and sustainability of the production of the analyzed fruit species, i.e. plum and cherry.

MATERIALS AND METHODS

A survey with representative producers of plums and cherries in the southern part of Serbia was used as the basic source of data for this research. In addition to the data collected by the survey, available internal records on family farms were used, as well as the database of the Statistical Office of the Republic of Serbia (SORS). On the basis of the collected input and output data, the average values of the initial parameters were determined and an analysis of the economic justification of plum and cherry production was performed using a calculative procedure. By applying static calculation methods, more important indicators of economic justification were determined: average net profit, accumulative rate and period of return of financial investments.

The average net profit is determined as the quotient of the sum of net profits in individual years and the number of years of the analyzed period. This value is compared with marginal net profit. The higher the average net profit is than the marginal, the more economically efficient production is, and vice versa. The accumulative rate is determined as a quotient between the average net profit and the total investment in production. Given that it is a relative indicator, the calculated amount is multiplied by 100%, thereby obtaining the answer to the question: What is the financial effect on each euro of invested capital?

The return on investment period was determined as a quotient between total investments and average net profit, and during the economic assessment, it was compared with the period of the projected cash flow analysis.

RESULTS AND DISCUSSIONS

According to statistical data [13], of the total area of agricultural land in the Republic of Serbia, i.e. of 27,860,228 ha, family holdings include 20,174,205 ha of agricultural land, while within the framework of business companies, cooperatives, etc. they use 7,686,022 ha. 72.41% of the land area is cultivated on family agricultural farms, and 27.59% is cultivated within economic companies, cooperatives, etc. Given that the production of plum and cherry in Serbia mainly takes place on family holdings, the possibility of their economic sustainability was investigated. As the main criterion for the sustainability of holdings in the southern part of Serbia, the profitability of the production of plum and cherry in the past two-year period was analyzed and projected for the next six years. Profitability was determined on the basis of data collected by a survey of 18 family holdings, on which there are different areas with plantations with plum and cherry trees. Average amounts were used in the analysis, and all indicators were calculated per 1 ha of area.

Economic analysis of the production of plums at family holdings

According to the data collected by the survey, the average yields, production costs and cost price of plums were determined, then the sales prices achieved by individual classes during 2021 and 2022 and the amounts are shown in Table 1.

In order to see the real picture of the economic results per unit of measure and other economic indicators of the production of plum, the analysis did not take into account incentives for plant products and other financial support from the state.

As can be seen in Table 1, the yield of plum was higher in 2022 compared to 2021. However, production costs per unit area were also higher in 2022 compared to 2021.

During both analyzed years, in the structure of plum production costs, the largest share was material costs - fertilizer, protection agents, fuel, etc., on average 45%, then labor costs 36% and other costs on average 19%. The amount of yield, the costs of individual inputs, as well as the economic result, vary by individual years, as well as by plum plantations.

Table 1. The cost of production in plum trees growing per 1 ha, 2020-2022

Indicator	Year			
	2021		2022	
Yield (t)	27.20		30.40	
The first class (t)	19.04		21.28	
The second class (t)	8.16		9.12	
Selling price (RSD/kg)				
The first class	38.00		40.00	
The second class	30.00		32.00	
Costs	Amount (RSD)	Share (%)	Amount (RSD)	Share (%)
Material	208,270	45.00	252,370	46.00
The work of workers	161,990	35.00	202,990	37.00
Depreciation	55,540	12.00	54,860	10.00
Foreign services	9,260	2.00	10,970	2.00
Other	27,770	6.00	27,430	5.00
Total:	462,830	100.00	548,620	100.00
Cost price per unit of measure (RSD/kg)				
The first class	18.00		19.00	
The second class	14.00		15.00	

Source: Author's calculation based on family holdings data.

In the period of full fertility, the costs of maintaining and cultivating the soil in the total costs have a small share, about 10%, the costs of fertilization about 13%, the costs of protection about 15%, the costs of pruning about 12%, the costs of harvesting about 45% and other costs make up 5%.

The selling prices of plums were different by year and in 2021 it amounted to 38.00 RSD/kg and is significantly higher than the cost price per first class unit in the amount of 18.00 RSD/kg. Also, the sales price of the second class in the amount of 30.00 RSD/kg is higher than the cost price of plums in the amount of 14.00 RSD/kg. In 2022, the sales price in the amount of 40.00 RSD/kg is above the cost price of the first class in the amount of 19.00 RSD/kg. Also, the selling price of the second class in the amount of 32.00 RSD/kg is above the cost price in the amount of 15 RSD/kg. Therefore, in both years, plum production was economically justified, and the achieved more favorable financial results are shown in table 2. According to the results determined by the calculative procedure (Table 2), on the analyzed family holdings, with the production of plum, a more favorable financial result was achieved in 2022 (594,340 RSD/ha) compared to 2021 (503,490 RSD/ha).

Table 2. Financial result of in the production of plum

Indicator	Amounts by year (RSD/ha)		
	2021	2022	Average 2021-2022
Gross Income	966,320	1,142,960	1,054,640
Total cost	462,830	548,620	505,725
Financial result	503,490	594,340	548,915

Source: Author's calculation based on family holdings data.

Gross income and therefore the financial result largely depend on the amount of yield. The yield of plum, to the greatest extent, depends on the variety, substrate, cultivation form and applied care measures. It is important to point out that, in addition to the natural consumption of inputs and yields, an important role in business is played by the relationships between input and output prices. If the market conditions are stable for a long period of time, it is possible to forecast the tendency of future business indicators. In order to analyze the economic sustainability of plum production on family holdings based on the average production and economic results for 2021 and 2022, projected revenues and costs for the next six-year period.

During the projection, the impacts of potential risk factors were taken into account, and the amounts per year for the period 2023-2028 year, are given in Table 3.

Table 3. Projected revenues and costs in the production of plum on family holdings, 2023-2028 (RSD/ha)

Indicator	Year					
	2023	2024	2025	2026	2027	2028
Income	1,050,500	980,450	1,100,050	1,030,300	980,600	1,110,080
Costs	510,300	490,700	520,150	500,200	80,750	560,030
Gross profit	540,200	489,750	579,900	530,100	499,850	550,050
Tax on gross profit	108,040	97,950	115,980	106,020	99,970	110,010
Net profit	432,160	391,800	463,920	424,080	399,880	440,040

Source: Author's calculation based on data collected on family holdings.

Given that it is a shorter period of time (six years), the amount of interest has no significant impact on the projected amounts of income and expenses, so static calculative methods were applied to assess the economic justification of investment for plantations of plum and cherry trees. At the same time, the efficiency coefficient, average net profit, accumulation rate and investment return time were determined from the indicators. The final amounts of indicators are given in Table 4.

Table 4. Indicators of economic justification of the production of plum on family holdings

Indicator	Amount
Investment investments (RSD/ha)	1,080,000
Coefficient of economy	2.04
Average net profit (RSD/ha)	425,313
Accumulation rate (%)	0.40
Payback period	2.53

Source: Calculation of the authors.

Although the analyzed plum tree plantations are in the period of full fertility, when determining the economic indicators, previously made investments in planting plantations were also taken into account (according to data from the producer's internal documentation on his own holding).

According to established indicators (Table 4), for every 100 RSD invested, 40 RSD of accumulation is achieved. Therefore, plum production is economical, and the average net profit is 425,313 RSD/ha. From the average amounts of net profit, the investments made in raising plantations (1,080,000 RSD/ha) can be recovered during the third year of exploitation of plum plantations. According to some researches in Serbia [8], one of the problems of plum production is the unfavorable way of using the fruits. About 75 percent of the fresh plums grown in Serbia are processed into brandy.

Certain producers of plum have a contract on business and technical cooperation with economic entities, with the aim of connecting within the market chain, improving competitiveness and improving the placement of fruit products. If risk events will occur, they will have a negative impact on agricultural manufacturing activities from a financial point of view and that may trigger bankruptcy for agricultural entities [3]. Agricultural insurance is particularly useful for risks caused by natural disasters.

These risks, by definition, cannot be controlled and are the effect of several factors, among which climate change plays an important role [3], [16], [17].

The potential in the production of plum and hers products, which Serbia as a country has, should be used better and more successfully. Given that the production of Serbian plum brandy was included in UNESCO's intangible cultural heritage in 2022, this should be used for greater European promotion and the European production market.

The income generated by the production of this alcoholic beverage was the driving force and incentive for the producers to work on restoring, improving and maintaining the long tradition of plum production in these areas.

Economic analysis of cherry production on family holdings

On the analyzed family farms, the ccherry yield was more favorable in 2022 compared to 2021. Due to rising input prices, cherry production costs per unit area were higher in 2022 compared to 2021. In the total costs of cherries production, the largest share was material costs 45-46%, followed by labor costs with a share of around 35-36%.

Cherries producers in Serbia have been in a very favorable economic position in recent years. Due to high demand, cherry trees plantations have been expanding in Serbia in recent years. The purchase price of cherry increases from year to year. Parameters and indicators of cherry production in 2021 and 2022 are shown in Table 5.

In the structure of cherry production costs, in both years, the largest share was the cost of materials (fertilizer, protection agents, fuel, etc.), about 46%, followed by the labor costs of workers, about 36%.

In the period of full fertility of the plants, the costs of maintaining and cultivating the soil in the total have an average share of about 9%, fertilization costs about 13%, protection costs about 17%, pruning costs about 10%, harvesting costs about 46% and other costs about 5% .

Table 5. The parameters of the production of cherry on family holdings, 2021-2022

Indicator	Year			
	2021		2022	
Yield (t)	8.00		9.00	
The first class (t) The second class (t)	5.60 2.40		6.30 2.70	
Selling price (RSD/kg)				
The first class The second class	120.00 105.00		140.00 125.00	
Costs	Amount (RSD)	Share (%)	Amount (RSD)	Share (%)
Material	174,690	45.00	246,830	46.00
The work of workers	135,870	35.00	193,170	36.00
Depreciation	46,580	12.00	59,020	11.00
Foreign services	7,770	2.00	8,050	1.50
Other	23,290	6.00	29,510	5.50
Total:	388,200	100.00	536,580	100.00
Cost price per unit of measure (RSD/kg)				
The first class The second class	51.40 45.10		62.60 56.00	

Source: Author's calculation based on family holdings data.

As for plum and cherry's the sales prices were different by year and in 2021 it was 140.00 RSD/kg, which is significantly higher than the cost price per unit of the first class in the amount of 51.40 RSD/kg.

Also, the sales price of the second class in the amount of 105.00 RSD/kg is higher than the cost price of plums in the amount of 45.10 RSD/kg. In 2022, the sales price in the amount of 140.00 RSD/kg is above the cost price of the first class in the amount of 62.60 RSD/kg. Also, the selling price of the second class in the amount of 125.00 RSD/kg is higher than the cost price in the amount of 56.00 RSD/kg.

Therefore, cherry production is economically justified in both analyzed years of production, and the amounts of income, costs and financial results are given in Table 6.

Table 6. Financial result of cherry production on family holdings

Indicator	Amounts by year (RSD/ha)		
	2021	2022	Average 2021-2022
Gross Income	924,000	1,219,500	1,071,750
Total cost	388,200	536,580	462,390
Financial result	535,800	682,920	609,360

Source: Author's calculation based on family holdings data.

According to the results determined by the calculative procedure (Table 6), on the analyzed family holdings, the financial result per unit of area in cherry production is significantly better than the financial result in plum production.

The amount of 682,920 RSD/ha was achieved in 2022, and is significantly higher than the result in 2021 (535,800 RSD/ha).

Although the yield per unit area is lower compared to the yield of plums, better economic results are achieved by the production of cherry due to a far more favorable selling price.

Based on the assumption that the market conditions are stable and that there are no significant price fluctuations in a long period of time, in order to sustain the production of cherry, it is necessary to forecast profitability in the future based on the current state of business results.

In order to analyze the economic sustainability of production of cherry on family holdings, similarly to plum, based on the average production and economic results for 2021 and 2022, projected revenues and costs for the next six-year period 2023-2028, and the amounts are given in the Table 7.

Table 7. Projected revenues and costs of the production of cherry on family holdings, 2023-2028 **(RSD/ha)**

Indicators	Year					
	2023	2024	2025	2026	2027	2028
Income	1,130,200	1,216,400	1,071,750	1,090,100	1,089,700	990,100
Costs	510,900	560,420	462,390	508,800	495,500	359,500
Gross profit	619,300	655,980	609,360	581,300	594,200	630,600
Tax on gross profit	123,860	131,196	121,870	116,260	118,840	126,120
Net profit	495,440	524,784	487,490	465,040	475,360	504,480

Source: Author's calculation based on data collected on family holdings.

Taking into account various production, market, social and social factors, revenues in the following six-year period are in the interval from 990,100 RSD/ha to 1,216,400 RSD/ha, costs from 359,500 RSD/ha to 560,420 RSD/ha, and net profit from 487,490 RSD/ha to 524,784 RSD/ha.

Therefore, these indicators confirm that the production of cherry is very profitable and provides stability in business, and this is a key indicator of the sustainability of production and, therefore, of family holdings. The analyzed plantations with cherry trees are in the period of full fertility, and when determining the economic indicators, the investments made in raising the plantations were also taken into account (according to the data of the internal documentation of the producer, that is, the owner of the plantations). Of the economic indicators, the coefficient of economy, average net profit, and rate of accumulativeness and return time of investments made in the raising of cherry trees were determined, and the final amounts are given in Table 8. For every 100 RSD invested in cherry production, 48 RSD of accumulation is achieved. The economy coefficient of cherry is 2.75 and is significantly higher than 1.

The average net profit is 492,099 RSD/ha. Based on the established economic indicators, it is concluded that cherry production is economical and profitable.

Table 8. Indicators of economic justification of the production of cherry on the family holdings

Indicators	Amount
Investment investments (RSD/ha)	1,020,000
Coefficient of economy	2.75
Average net profit (RSD/ha)	492,099
Accumulation rate (%)	0.48
Payback period	2.07

Source: Calculation of the authors.

From the average amounts of net profit, the investments made in the raising of the plantations with cherry trees (1,020,000 RSD/ha) can be recovered in the third year of exploitation of the plantations.

During the last years in Serbia, due to the high demand and favorable sales price, cherry is a very profitable fruit species and the producers achieve profits above expectations. This basically provides producers with security to cover business costs settle family obligations and to a significant extent achieve accumulation with which they can plan new investments on the family holdings.

CONCLUSIONS

Research results that were obtained by a calculative procedure according to data from representative family farms in the area of southern Serbia a more favorable financial result was achieved with plum production in 2022 (594,340 RSD/ha) compared to 2021 (503,490 RSD/ha). For every 100 RSD invested in plum production, 40 RSD is accumulated, and the average amount of net profit is 425,313 RSD/ha. Investments in raising plantations in the amount of 1,080,000 RSD/ha can be recovered in the third year of exploitation of plum plantations from average amounts of net profit. Observing per unit area, the financial result per unit area is very favorable in production of plum. The amount of 682,920 RSD/ha was achieved in 2022, and is significantly higher than the result in 2021 (535,800 RSD/ha).

Although the yield per unit area is lower compared to the yield of plum, better economic results are achieved by due to a much more favorable selling price, the production of cherry is more profitable. Significant accumulativeness is achieved, where for 100 Serbian dinars invested in the production of cherries, 48 Serbian dinars of accumulation is realized. Also, the results show that cherry production is economical, during its production an average net profit is achieved in the amount of 492,099 RSD/ha.

From the average amounts of net profit, the investments made in the raising of cherry plantations (1,020,000 RSD/ha) can be recovered in the third year of exploitation of the plantations.

During the last years in Serbia, due to high demand and favorable purchase price, cherry is a very profitable fruit species. According to the results of the analysis, the production of plum and cherry on family farms in Serbia is economically viable. In order to improve the production results of these two fruit species in Serbia, there is a need to carry out micro-regionalization and determine favorable areas for raising plum and cherry plantations.

The possibility of improving the production of plum and cherry can be realized through various support measures at the state and local level. By using scientific achievements and engaging professional services in the raising and use of plantations, it is necessary to carry out a proper selection of plum and cherry products and to enable competitiveness on the domestic and foreign markets through marketing. With permanent education of plum and cherry producers, it is possible to contribute to the improvement of the existing business and improve profitability results.

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A MODEL OF GOOD PRACTICES IN SUSTAINABLE RURAL TOURISM FROM THE MOUNTAIN AREA - A CASE STUDY "GURA RAULUI", SIBIU COUNTY, ROMANIA

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Abstract

The aim of the paper is to present a model of good practices in sustainable rural tourism in the mountain area of Romania, exemplifying a well known tourist village. from the Sibiu County. At the beginning, there were described the stage of development of rural tourism in the mountain commune named "Marginimea Sibiului", in terms of the structure of the tourist accommodation and public food units, touristic and anthropological objectives, the promotion of the tourist offer. Then, there were calculated and interpreted some indicators of the tourist circulation The second stage of the research analyzes the expectations of 360 tourists from a vacation spent in the tourist village of Gura Râului, the selected case study, as a model of good practices in sustainable rural tourism. The survey was carried out based on a structured questionnaire including 13 questions, which was utilized as a working tool. The respondents' answers were collected, summarized and then the data were statistically processed using Excel, v. 365 Microsoft Corporation, Redmond, WA, USA. The results showed that Gura Râului becomes a more attractive destination for the rural tourism lovers and a real example of sustainable rural tourism to be followed by other mountain villages of Romania.

Key words: *sustainable, rural tourism, mountain area, Gura Râului, Romania*

INTRODUCTION

Rural tourism contributes to the economic, cultural, social, and environmental sustainability of rural areas [26]. As a rule, rural tourism is associated with the concept of sustainable tourism [20]. It allows the diversification of the activities of agricultural holdings, protects extensive agriculture, creates employment opportunities especially for women, reduces the depopulation of villages, allows the direct exploitation of food products produced by peasants, and promotes local culture, products, and services [8, 17]. The creation of jobs in the rural environment is even more important, as the number of people employed in agriculture in Romania in 2022 was 878 thousand people, representing only 65.7% of the agricultural workforce, existing in 2013 [13]. Rural tourism jobs involve improving the professional and digital skills of rural residents, especially young people working in the service sector [33].
[1] state that the sustainable development of rural areas requires a balance between already existing economic activities and tourism activities.
Rural tourism in general, and in a special way in mountain villages, contributes to keeping the cultural heritage and rural lifestyle [24]. In such of communities, rural tourism must value the connection between man and nature, on the use of extensive agricultural practices, with an emphasis on the superior quality of the food products obtained [18].
In U.E. in 2021 there were 1,832 million nights spent in EU tourist accommodation [20]. 43.1% of the number of overnight stays in 2021 in tourist accommodation structures were recorded in

the months of July and August, indicating a high degree of seasonality.
However, the number of nights spent in EU tourist accommodation by domestic tourists was 17.9 % lower in 2021 than it had been in 2019, respectively, in the pre-pandemic period [10, 11].
In 2022, the European Union had 12,696,794 places (beds) in the tourist accommodation structures of the rural area, which represented 43.80% of the total existing accommodation capacity [9]. This aspect reflects how important is the development of rural tourism for the member states.
In this context, the goal of the research is to analyse the actual state of development of rural tourism in Gura Râului village, Sibiu County and to identify what tourists expect from a vacation spent in the mountain area, at Gura Râului.

MATERIALS AND METHODS

The research work was based on a large variety of information from the literature in the field and on the collection of information from the case study in Gura Râului village.
The methodology included at the beginning desk research methods and procedures to collect the primary data from official information sources and data bases regarding lodging and travel services provided. In this case it was used the site of The National Authority for Tourism under the coordination of the ministry in charge of tourism activities and also the data were picked up from the Ministry of Agriculture and Rural Development. After setting up the data collection for this research work, there were calculated some competitiveness indicators of rural tourism in Gura Râului commune, Sibiu County.
It is about the following indicators:
The tourist flow density needed to be calculated as a ratio between the number of arrivals and the number of resident population (January 1) and it reflected the direct connection between tourist traffic and the resident population in the village [25].

TD = TA/P………................................ (1)

where:
TD = tourist traffic density
TA = total number of arrivals
P = population of the locality on 1 January

The intensity of tourist flow was determined dividing the number of overnight stays to the resident population in the village [2].

TI = Os/P………................................. (2)

where:
Ti = tourist traffic intensity
Os = number of tourist overnight stays
P = total population on 1 January

To assess the size of the tourist development in the studied area, it was evaluated the tourist operation rate, whose formula involves to calculate the ratio between the total number of accommodation units and the resident population.

Tfr = Tacu/P……................................... (3)

where:
Tfr = tourism function rate
Tacu = total number of accommodation units
P = total population on 1 January

A sociological survey was run in the second stage of the research in order to quantify the expectations of young people who love to spend a vacation in such a charming rural area and in the Gura Râului village. In order to solve this problem, it was developed a structured questionnaire which served as a working tool.
The questionnaire consisted of 13 questions regarding rural tourism as follows:
Q1 – What were your sources of information to choose a rural tourism destination where to spend your holiday?
Q2 - Ways to book the tourist stay?
Q3 - On a scale of 1 to 5 how much do you prefer Mărginimea Sibiului as a holiday destination?
Q4 - Can you locate the commune of Gura Râului?
Q5 - What motivates you to choose Gura Râului like a tourism destination?

Q6 - Which is the preferred season for spending a holiday at Gura Râului?
Q7 - What is the distance between your home and Gura Râului commune?
Q8 - What means of transportation did you use during a vacation in a rural tourism destination?
Q9 - What is the length of stay in a rural tourism destination?
Q10 - What kind of tourist services do you prefer?
Q11 - What are the most attractive activities you want to do in a rural tourism destination if you stay in the local community?
Q12 - What kind of local products do you prefer to buy in the tourist village?
Q13 - On a scale from 1 to 5, how much would you like to return to the Gura Râului tourist village and recommend it to others?

The sample size was 360 respondents. Respondents received the questionnaire on their email address and were asked to share it with other friends/acquaintances. The questionnaire was also distributed through social media platforms. Responses were collected between March 1 and April 30, 2022.

The questionnaire also included questions to classify respondents by age, gender, domicile, level of education, number of persons in the household, average monthly gross income level.

Then, using Excel, v. 365 Microsoft Corporation, Redmond, WA, USA, the data collected based on the respondents' answers were statistically processed.

According to the well known procedures which are used in processing the answers collected from field survey, we passed to calculate the frequencies and the shares of the received answers using:

- *Semantic Differential Scale* (Osgood, C.E.,1957), to highlight the intensity of the opinions in terms of the weighted arithmetic mean for each item of a question, using the formula:

$$\sum_{i=1}^{n} f_i \qquad (4)$$

where:

x_i is the score linked to the evaluation, f_i is the frequency, more exactly the number of answers registered for each score.

- *Likert Scale* (1932), emphasizes the agreement and disagreement of the respondents related to an item of a question. In this research, the 5 Point Likert scale was utilized [14].

Suggestive graphics were set up to help the readers to better understand the analyzed phenomenon. The tables synthesized a part of the results. Finally, the results were correspondingly interpreted and the main conclusions resulting from this research were drawn.

RESULTS AND DISCUSSIONS

Case study: Analysis of the rural tourism infrastructure in Gura Râului commune and the determination of tourism competitiveness indicators

Geographical, demographical and cultural description

The poet Lucian Blaga states: ”*You should see Gura Râului sometime to understand what a corner of heaven with an ancient tradition means in Romanian culture*”.

Gura Râului commune in Sibiu county, Romania is one of the 18 localities that form the well-known pastoral area "Mărginimea Sibiului". In this region, the tourists have the opportunity to admire the beautiful mountain scenery and to benefit of the authentic cultural experiences which are harmoniously combined, which contributed to the awarding in 2015 of the title of "European destination for tourism and gastronomy" [29].

In the past, the area was known for transhumance of sheep, but currently only four localities practice it: Poiana Sibiului, Jina, Tilișca and Rășinari. The sustainable development of the Mărginimea Sibiului area must be achieved by revitalizing traditional economic activities and rural tourism [27]. The importance of rural tourism in Sibiu County and in the "Marginimea Sibiului" area has grown year by year [21]. In the "Mărginimea Sibiului" area, the local communities have developed over time a mixed economy, based on agriculture, animal husbandry, especially sheep breeding, handicrafts, and in the last thirty years it has become a well-known destination for rural tourism and agritourism. In this area in 2021, 182 tourist structures with accommodation function were operating [7].

Gura Râului commune had a population of 3,811 inhabitants (ins) on January 1, 2023 and is a compact locality, with the hearth of the village located on the Cibin River valley. The locality is 18 km from the city of Sibiu, being in the mountain area at an altitude of 544 m [12] and is documented since 1380 [15]. The total area of the commune is 10,545 km^2, with a population density of 36 inhabitants/km^2.

The structure of the land fund of the commune includes 3,882 ha - area of grain cultivation and animal breeding, of which 942 ha are arable land and 2,958 ha are pastures and hayfields. 1,312 households are registered in the commune, of which 1,312 are owners of agricultural land and 193 are animal breeders or bee families. The forest area of the commune is 6,217 ha [16].

Natural tourist attractions

The main attraction of the commune is the beauty of the mountain landscape. The reservoir of 65 ha surface situated in the vicinity provides edible water both for the whole county, and also for the municipality and all kind of localities in the region.

In the proximity of the commune, it is situated the Cindrel Natural Park, which has a surface of 9,873.9 ha and is located on the territories of the communes of Gura Râului, Rășinari, Tilișca and Jina) and the Iezerele Cindrelului Nature Reserve, with an area of 609.6 ha.

Anthropogenic tourist attractions

In the commune there is a village museum established in 1969 which houses a village collection of ethnography and local history. In the locality there are several historical monuments, among which we mention: an Orthodox church (18th century), a hydraulic textile installation (19th century), a covered wooden bridge (19th century), wooden houses (19th century).

The commune was famous in the past for the installations that used water power, such as mills, mills or piues. Today, such hydraulic installations are still preserved in households, such as oil presses [28].

In the period 2007-2010, the Sibiu County Council and the Sibiu Regional Ecomuseum Association organized a symposium here entitled "Water Civilization" through which these hydraulic installations were highlighted.

The local public authority understood the importance of organizing local events that would attract tourists and help promote local identity and preserve traditions [5]. On the first weekend of July, the "Peony Festival" is held in the commune, to pay tribute to the mountain peony (*Rhododendron Rotschy* or the smardarul) that blooms in the nearby mountain area. The event is organized over two days and includes an "Evening as in the barn", with local folklore and a specific menu and a folklore show with the participation of amateur artist ensembles from the area [31]. In the commune there is a vocal group that works in addition to the cultural home. The locality also organizes the celebration for wearing the traditional costume.

The structure of the accommodation and catering base

In the commune of Gura Râului, 31 tourist structures with accommodation function are classified, which include rural tourist guesthouses, agrotourism guesthouses, hotels, cabins, and rooms for rent, with a total capacity of 468 places. Of these, 18 (58.06%) are rural tourist guesthouses, which offer 249 places for accommodation (57.48%) (Table 1).

Their comfort category is 3 stars/daisies for 61.29% of the tourist structures, 4 stars/daisies for 12.90% of the structures and 2 stars/daisies for 16.13 of the accommodation spaces. Some of the rooms for rent in citizens' homes are classified at 1 star, representing 9.68% of the total number of tourist structures.

There are two restaurants, a bar and a wine cellar within the locality, with a total capacity of 278 seats. Also, one of the 35 existing local gastronomic points in Sibiu County was established in the village [18].

Table 1. The structure of the accommodation base

Type of accommodation unit	Specification					
	No	%	Number of rooms	(%)	Number of accommodation places	(%)
Tourist guesthouse	18	58.06	120	57.14	269	57.48
Agritourism guesthouse	2	6.45	11	5.24	26	5.56
Hotel	1	3.23	30	14.29	61	13.03
Chalet	5	16.13	21	10	46	9.83
Rooms for rent	5	16.13	28	13.33	66	14.10
Total	**31**	**100**	**210**	**100**	**468**	**100**

Source: own calculation base on [17].

In the commune there is a sheep pastrami producer that has registered its product on the optional "mountain product" and "traditional product" quality schemes.

Indicators of tourist traffic

Fig. 1. Dynamics of tourist traffic density in Gura Râului, between 2018-2022
Source: Own calculation based on [19].

Figure 1 shows that in 2022 it was observed the highest value of tourist traffic density accounting for 2.04 in the whole interval 2018-2022.

The lowest value of the indicator was 0.71 carried out in 2018.

During the Covid 19 pandemic, small capacity tourist accommodation structures, especially those in the mountain area, responded to the demand for accommodation for families or small groups, who preferred them for sanitary safety [22].

The two indicators, the density of tourist traffic and the intensity of tourist traffic increased in the analysed time interval.

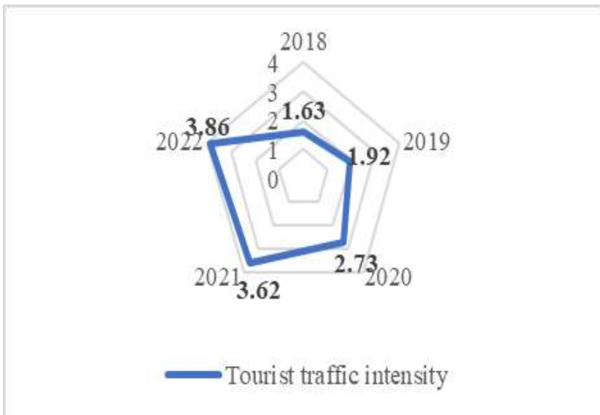

Fig. 2. Dynamics of tourist traffic intensity Gura râului, between 2018-2022
Source: Own calculation based on [19].

During the Covid 19 pandemic and immediately after it, tourists preferred to spend their holidays in small tourist structures, especially in the mountain area.

The rate of the tourist function has for the year 2022 the value of 0.008.

Promotion of accommodation services

The tourist structures with accommodation function in the commune of Gura Râului promote their tourist offer through the platforms: Facebook, Travelminit, Booking, Turistinfo, Directbooking, Agoda, Tripadvisor, La Pensiuni, România Turistica, Sky Trip, Tourism guide, and through the websites own [6]. The promotion of services has been carried out since 2014 mainly through the Internet and less through collaboration with travel agencies [31].

The expectations of young tourists from a vacation spent in the tourist village of Gura Râului, Sibiu County

Socio-demographic data of the respondents

The questionnaires on rural tourism and customers preferences have been applied to a number of 360 respondents. Analysing the data obtained using questionnaires, by gender of the respondents, it can be observed that these were applied to 27.5% males, and to 72.53% females.

Table 2. Data on respondents

Specification		Frequency	%
Gender	Male	99	27.5
	Female	261	75.7
	Total	360	100
Domicile	Urban	173	48.06
	Rural	187	51.94
	Total	360	100
Age (years)	18-29	176	48.88
	30-39	71	19.72
	40-49	75	20.84
	50-59	30	8.34
	Above 60	8	2.22
	Total	360	100
Last school completed	Gymnasium	1	0.28
	Vocational school	5	1.39
	Gigh schools	99	27.50
	Post high school	18	5.00
	Faculty	132	36.67
	Masters	84	23.33
	PhD	21	5.83
	Total	360	100
Family income* (Lei)	Under 3,000 lei	43	11.94
	3,001-7,000 lei	159	44.17
	7,001-10,000 lei	89	24.72
	Above 10,001	69	19.17
	Total	360	100
Persons in household	1	12	3.33
	2	83	23.06
	3	81	22.50
	4	114	31.67
	5	47	13.06
	Above 6	23	6.38
	Total	360	100

*1 euro = 4.9720 lei on 27 December 2023
Source: Own calculation.

The domicile of the respondents is in the case of more than half of the people (187) in the rural area (51.94%). Depending on the age of the respondents it was found that most of them were between the ages of 18-29 years (48.88%), followed by those between the ages of 40-49 years (20.84%), afterwards by the respondents between the ages of 30-39 years (19.72%), finding at the opposite pole, those with ages over 50 years (10.56 %) (Table 2).

Most of the respondents (247 people) are young, under the age of 39 (68.60 %). More than half of the respondents (237 people) graduated from at least one college (65.83 %). The average monthly income of the household is below 7,000 lei (about 1,408 euro/month, household) for 56.11% of the respondents. It is observed that in the households of approx. 80% of the respondents are under 4 people.

Respondents' answer to the questionnaire

As can be seen from Fig. 3, the main sources of information regarding the possibility of spending a holiday in Romania are relatives/friends (86.67%), Booking (81.94%), the accommodation units' own websites (71.11%) and Facebook (72.22%). In general, young people are used to using the Internet for information and are familiar with the main social networks or booking platforms.

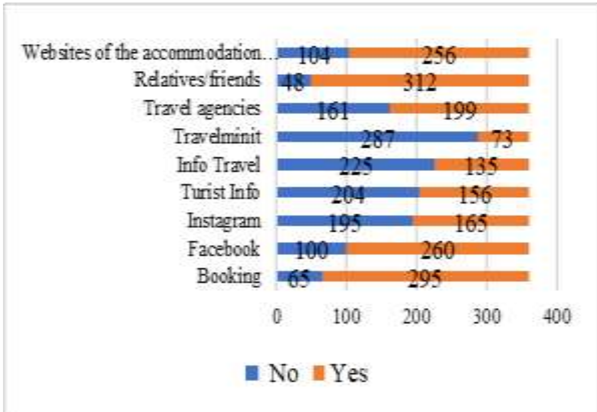

Fig. 3. The main sources of information about holidays in Romania
Source: Own calculation.

Fig. 4. The way in which the accommodation reservation is made.
Source: Own calculation.

The majority of respondents, more exactly 82.78%, being young and familiar with the use of the Internet, they usually practice to make make reservation directly on the website of the accommodation units for tourists (Fig. 4).

The results obtained regarding the use of the Internet and access to social networks are consistent with the statistical data of the E.U. which shows that in 2022, 84% of people use the internet daily and 58.2% of people aged 16-74 have accessed social media accounts in the last three months. [11].

Recently published studies emphasize the importance of technology, mobile phone applications and devices (identification of GPS coordinates, digital maps, the Questo application for the identification of tourist attractions, software that allows the identification of plants or types of clouds) that can be used for sports or in during nature activities The results obtained regarding the use of the Internet and access to social networks are consistent with the statistical data of the E.U. which shows that in 2022, 84% of people use the internet daily and 58.2% of people aged 16-74 have accessed social media accounts in the last three months. [3; 18; 32].

In order to be the extent to which the respondents would choose a rural tourism destination for a holiday, a 5-point Likert scale was used (1 – total disagreement, 3 – neutral, 5 – total agreement).

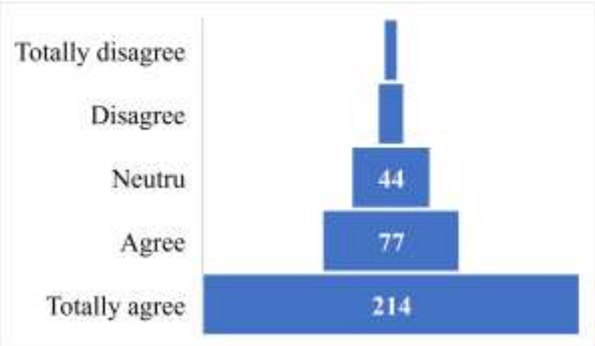

Fig. 5. The preference for choosing the Mărginimea Sibiului area as a holiday destination.
Source: Own calculation.

They were asked to specify how much they prefer the area of Mărginimii Sibiului as a holiday destination (Fig. 5).

More than 80% of people agree with choosing this area as a holiday destination, which demonstrates the area's popularity as a rural tourism destination.

The respondents know the locality of Gura Râului whose membership was attributed to Sibiu county (96.67%), Mărginimea Sibiului area (96.39%), with a tradition of shepherding (79.92%).

The main motivations for which respondents would choose to spend a vacation in Gura Râului are shown in Fig. 6.

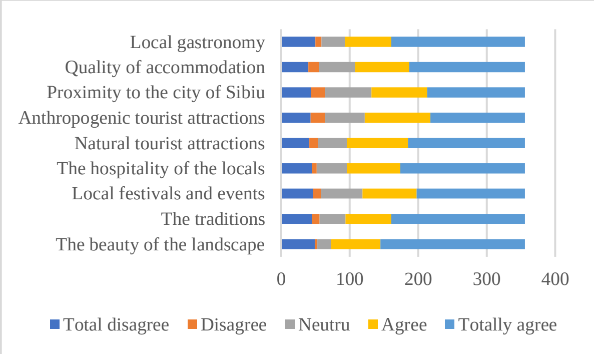

Fig. 6. The main reason why tourists choose to spend a vacation in the village of Gura Râului
Source: Own calculation.

Using the Semantic differential, the obtained scores allowed to classify the motivations of the respondents in the decreasing order of their importance as follows: 1- The beauty of the landscapes; 2- Traditions; 3- Local gastronomy; 4- The hospitality of the locals; 5– Natural tourist attractions; 6- Quality of accommodations; 7– Local festivals and events; 8– Anthropogenic tourist attractions; 9 – Proximity to the City of Sibiu.

The general average score was 3.92 and considering this level, we may easily notice that almost all the motivations regarding the choice of a holiday in Gura Râului as a rural touristic destination registered higher scores, except the local festivals and events, anthropogenic tourist attraction and, the proximity to the City of Sibiu (Table 3).

Table 3. The scores reflecting the most important motivations of the respondents to choose Gura Râului as their holiday destination

	Score	Rank
The beauty of the landscape	4.11	1
The traditions	4.01	2
Local festivals and events	3.83	7
The hospitality of the locals	3.98	4
Natural tourist attractions	3.95	5
Anthropogenic tourist attractions	3.76	8
Proximity to the city of Sibiu	3.74	9
Quality of accommodation	3.92	6
Local gastronomy	3.99	3
Average score	**3.92**	**-**

Source: Own results based on social survey

This shows that respondents want to visit touristic villages, especially from mountains area for their beauty of the landscapes, where the local traditions are well conserved, and the hosts are full of hospitality and offer a large range of local gastronomy.

Statistical data after the Covid 19 pandemic show that 82% of Europeans were willing to change their travel habits for more sustainable practices. These mostly refer to visiting less populated tourist destinations, holidays spent closer to home and eating local, fresh food The results obtained regarding the use of the Internet and access to social networks are consistent with the statistical data of the E.U. which shows that in 2022, 84% of people use the internet daily and 58.2% of people aged 16-74 have accessed social media accounts in the last three months [26].

The preferred season for a holiday at Gura Râului is summer in the case of approx. 96% of respondents (Fig. 7). The reasons why tourists choose a vacation at Gura Râului in the summer are: the beauty of the landscape (27%), the possibility of practicing activities in nature (25%), participation in the "Peony Festival" (21%) or the "Romanian Port Festival" (13 %) and the desire to visit new places in the summer (14 %).

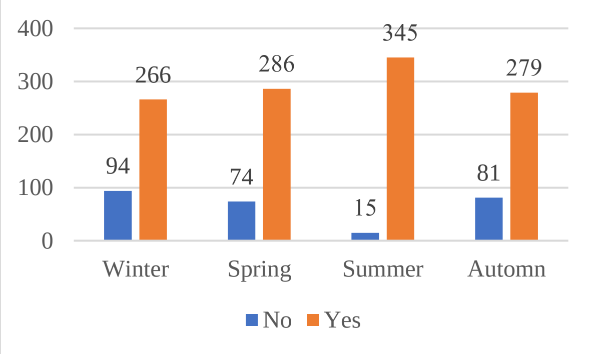

Fig. 7. Favorite season for vacation at Gura Râului
Source: Own calculation.

To find out how far Gura Râului is from the respondents' place of residence, they were asked to specify this distance in km. The 360 recorded data were then processed statistically (Table 4), resulting in an average distance of 133.14 km.

Table 4 Descriptive statistics of the data regarding the distance between the village of Gura Râului and the respondent's place of residence

Mean	133.14
Standard Error	27.05
Median	22.50
Mode	20.00
Standard Deviation	513.23
Sample Variance	263,407.90
Kurtosis	158.94
Skewness	11.28
Count	360.00
Confidence Level (95.0%)	53.20

Source: Own results based on social survey,

Using the Likert scale with five steps the mean of transportation to the chosen tourism village, we observed that 88 % of tourists mentioned their own car (4.4 score)(Table 5).

Table 5 Preferred mode of transport to reach your holiday destination

	Score	Rank
Car	4.4	1
Minibus	2.11	3
Bus	2.1	4
Bicycle	2.45	2
Motorcycle	2	5
Average score	2.61	-

Source: Own results based on social survey.

On the second position was bicycle which was used by 49% of the questioned individuals, who preferred this mean of transportation because they like a sporty lifestyle, and they are young people (Table 5).

Regarding the length of a holiday spent in a touristic village, most of the questioned persons (70%) affirmed that it was between 1 and 4 days. They prefer to use weekends for relaxation and activities in nature. About 24.44 % young tourists spent between 5 and 14 days, and only 5.28% had a vacation longer than two weeks (Fig. 8). During a vacation in a tourist village, in addition to accommodation services, 93.33% of those surveyed prefer to benefit from public catering services.

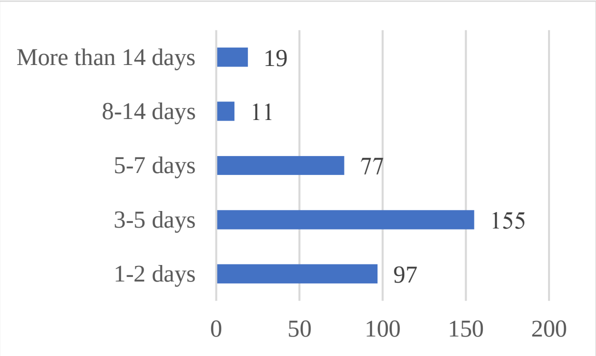

Fig. 8. Length of stay in a rural tourism destination.
Source: Own calculation.

During a holiday in the countryside, almost half (46.67%) of the respondents prefer to serve all three meals, 36.11% prefer half board and only 17.33% prefer for accommodation with breakfast. At the same time, 93.61% of people prefer local gastronomy, specific to the area, with culinary preparations made from local raw materials, depending on the season.

Tănase et al (2023) showed that when traveling to rural areas, they are interested in the elements of cultural uniqueness, culinary diversity and the price of services [34].

The average score calculated based on 5 Point Likert scale for all the 21 activities possible to be done by tourists in a rural tourism destination was 3.75. A number of 11 activities recorded a higher score reflecting their importance and in the decreasing order they are the following: 1- Mountain hike, 2- Campfire, 3 – Observation of flora/fauna, 4 - Visiting the hydroelectric plant, 5 – Participation in the local events, 6 - Horseback riding/carriage rides, 7 - Collection of medicinal plants/forest fruits, 8 - Attending a brunch and Visits to the farm/stable, 9 - Learning a folk craft, 10 - Visit to an ethnographic museum, 11 - Folkloric evenings (Table 6).

Table 6. The scores for the most attractive activities for tourists in a mountain rural tourism destination

Activities	Score	Rank
Mountain hike	4.34	1
Fishing/hunting	3.14	20
Cycling	3.66	13
Horseback riding/carriage rides	3.91	6
Observation of flora/fauna	4.03	3
Collection of medicinal plants/forest fruits	3.89	7
Paraglider flights	3.31	19
Team sports games	3.37	17
Detox/spa treatments	3.34	18
Winter sports	3.68	12
Folkloric evenings	3.82	11
Campfire	4.21	2
Learning a folk craft	3.87	9
Agricultural activities	3.51	16
Participation in local events	3.93	5
Attending a brunch	3.88	8
Cooking classes	3.65	14
Visits to the farm/stable	3.88	8
Visit to an ethnographic museum	3.83	10
Visiting the hydroelectric plant	3.96	4
Mountain biking	3.54	15
Average score	**3.75**	**-**

Source: Own results based on social survey.

Knowing the activities that tourists want is important both for guesthouse owners, for representatives of the local public administration, but also for other entrepreneurs in the tourist destination.

A study on youth preferences for ecotourism shows that the main activities that young people want to do in an ecotourism destination are hiking, tasting traditional gastronomic dishes and participating in local events. The possibility of practicing some recreational activities, the quality of local gastronomy and accommodation services are at the basis of the decision to choose an ecotourism destination [32].

Almost all respondents (98.9%) want to buy local and traditional products. Among the local products that tourists want to buy from a mountain tourist village, we mention: homemade bread (91.11%), dairy products (63.89%), meat products (59.17%), craft products (58.61%), eggs (54.72%), vegetables and fruits (53.33%) and fresh milk (51.94%). A study published in 2013 shows that traditional products support the local economy and contribute to the preservation of cultural identity [4; 30].

Using the Likert scale with five steps the desire to return to the town of Gura Râului was expressed with total agreement by 284 people (78.88%) or agreement by 51 people (14.44%). These people know the tourist village of Gura Râului well and had a positive vacation experience in this locality.

CONCLUSIONS

Gura râului commune in Sibiu County is located in the mountain area and is part of the famous "Mărginimea Sibiului" sheep breeding area. Rural tourism in the locality has been carried out for more than 25 years, and to the attractiveness of the village has been contributed by: the beauty of the mountain landscape; environmental quality; the existence near the village of a hydropower plant, a water storage lake and some protected areas; the events organized at the local level; the existence of extensive farming practices, especially those related to the rearing of ruminants; the existence of craft workshops that in the past used the power of water for the needs of domestic industry (for the processing of wood, wool or food oils); small local businesses related to the processing of meat and offal into local products; the existence of a village museum and historical monuments; the existence of local groups of amateur artists; well preserved traditions; the entrepreneurial spirit of the locals.

Currently, 31 tourist accommodation structures operate in the commune, with a total capacity of 468 places. The tourist density index in the locality increased from 0.71 in 2018, reaching 2.04 in 2022. The tourist traffic intensity index also increased from 1.63 in 2018 to 3.86 in 2022. The evolution of the two indices demonstrates that Gura râului tends to become a well-known rural tourism destination.

Rural tourism entrepreneurs promote their services through national accommodation booking platforms or their own websites and less through collaboration with travel agencies.

Tourists who want to spend a holiday in the countryside get recommendations from relatives/friends, get information from Booking, or from social networks and pension websites. More than 80% of young people use to book their accommodation services through hostel websites. Hence the need for rural tourism entrepreneurs to invest resources to promote their services through their own websites and social networks.

The basis for choosing the village of Gura râului as a holiday destination is the beauty of the landscape, the well-preserved traditions, and the local gastronomy. Most tourists choose to spend a vacation here, especially in the summer, which allows them to spend as much time as possible in nature, to practice different leisure activities and to participate in the local festival that has a national reputation. The top three activities according to tourists' preferences are mountain hiking, campfire and observing flora and fauna.

The average distance between the town of Gura râului and the residence of the 360 respondents is 133.14 km, the preferred means of transport being the personal car, which confirms the current trends for short holidays, over shorter distances.

Over 90% of tourists opt for accommodation and food services. The promotion of local gastronomy, based on fresh and seasonal raw materials, cooked according to traditional recipes, is of great importance and contributes to preserving the elements of culinary uniqueness. The high proportion of tourists (approx. 99%) who want to buy local dishes, such as bread and meat or milk products, is noteworthy. Unlike other communes in the mountainous area of Sibiu County, in Gura râului there is a low interest of the locals in registering their products on the optional national quality schemes. Most of those who process the local raw material according to recipes specific to local gastronomy sell their products directly to guesthouse owners or to tourists. It can thus be said that through rural tourism the entire local community supports extensive agriculture in the locality, thus contributing to the creation of short food chains and improving the quality of life of farmers.

The success enjoyed by rural tourism in Gura râului is also confirmed by the fact that tourists want to come back here on vacation.

Gura râului is the second commune in Sibiu County in terms of the number of tourist structures, and the rural tourism practiced here can be considered an example of good practices in the field. Rural tourism contributes to the diversification of the local economy and stimulates rural development.

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CHALLENGES AND PROBLEMS IN THE DEVELOPMENT OF LAND RELATIONS IN BULGARIA

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Abstract

The implementation of the Common Agricultural Policy after 2007 has brought new dynamic changes to the business environment where this primary Bulgarian industry functions. Getting financial incentives to support income as well as incentives to comply with other European policies distorts the business environment in Bulgaria. The land reform has been a key element of the agricultural transformation during the long-term transition in Bulgaria, which aims to create favourable conditions for the establishment of market economy by decentralizing the process and restoring the right of ownership to all owners and their heirs. The problems related to the study of land relations are of eternal relevance and significance. The importance of land relations is much more essential for the sustainable development of the viable rural regions in Bulgaria, having in mind the favourable natural conditions and the traditions inextricably interwoven with the agricultural sector in the country. The comprehensive research of land relations is a key condition for studying their impact on the socio-economic processes and relations, thus focusing on certain synergistic opportunities for the agricultural sector in Bulgaria. The purpose of this article is to describe, present and analyze the role and challenges of land relations, as well as the related issues that are fundamental for the state of agriculture and the place of the sector in Bulgarian economy as a whole. The study also has a narrow focus on achieving the key goal of intensifying the links between education, business and public authorities in general. For the research analysis we will apply the scientific approach as well as the following methodological framework such as complex and structural analysis. The study focuses on the challenges and problems in the development of land relations in Bulgaria, as well as the range of land relations related to the social, economic, management and legal environment in Bulgaria. The institutional environment in Bulgarian agriculture is a complex system of symbiotic relationships, dynamically changing under the influence of national and sectoral legislation. The challenges and issues of land relations are an extremely complex social phenomenon. The economic, social and environmental influences involved in it has a two-way impact on the agricultural sector. The harmonization and improvement of institutional framework in compliance with the requirements of the EU - development of sectoral legislation, re-structuring of agricultural farms, as well as various aspects of the implementation of the CAP, competitiveness and development of rural regions, are part of the issues and challenges related to the sustainable development of land relations and the agricultural sector in Bulgaria.

Key words**:** *land relations, land reform, challenges, Bulgaria*

INTRODUCTION

Contemporary challenges in the world and global crises require new economic thinking to predict and propose different management solutions [14].

Getting financial incentives to support income as well as incentives to comply with other European policies distorts the business environment in Bulgaria [1].

The importance of land relations is much more significant for the sustainable development of the viable rural regions in Bulgaria, having in mind the favourable natural and climatic conditions and the traditions inextricably interwoven with the agriculture in the country [2].

The comprehensive research of land relations is an essential condition for studying their impact on the socio-economic processes and relations, thus focusing on certain synergistic opportunities for the agricultural sector in Bulgaria [2]. The land reform has been a key element of the agricultural transformation during the long-term transition in Bulgaria, which aims to create favourable conditions for the establishment of market economy by decentralizing the process and restoring the right of ownership to all owners and their heirs [3].

Ever since the crucial 1989 the agricultural sector has experienced some serious changes, the most important of them being the implementation of the land reform and restitution of land in its real borders, and it has also faced some serious issues such as destruction of the old production structures, privatization, as well as the lack of purposeful government policy or support for Bulgarian agriculture [4].

European subsidies are an attractive reason for a large number of farmers. Unfortunately, they are not always reinvested in business activity, and the payment per unit of area provokes a number of imbalances in the industry [14].

In some cases, the new owners are not available for working the land and in this case land rent is a good solution practiced by the commercial agricultural holdings.

Land price has changed across the time increasing its level and between rent and land price is a close relationship [5, 6].

Land relationships have changed in various ways and the recent research studies have proved this aspect [8, 9, 10, 11].

When providing European financial means to support the income of agricultural producers, priority is given to the consideration and synchronization of national priorities and the achievement of results in all EU Member States [13].

The purpose of this article is to analyze the role and challenges of land relations, as well as the related issues that are fundamental for the state of agriculture and the place of the sector in Bulgarian economy as a whole.

This article continues our research in the field within the project "Land Relations and European Policy: Synergy and Prospects for Bulgarian Agriculture" - KP-06–H35/2.

MATERIALS AND METHODS

The relevance and need for development of a methodology related to the study of land relations in Bulgaria is derived from the link between the land management and the increasingly dynamic regional and national processes related to circular economy policies, bio-economy and food security. The research guidelines are harmonized not only with the Bulgarian strategic objectives, but with the latest and most up-to-date policies for European society. The study also has a narrow focus on achieving the key goal of intensifying the links between education, business and public authorities in general.

For the research analysis we will apply the scientific approach as well as the following methodological framework such as complex and structural analysis.

RESULTS AND DISCUSSIONS

The processes in land relations, as public relations, are dominated by the constant changes in the institutional environment and socio-cultural traditions. The research of land relations does not focus only on a single issue, but on many issues related to the social, economic and legal environment in Bulgaria [12].

The large number of small-scale agricultural farmers is typical for Bulgaria and the main reason for this is the land reform carried out in the 1990s, when the land was returned in real borders to its owners and their heirs. The small-scale agricultural production is result not only of the land reform, it has also its traditional roots in Bulgaria. In the past, before the process of collectivization, landowners cultivated small plots of land that were sufficient to produce enough agricultural produce and food to satisfy their own needs. Nowadays, Bulgaria is characterized by a number of small-scale farmers who use 203 930 ha of agricultural land, or 5% of the total agricultural land in the country. The average size of small-scale farms is 2.4 ha compared to 12.1 ha for all agricultural producers [2].

The institutional environment in Bulgarian agriculture is a complex system of symbiotic relationships, dynamically changing under the influence of national and sectoral legislation. The administration of land relations, land use in particular, often sets important boundary conditions for land markets. The institutional framework is a decisive factor. The social environment of development has the longest and lasting influence on all other processes.

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These elements of the institutional framework constitute the system that ensures the functioning of the market, its impact on the maturity of land relations and the importance of economic results in the sector for creating a value chain in the national economy.

In 2021 the agricultural land in Bulgaria was 5,227,350 ha, which represented about 47% of the territory of the country. The utilized agricultural area (UAA) is formed from arable land, perennials, nurseries, permanent grassland and kitchen gardens. In 2021, it was 5,046,597 ha - without significant change compared to the previous year, representing 45.5% of the country's territory. The arable land includes areas where crop rotation is applied, as well as temporary wheat and legume fields, fallows and greenhouses. In 2021, the arable land increased by 0.3% on an annual basis, to 3 486 748 ha or 69.1% of the used agricultural area.

The utilized agricultural area (UAA) is formed from arable land, perennials, nurseries, permanent grassland and kitchen gardens. In 2021, it was 5,046,597 ha - without significant change compared to the previous year, representing 45.5% of the country's territory.

In 2021, the uncultivated land occupied 180,753 ha (about 1.6% of the country’s area) - an insignificant increase of 0.06% above the previous year’s level (Table 1).

Table 1. Arable land, used agricultural area and agricultural area for the period 2017-2021 (ha)

Land destination	**2017**	**2018**	**2019**	**2020**	**2021**
wheat	1,197,768	1,237,736	1,250,478	1,203,964	1,247,453
barley	138,122	115,773	112,264	131,340	139,109
rye and triticale	30,639	29,767	28,163	25,875	35,053
oat	19,730	16,886	13,866	11,386	10,421
maize	461,085	478,357	641,555	642,373	633,735
other cereals	19,600	24,641	26,352	22,757	21,903
sunflower	934,715	859,910	789,604	888,200	840,185
tobacco	10,506	8,668	4,849	5,440	3,015
industrial oil crops	181,067	203,397	158,305	120,055	142,838
other industrial crops	58,848	46,640	57,878	65,209	64,261
potatoes	12,909	14,611	11,177	11,524	12,363
peas, beans, broad beans, lentils and other pulses	78,389	103,445	42,167	24,989	30,584
ARABLE LAND:	3,473,825	3,463,370	3,461,615	3,477,514	3,486,748
Kitchen gardens	15,258	14,836	14,636	14,231	13,728
Total permanent crops:	148,094	153,029	152,738	151,518	149,042
Permanent grasslands and meadows - orchards	1,392,352	1,399,041	1,408,481	1,403,988	1,397,079
UTILIZED AGRICULTURAL AREA:	5,029,529	5,030,276	5,037,470	5,047,252	5,046,597
AGRICULTURAL AREA	5,224,402	5,226,194	5,222,925	5,227,902	5,227,350

Source: Ministry of Agriculture, Agrostatistics Department, Bulgaria [7].

CONCLUSIONS

In the context of a global economic and food crisis, Bulgarian agricultural policy needs an efficient approach that will guarantee sustainable development and competitiveness of Bulgarian agriculture [1].

A main factor for the dynamic changes in Bulgarian agriculture and land relations are the historical changes in the social model of society. The subsequent changes in the implementation of Community policy and the accompanying mandatory provisions trigger new changes in the industry. The institutional environment in Bulgarian agriculture is a complex system of symbiotic relationships, dynamically changing under the influence of national and sectoral legislation. The administration of land relations, land use in particular, often sets important boundary conditions for land markets. The institutional framework is a decisive factor.

The challenges and issues of land relations are an extremely complex social phenomenon. The economic, social and environmental influences involved in it has a two-way impact on the agricultural sector. Property rights have the potential to be a theoretical basis for overcoming a number of imbalances, they also have the potential to ensure market efficiency and social justice.

The relevance and the key role of building a social environment revealing the importance of land relations in the implementation of the Common Agricultural Policy is also determined by the changes envisaged to be introduced during the new program and budget period. After the crucial 1989 the agricultural sector has experienced some serious changes, the most important of them being the implementation of a compulsory land reform and restitution of land in its real borders; the sector has also faced some serious issues such as destruction of the old production structures and lack of new ones to replace them, privatization, absolute abdication of the state from agriculture as well as lack of purposeful government policy or support for Bulgarian agriculture. The overall study and analysis of land relations represent a constant condition for studying and presenting their impact on the socio-economic processes in Bulgaria.

ACKNOWLEDGEMENTS

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YIELD AND PROFITABILITY OF SOYBEAN CROP

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Abstract

Soybean is a crop with major benefits for the environment, under the conditions of using good agricultural practices, by fixing atmospheric nitrogen which reduces fertilization with mineral nitrogen and its leaching. The integration of soybean in the crop rotation is beneficial and can create conditions for its relaunch and long-term viability so that European consumption can be covered and the dependence on imports can be reduced. The case study carried out on two farms in Romania, South - Muntenia Region, highlighted that, under irrigation conditions, this crop had productions of over 4,000 kg/ha. The capitalization price increased during the analysis period, so the farms recorded a positive and ascending result in the period 2019-2021, except the 600 ha farm, which in 2019, recorded a loss because the crop was not irrigated and the production average (1,712 kg/ha) was insufficient for profit obtaining.

Key words: *soybean crop, yield, profitability, farms*

INTRODUCTION

Soybean cultivation can benefit the environment by fixing atmospheric nitrogen in the soil and thus helping to reduce the doses of mineral fertilizers applied and the risk of nitrogen leaching [7, 10, 13, 15].

The soybean crop is of particular importance both from an agronomic and food point of view, being a major source of protein (on average 40%) and oil (approx. 20%) [14]. At a production of 2 t/ha, approx. 700 kg of crude protein and 400 kg of oil can be obtained [6]. Moreover, the introduction of soybeans in crop rotation can be an important way to improve chemical nutrients and microbial activity in the soil and to improve soil health in agroecosystems [8]. Worldwide, the main suppliers of the soybean market, with approximately 80% of world production, are the United States of America, Brazil, and Argentina, imports into the European Union are dependent on these countries [11,14]. To counteract this deficit, the European Union emphasizes the local production of soybeans to contribute to reducing the carbon footprint and increasing economic independence [19]. In recent years, soybean production increased at the European level by about 6.40% reaching 9.5 million tons (2021), but its potential is not fully exploited [4,15].

The National Strategic Plan of Romania for 2023-2027 supports interventions that promote the voluntary application of agricultural methods and techniques by granting compensatory payments, intended to support the reliable income of farmers and the resilience of the agricultural sector to increase long-term food security and agricultural diversity [17,18], as well as to ensure the economic sustainability of soybean agricultural production in the EU. The most important of these objectives are the economic sustainability of agricultural production (BISS, CRISS, and CIS-YF), the application of environmentally beneficial practices applicable to arable land (PD-04); practicing environmentally friendly agriculture in small farms (PD-05); strengthening market orientation and increasing the competitiveness of agricultural farms (coupled support PD-09, direct subsidy) [18]. The direct support offered through PD-09, in 2023, was 26.4 million euros, with a planned amount of 150 euros/ha for an area of at least 176,000 hectares, and for eligibility, farmers were required to capitalize on the minimum annual production of 1,300 kg/ha, to the processing units and/or to use the production for own consumption at the farm level, for animals feeding, and the seed must be certified according to national legislation [2]. In Romania, the areas cultivated with soybeans started to grow since 2015, compared to the period 2010-2014, the largest cultivated area being recorded in 2020 (174.61 thousand ha) after which they recorded a decrease of 25.55 thousand ha in 2021 [12]. Regarding the average soybean production in Romania, the most favorable years were 2018, 2014, and 2017, with more than 2.5 t/ha, which highlights the fact that, in Romania, the soybean could be a profitable crop. In the years with drought, the average production did not decrease significantly, the levels of over 2 tons/ha confirm that, for the most part, the area cultivated with soybeans is in the irrigated system. Compared to the cultivated area, the total production of soybeans in Romania was over 200 thousand tons in 2014 [12].

Table 1. Indicators of the soybean crop in Romania

SPECIFICATION	U.M.	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Area	1,000 ha	63.95	72.06	79.79	67.67	79.91	128.16	127.27	165.14	169.42	158.15	174.61	149.04
Total production	1,000 tons	158.66	150.93	110.40	158.65	214.69	277.30	278.69	416.37	492.68	440.12	353.64	361.30
Yield	tons/ha	2.48	2.10	1.38	2.34	2.69	2.16	2.19	2.52	2.91	2.78	2.03	2.42

Source: https://ec.europa.eu/eurostat/data/database [9].

MATERIALS AND METHODS

This paper was based on the data provided by the farmers from Ialomita county, Romania, and extracted both from the financial-accounting database of the two farms taken under study (of 3,000 ha and 600 ha respectively) and from the answers given by them through a questionnaire. The technical-economic indicators analyzed in the 2019-2021 period were: the areas cultivated with soybean, the productions, the subsidies received, the gross product, the expenditures made on soybean, the result from the exploitation of this crop, and the production yield. Along with an extensive bibliography on soybean cultivation, this study is valuable for farmers in terms of influencing the decision to introduce this valuable crop into their crop plan.

RESULTS AND DISCUSSIONS

In Romania, the practice of agriculture is based on the conditions offered by the major productive potential, which other countries do not have [1,16]. Soybean cultivation has multiple advantages from an economic and nutritional point of view, but despite these European countries produce only a small part of the global production. Even if it is a water-demanding crop, most farmers in Romania grow soybeans to meet the payment for greening or if they have irrigation systems [3]. Soybean can also be successfully integrated into the crop rotation of most crop rotations and is one of the best forerunners for field crops [7, 10, 15]. Integrating soybeans into crop rotation can create conditions for the revival and long-term viability of the crop so that European consumption can be met and dependence on imported soybeans can be reduced [5].

The yield and profitability of soybean cultivation in the "3,000 ha" farm

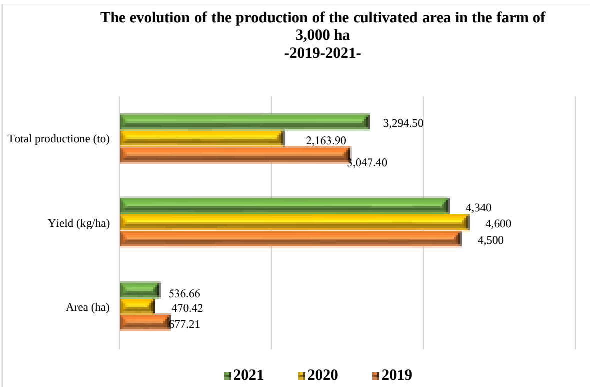

Fig. 1. "3,000 ha" farm: soybean areas and production
Source: Own design.

Soybean crops brought high yields to the "3,000 ha" farm and considerable economic benefits. This crop was cultivated on 677.21 ha in 2019, the area registering a 30.54% decrease in 2020 and an increase of 14.08% in 2021 compared to 2020.

Table 2. Farm"3,000 ha" - indicators of soybean crop

Specification	**M.U.**	**Year**			**Variation**			
		2019	**2020**	**2021**	**2020/2019**		**2021/2020**	
					Absolutely	**%**	**Absolutely**	**%**
Soybean cultivated area	ha	677.21	470.42	536.66	-206.79	0.69	66.24	1.14
Average production	kg/ha	4,500	4,600	4,340	100	1.02	-260	0.94
Total production	tons	30,474	21,639	32,945	-8,835	0.71	11,306	1.52
Production value	lei	4,875,912	3,808,520	5,822,761	-1,067,392	0.78	2,014,241	1.53
Subsidies	lei	873,306	683,736	705,900	-189,570	0.78	22,164	1.03
Raw product	lei	5,749,218	4,492,256	6,528,661	-1,256,962	0.78	2,036,405	1.45
Soybean operating expenses	lei	3,643,275	2,801,078	3,328,843	-842,197	0.77	527,765	1.19
Production cost	lei/kg	1.20	1.29	1.43	0.09	1.08	0.14	1.11
The exercise price	lei/kg	1.60	1.76	2.50	0.16	1.10	0.74	1.42
The operating result per hectare cultivated with soybeans	lei/ha	3,110	3,595	5,962	485	1.16	2,367	1.66
The operating result on the area cultivated with soybean	lei/ area	2,105,943	1,691,178	3,199,818	-414,765	0.80	1,508,640	1.89

Source: Own processing of data.

The average soybean crop production evolved during the analysis period, as follows: they increased in 2020 by 2.22% compared to 2019 and decreased in 2021 by 5.65% compared to 2020. Total production in 2020 decreased by 28.99% compared to 2019 and in 2021 it increased by 52.23% compared to 2020. The gross product achieved per hectare cultivated with soybean was 12.62% higher in 2020 compared to 2019, and in 2021 increased by 27.39% compared to 2020.

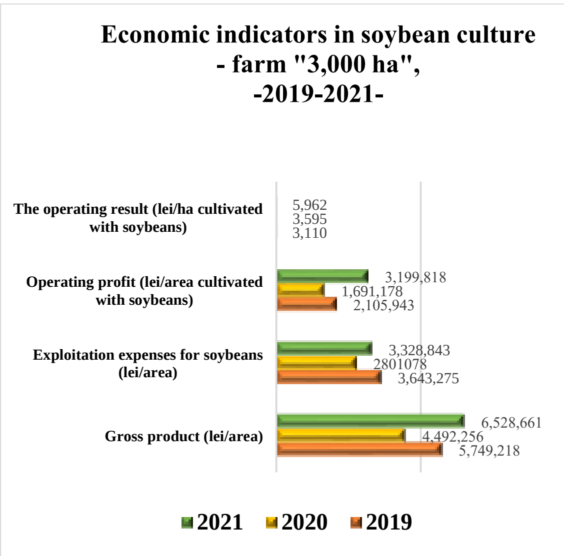

Fig. 2. The "3,000-ha" farm: economic indicators for soybean crop
Source: Own design.

The best year for the soybean crop in terms of operating profit was 2021, the year in which its value exceeded the result of 2019 by 51.94% and the result of 2020 by 89.20%.

The production cost of the soybean crop increased during the analyzed period from 1.20 lei in 2019 to 1.29 lei, in 2020 and 1.43 lei in 2021, simultaneously with the increase in operating expenses for this crop. The capitalization price exceeded the production cost in 2019 by 0.40 lei, in 2020 by 0.47 lei, and in 2021 by 1.07 lei. Soybean crop operating expenses fluctuated, decreasing in 2020 by 22.80% compared to 2019 and increasing in 2021 compared to 2020 by 19.05%. To reach the profitability threshold for soybean cultivation, the "3,000-ha" farm must have an average production of 2,277.05 tons (2019), 1,591.52 tons (2020), and 1,331.54 tons (2021).

Under these conditions, the 3,000-ha farm had an obvious profitability in the soybean crop during the analyzed period. Thus, the production surplus in 2019 was 770.40 tons, in 2020 was 572.41 tons, and in 2021, 997.57 tons (Table 3 and Figure 3).

Table 3. The yield and profitability of the soybean crop on the 3,000-ha farm

Specification	**2019**	**2020**	**2021**
	-tons-		
Soybean production yield necessary to cover operating expenses	2,277.05	1,591.52	1,331.54
Soybean production surplus/deficit after covering operating expenses	+770.40	+572.41	+997.57

Source: Own processing of data.

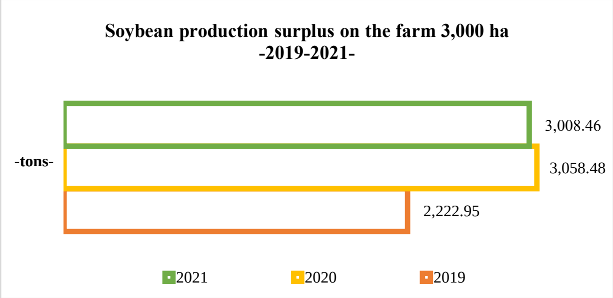

Fig. 3. The "3,000 ha" farm: the soybean production surplus
Source: Own design.

The yield and profitability of soybean cultivation in a "600-ha" farm

The soybean was introduced in the crop structure in the autumn of 2019 and later in 2021, the year in which the farm also introduced irrigation to this crop, considering that soybean is a water-consuming plant.

In 2019, the "600-ha" farm cultivated soybean on 15.76 ha, and in 2021, on 156.35 ha. The average production was lower in 2019, i.e. 1,712 kg/ha, the year in which the crop was not irrigated, and 2,442 kg/ha more, i.e. 142.72% higher in 2021, the year in which the crop was irrigated (4,154 kg/ha).

The gross product realized for the area cultivated with soybeans increased significantly from 2021 compared to 2019, against the background of a tenfold increase in the cultivated area, and also of a production 1.43 times higher compared to the previous crop year.

Table 4. Farm"600-ha" - indicators for soybean crop

Specification	M.U.	Year		Variation 2021/2019	
		2019	2021	Absolutely	%
Soybean cultivated area	ha	15.76	156.35	140.59	9.92
Average production	kg/ha	1,712	4,154	2,442	2.43
Total production	t	26.98	649.48	622.50	24.07
Production value	lei	35,075	1,467,820	1,432,745	41.85
Subsidies	lei	20,039	222,957	202,918.3	11.13
Raw product	lei	55,114	1,690,777	1,635,663	30.68
Soybean operating expenses	lei	95,968	1,301,378	1,205,410	13.56
Production cost	lei/kg	3.56	2.00	-1.56	0.56
The exercise price	lei/kg	1.30	2.26	0.96	1.74
The operating result per hectare cultivated with soybeans	lei/ha	-2,630	2,197	4,827	-0.84
The operating result on the area cultivated with soybeans	lei/ area	-41,450	343,499	384,949	-8.29

Source: Own processing of data.

The production obtained in the soybean crop as well as the production expenses influenced the cost of this agricultural product, determining the efficiency of the activity carried out in this crop. In 2019, the production cost was three times higher than the recovery price, against the background of small productions, and in 2021, the price exceeded the cost by 0.26 lei/kg.

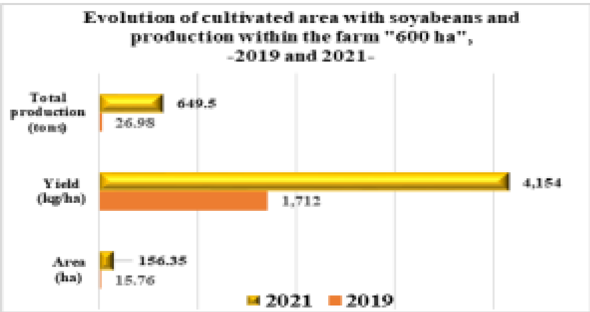

Fig. 4. "600-ha" farm: soybean areas and production
Source: Own design.

The exploitation results for the soybean crop in 2019 were negative, against the background of small and positive productions in 2021, a situation justified by the introduction of irrigation to this crop.

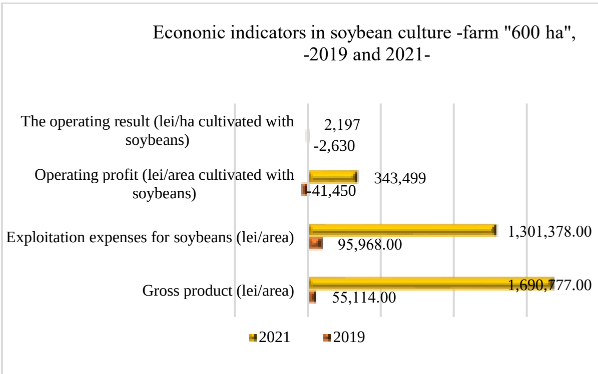

Fig. 5. The "600-ha" farm: economic indicators for soybean crop

To reach the profitability threshold in soybean crops, in the "600-ha" farm, an average production of 73.82 tons (2019) and 575.83 tons (2021) was required. In these conditions, the farm of "600-ha" registered profitability of the soybean crop only in 2021.
The production surplus that led to the recording of positive results in 2021 was 73.67 tons, but in 2019 there was a soybean production deficit of 46.84 tons so the "600 ha" farm failed to reach the profitability point for this crop (Table 5 and Figure 6).

Table 5. The yield and profitability of the soybean crop on the 3,000-ha farm

Specification	2019	2021
	-tons-	
Soybean production yield necessary to cover operating expenses	73.82	575.83
Soybean production surplus/deficit after covering operating expenses	-46.84	+73.67

Source: Own processing of data.

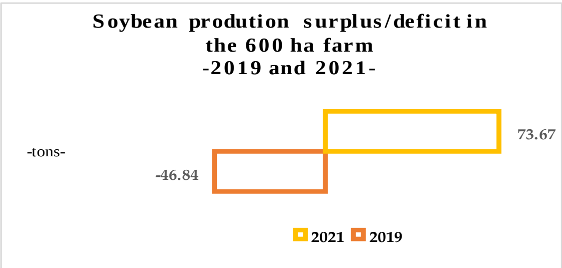

Fig. 6. The "600-ha" farm: the soybean production surplus/deficit
Source: Own design.

CONCLUSIONS

This study highlighted that the benefits of soybean cultivation are evident in terms of achieving an efficient rotation in most crop rotations, maintaining soil fertility, being one of the best precursors for all species in the large crop, biologically fixing atmospheric nitrogen, and thus avoiding nitrogen leaching. By applying good practices in agriculture, constant state funding, and sustained work by farmers, soybean crops can have economic benefits through significant productive potential, financial benefits through additional income from subsidies, and medium and long-term benefits through quality improvement soil, so:
-The profitability of the soybean crop in the "3,000-ha" farm can be reached when its yield per cultivated hectare has been at least 3,362.39 kg/ha (2019), 2,350.11 kg/ha (2020) and 1,966.21 kg/ha (2021).
-The profitability of the soybean crop in the "600-ha" farm can be reached when the yield of this crop per hectare cultivated with soybeans is at least 4,684.11 kg/ha (2019) and 3,682.96 kg/ha (2021).

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PRODUCTIVITY AND EFFICIENCY OF MAIZE *(ZEA MAYS)* FARMERS IN ADAMAWA STATE, NIGERIA

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Abstract

Resource allocation and productivity are important aspect of increased food production which is also associated with the management of the farmers who employ these resources in production. Furthermore, efficiency in the use of available resources is a major pivot for profitable farm enterprise and sustainability. Therefore, inefficiency in the use of resources, wrong choice of enterprise combination and cropping system constitute the major constraints to increased food production in Nigeria. Adamawa State has favourable ecology for both rainfed and irrigated maize production, but the increasing demand for maize lags behind supplies. This study was therefore conducted to examine Productivity and Efficiency of Maize (Zea mays) Farmers in Adamawa State. Socio- economic characteristics of respondents; allocative, technical and economic efficiencies of maize production and factors of inefficiencies of production among respondents were specifically examined . Data were collected from 337 maize farmers and subjected to descriptive statistics and inferential statistics. Results showed that respondents had a mean age of 44 years, attained one form of formal education or the other with mean of nine years of schooling, mean household size of eight people, well experienced with mean experience of 21 years and mostly small scale farmers cultivating an average of 1.89 hectares. The stochastic production frontier analysis indicated that 84.01% of the variations in the technical efficiencies were jointly explained by the production variables in the model. Seeds, fertilizers and farm size were statistically significant ($p \leq 0.01$) and positively related with maize output. Education and extension contact were statistically significant ($p \leq 0.05$) and increase technical efficiency among respondents. Furthermore, the stochastic cost function analysis indicated that 80.24% variations in allocative efficiencies were as a result of the variables included in the model. Cost of fertilizers, seeds and herbicides were statistically significantly ($p \leq 0.01$) whereas labour was statistically significant ($p \leq 0.10$). Extension contacts increase allocative efficiency significantly. The mean values obtained were 0.79, 0.88 and 0.69 for Technical Efficiency (TE), Allocative Efficiency (AE) and Economic Efficiency (EE) respectively. High cost of inputs, inadequate credit facilities, Striga infestation and drought were the major constraints of maize production. It is concluded that farmers are not fully efficient in the allocation of resources for production. Formation of cooperative association by farmers and training of farmers by both government and non governmental agencies were some of the recommendations made in the study.

Key words: *efficiency, productivity, stochastic frontiers, maize*

INTRODUCTION

Maize (*Zea mays L*) is the first most cultivated in Nigeria in terms of area (12,403,330 ha) and with a production of about 12.40 MMT in the year 2020 making the country the second largest producer in the continent, after South Africa with 16 MMT [17, 23]. Production statistics shows an average of 1.8 MT/Ha which is very low when compared to Egypt and South Africa where the yields are 7.7MT/Ha and 5.3MT/Ha [16]. In Nigeria, the largest volumes of maize are produced in the Northern region, particularly in Kaduna, Borno, Niger, Adamawa and Taraba and in the South-Western States of Ogun, Ondo and Oyo [5].

According to [3], maize exists in colours, shapes, sizes, textures with 50 different species. When eaten fresh form, it provides A, C, and E. It is a rich source of carbohydrate, essential protein, minerals, and dietary fibre. Maize stover produces an average of 6.89 t/ha of dry matter is used for livestock feeds [25]. Maize production has the potential to mitigate the present food insecurity and alleviate poverty [5].

Adamawa State is predominantly agrarian with agriculture contributing 53.70% of the State Gross Domestic Product, GDP. Most production is done by small scale and subsistence farmers with high dependence on rainfed agriculture only a paltry 5% is irrigated agriculture out of the huge potential of the over 200,000 hectares of irrigable land in the state. About 2.87 million hectares out of 3.9 million hectares is arable land that support Agricultural development where 67% of the farmers are classified as small holder with farm size of between 0.8 ha- 3.5 ha whereas others belong to medium – large scale farms with farm holding of 3.5 – 4.5 hectares and above 5 hectares respectively. The use of fertilizer for production is very low (5.95 kg per hectare which is about two times lower than the West Africa regional average [13]. Maize is one of the major staples in the state in high demand but production has been low with average yield ranging from 941 kg/ha to 1.1ton/ha lower than 1.8ton/ha national average attributed to poor resource management, low and erratic rainfall and security challenges in the North East. Maize ranks first among all crop cultivated in the State with 178,000 ha or 6.2%, followed by sorghum with 124,000 ha or 4.3% [19].

The study of productive efficiency started with the pioneering works of Michael Farrell in 1957 where three measures of efficiency; technical, allocative and economic efficiencies were identified. Technical Efficiency (TE) is the achievement of the maximum potential output from a given quantity of inputs under a given technology. It is the attainment of production goal without wastage [15]. Allocative efficiency on the other hand has to do with the extent to which farmers make efficient decision by using inputs up to the level at which their marginal contribution value is equal to the factor cost. Economic efficiency combines both technical and allocative efficiency. Economic efficiency occurs when a firm chooses resources and enterprises in such a way as to attain economic optimum [9, 20]. The analysis of efficiency is generally associated with the possibility of farms producing a certain optimal level of output from a given bundle of resources or certain level of output at least cost. Efficient use of resources for increased production has shifted attention from technology adoption among farmers in Nigeria.

A good number of researchers have used the stochastic frontier production function analyses in their studies on maize production in Nigeria (26, 14, 4, 11).

However, [1] analyzed production efficiency and the factors influencing technical efficiency (TE), allocative efficiency (AE) and economic efficiency (EE) as well as the returns to scale of maize production in some selected communities of Orlu Local Government Area of Imo State.

Despite this, efforts have not been made to examine Productivity and Efficiency among Maize (*Zea mays)* Farmers in Adamawa State, Nigeria. Socio- economic characteristics of the respondents; allocative, technical and economic efficiencies in maize production, factors of inefficiencies of production and constraints were specifically examined in the study area.

MATERIALS AND METHODS

Study Area

The research was carried out in Adamawa State located at the North-Eastern part of Nigeria. It lies between latitude 7^0 and 11^0N of the equator and longitude 11^0 and 14^0E of the Greenwich Meridian. It shares boundary with Taraba State in the South and West, Gombe in the North-West and Borno to the North. It also has an international boundary with the Cameroon Republic along its eastern border. The State has a land area of about 38,741km^2 projected population of 4.2 million people where an estimated 60% reside in the rural areas [28]. Adamawa state has a tropical wet and dry climate. Dry season lasts for a minimum of five months (November-March) while the wet season spans April to October. The major agro ecological formation of the state includes, the Guinea Savannah divided into Southern and Northern Guinea Savannah, and Sudan Savannah. The mean annual rainfall ranges from 700 mm to 1,050 mm [2, 13]. The state is blessed with River

Benue, Kiri, Kilange, Mayo Inne, Chouchi and Lake Gerio, Tallum, Dwam and Kiri Dams. The major occupation of the people is farming as reflected in their two notable vegetation zones - Sub-Sudan and Northern Guinea Savannah - known for cotton and groundnut production as the main commercial crops while the food crops produced in the State include maize, yam, cassava, guinea corn, millet and maize. Other important crops grown include cowpea, wheat, millet, sweet potato, Bambara nuts and vegetables such as onion, pepper, tomato and garden egg. Agriculture is the dominant means of livelihood of citizens of the State where it accounted for 70- 80%. Communities living on the banks of the rivers engage in fishing while others are herdsmen [19].

Source of Data and Sampling Procedure

Primary data were collected for this study using structured questionnaire. The data were collected on the 2022/ 2023 cropping season from December 2022 and January 2023.

A multi stage, purposive and random sampling technique was employed in selecting the sample**d** farmers. First, the study area was stratified based on the four Adamawa Agricultural Development Programme (AADP) agricultural zones where Maiha LGA (Zone1), Girei LGA (Zone II), Ganye and Yola LGAs (Zone III) and Demsa LGA (Zone IV) were purposively selected. The second stage was the purposive selection of villages based on their relative importance in maize production. A total of 14 villages were selected from the five Local Government Areas. A population of 3563 farmers was obtained from farmers' association register where 366 were randomly selected proportionate to their population size (Table 1) and served with structured questionnaire to collect the desired data Out of this number, 337questionnaires were correctly filled and used for analysis.

Table 1. Sample Selection from Sampling Frame

Zone	**Selected LGAs**	**Selected Villages**	**Registered Farmers**	**10% of Registered Farmers**
Zone I	Maiha	Mayo Nguli	343	34
		Jalingo Maiha	300	30
Zone II	Girei	Jabbi Lamba	164	16
		Murke	153	15
		Dumne	401	40
Zone III	Ganye	Sugu	408	41
		Gurumpawo	305	31
		Bakari Guso	285	29
	Yola South	Namtari	114	11
		Gongoshi	205	21
		Rumde Mallum	257	26
Zone IV	Demsa	Kpasham	351	35
		Tagombali	144	11
		Ngbekindawe	225	23
			3,655	366

Source: Field Survey 2023.

Analytical Techniques

The use of the stochastic frontier production function has some conceptual advantage in that it allows for the decomposition of the error term into random error and inefficiency effects rather than attributing all errors to random effects [27, 20].

The specification after Battese, *et al* [8] is:

$$Ya = f(Xa:\beta) + (V - U) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots .. (1)$$

where:

Y_a = Production of the ith firm

X_a = Vector of input quantities of the ith firm
β = Vectors of unknown parameters
V = Assumed to account for random factors such as weather, risk and measurement error. It has zero mean, constant variance, normally distributed and independent of U. It covers random effects on production outside the control of the decision unit.
U = is non negative error term having zero mean, and constant variance [27]. It measures the technical inefficiency effects that fall within (because the errors could be controlled with effective and adequate managerial control of the firm), the control of the decision unit [6]. The production technology of the farms was assumed to be specified by the Cobb- Douglas functional form. Bravo-Ureta and Pinheiro [9] and Ogundari [20] reported that the stochastic frontier models are better estimated using the Cobb- Douglas functional form because of its simplicity and wider use in farm efficiency analyses in both developing and developed countries.
The Stochastic Frontier Cost Function is specified as:

$$Ln\ Ca = f(Pa, Ya{:}\ \beta) + (V + U) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

where:
C_a = total cost of production of the ith firm
P_a = input prices
Y_a = Output of the i^{th} firm
β = parameters to be estimated
V = systematic component which represents random disturbance cost due to factors outside the scope of the firm.
U = one sided disturbance term used to represent cost inefficiency and is independent of V. The cost efficiency of an individual firm is defined in terms of the ratio of observed cost (b) to the corresponding minimum cost ($c^{\mathbf{min}}$) under a given technology.

$$CE = \frac{cb}{(cmin)} = \frac{f(PXi{:}Y*X;\beta)+(V+U)}{f(PXi*Y*X;\beta)+(V)} = exp(U)\ldots\ldots\ldots\ldots\ldots \quad (3)$$

where:
CE = Cost efficiency,
Cb = the observed cost and represents the actual total production cost;
C^{min} = the minimum cost and represents the frontier total production cost or least total production.
Stochastic frontier production function analysis was used in the estimation of technical, allocative and economic efficiencies of maize production.

The Empirical Stochastic Frontier Production Model

The stochastic frontier production model used is specified as follows:

$$LogY_1=\beta_o+\beta_1 logX_1+\beta_2 logX_2+\beta_3 logX_3+\beta_4 log X_4+\beta_5 logX_5+V_i - U_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

where:
Y_1 = Output (kg of maize) of the i^{th} farmer
X_1 = Maize Seeds(kg)
X_2 = Farm size (Hectares)
X_3 = Fertilizer (kg)
X_4 = Herbicides (litres)
X_5 = Labour (mandays)
V and U as previously defined.
The technical efficiency of maize production is defined as the ratio of observed production to the corresponding frontier production associated with no technical inefficiency.
TE = exp ($-u_i$) so that 0≤ TE 0≤ 1
Variance parameters are: $\sigma^2 = \sigma^2_v + \sigma^2_u$ and $\gamma = \sigma^2_u / \sigma^2$
so that 0≤ γ 0≤ 1.
The inefficiency model is defined by:

$$U_i = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 \ldots\ldots\ldots\ldots\ldots (5)$$

where:
U_i = Technical inefficiency effect
Z_1 = Age of maize farmer (in years)
Z_2 = Family size
Z_3 = Education (years spent in school)
Z_4 = Extension contact (Number of contacts).

Empirical Stochastic Frontier Cost Production Model

The empirical stochastic frontier cost production model used is specified as follows:

$LogC_1 = \beta_0 + \beta_1 \log P_1 + \beta_2 \log P_2 + \beta_3 \log P_3 + \beta_4 \log P_4 + \beta_5 \log P_5 + V_i + U_i$.......................(6)

where:
C_1 = Total production cost (naira)
P_1 = Cost of maize seeds (naira)
P_2 = Cost of fertilizers (naira)
P_3 = Cost of herbicides (naira)
P_4 = depreciation on fixed cost items (naira)
P_5 = Cost of Labour (naira)
The inefficiency model is defined by:

$U_i = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4$.................(7)

where:
U_i = Cost inefficiency effect
Z_1 = Age of maize farmer (in years)
Z_2 = Family size
Z_3 = Education (years spent in school)
Z_4 = Extension contact (Number of contacts).
σ^2, δ, γ, βs are unknown parameters that were estimated. The Maximum Likelihood Estimates (MLE) for all the parameters of the stochastic frontier production and cost functions were obtained using the computer program FRONTIER version 4.1c [10].

RESULTS AND DISCUSSIONS

Socio-economic Characteristics of Respondents

Table 2 showed that the average farm size cultivated was 1.89 ha. The least hectarage under cultivation was 0.5hectare with a maximum of 10 hectares. Ndaghu *et al.* [18] reported the preponderance of small scale maize farmers in Adamawa State, Nigeria. The mean age was 44 years with minimum and maximum of 20 and 70 years. The implication is that they are ageing with the consequence of declining productivities. Opaluwa [21] reported a mean age of 49 years among maize farmers in Kogi State, Nigeria. Production is affected when farmers get older Respondents in the study area are well experienced with the average experience of 21 years in maize cultivation. Most of the farmers might have perfected their farming skills over years. Respondents are characterized by large family sizes as evidenced by the mean family size of eight people which is lower than nine people as reported by [14] among maize farmers in Oyo State Nigeria. Adedeji *et al.* [3] found out that large family sizes are sources of labour for production. Furthermore, the mean years spent in formal school was nine years which indicated the preponderance of educated farmers. The ability to deal with or adjust successfully to technological change for better performance is likely to be easy. The result is in agreement with [16] and [3] who reported substantial number of educated maize farmers in rural areas.

Table 2. Summary of Descriptive Statistics of Variables

Variable	Mean	Std. Dev.	Minimum	Maximum
Farm size (hectares)	1.89	1.474315	.5	10
Age (years)	44	10.36763	20	70
Experience(years)	21	11.09805	1	50
Family size (number of people)	8	4.546713	2	30
Education(years spent in school)	8.991667	6.103444	0	19

Source: Field Survey, 2023.

Technical Efficiency of Maize Production

Table 3 is the estimates of the parameters for the frontier production function, the inefficiency model and the variance parameters of the model. The variance parameters of the stochastic frontier production function sigma squared (δ^2) and gamma (γ) were significantly different from zero at one percent level. Gamma indicates that the systematic influences that are unexplained by the production function are the dominant sources of random error. The gamma estimate which is 0.9420 shows the amount of variation resulting from the technical inefficiencies of the maize farmers. This means that 94.20% of the variation in farmers output is due to difference in technical efficiency.

The coefficient for seeds (0.3809) is positive and statistically significant ($p \leq 0.01$). A unit increase in quantity of seeds will result to an increase in output by 0.3809 kg. This result is in agreement with [5] who reported seeds have overriding importance in maize production in Nigeria. Idowu and Busayo [14] also reported a significant relationship between seeds and output of maize among farmers in Oyo State, Nigeria.

The estimated coefficient for farm size was 0.1997 and statistically significant ($p \leq 0.01$) and plays a critical role in maize production. Farm size has been found to be one of the most important factors of maize production [22]. This result is in agreement with [14] who examined Technical Efficiency among maize farmers in Oyo State and found out that land was a factor of maize production.

The coefficient for fertilizer was 0.1385 and statistically significant ($p \leq 0.01$). This implies that fertilizer is a positive and significant factor that influences the output of maize farmers. A unit increase in fertilizers will result to an increase in output by 0.1385 kg *ceteris paribus*. This result is in line with [21] who reported that fertilizer was significant in maize production in Kogi State, Nigeria. The coefficient for herbicides is 0.0523 and this was statistically significant ($p \leq 0.1$). This implies that herbicides are a positive and significant factor that influences the output of maize farmers. Herbicides are required in the control of weeds in maize farms. A unit increase in the use of herbicides for weed control in maize farm will give a corresponding increase in maize output by 0.0523 kg ceteris *paribus*. This result is in line with [14] and [3] who reported that herbicide was significant in maize production in Oyo State and Osun State respectively.

The estimated elasticity for labour (0.0687) and this was statistically significant ($p \leq 0.05$). Maize production is labour intensive and is used in combination with herbicides for production. There are production activities that require manual labour such as fertilizer and herbicide application, planting harvesting shelling, bagging loading and off loading. A unit increase in the use of labour will lead to increase in maize output by 0.0687 kg ceteris *paribus*. This result is in line with [3] who reported that labour was significant in maize production in Osun State, Nigeria.

Table 3. Maximum Likelihood Estimate of parameters of Cobb- Douglas Stochastic Frontier Production function for Maize farmers

Variable	Parameter	Coefficient	Standard error	T. value
Production factors				
Constant	β_o	0.2639***	0.0817	3.23
Seeds	β_1	0.3809***	0.0411	9.27
Farm size(Hectares)	β_2	0.1997***	0.0290	6.89
Fertilizer	β_3	0.1385***	0.0251	5.52
Herbicides	β_4	0.0523*	0.0289	1.81
Labour	β_5	0.0687**	0.0293	2.34
RTS		0.8401	0.03068	
Inefficiency model				
Constant	δ_0	-0.4786	0.4991	-0.96
Age	δ_1	-0.0112***	0.0034	-3.29
Family size	δ_2	0.3726**	0.1752	2.13
Education	δ_3	-0.8899**	0.3176	-2.80
Extension Contact	δ_4	-0.2454**	0.0981	-2.50
Variance parameters				
Sigma squared	δ^2	0.2458***	0.0778	3.16
Gamma	Γ	0.9420***	0.2100	4.49
Log likelihood function	LLF	15.43		

Source: Field Survey, 2023 *** Significant at 1 percent ** Significant at 5 Percent

The empirical results show that, from the estimates of the Cobb-Douglas production function model, the estimated elasticities of mean maize output with respect to, seeds, farm size, fertilizer, herbicides and labour at mean input values were 0.3809, 0.1997, 0.1385, 0.0523 and 0.687 respectively. This indicates that, if land under maize production with the required quantities of seeds, fertilizer, herbicides and labour individually increased by one per cent, then the mean production of maize is estimated to increase by 0.3809, 0.1997, 0.1385, 0.0523 and 0.687 percent respectively. This is because the estimated output elasticity with respect to all the variables was found to be positive. The returns to scale (RTS) of 0.8401 shows a decreasing returns to scale. Abubakar and Onwujiobi [1] obtained a much lower RTS of 0.216 among maize farmers in some selected communities of Orlu Local Government Area of Imo State, Nigeria. This implied that the value reported in this study is not an isolated case, thereby further underscoring the need to expand the scope of maize production by reduction in wasteful use of resources in Adamawa State to meet the growing demand for the crop both for food and formulation of livestock feeds.

Determinants of Technical Inefficiency among Respondents

Variables of the technical inefficiency effect estimated in the model and the result is presented in Table 3. The result of the inefficiency model shows that the coefficients of the efficiency variables with the exception of age and family size had the expected signs. The coefficient for age was positive and statistically significant ($p \leq 0.05$) and increases inefficiency among farmers. Declining productivity is usually observed among older farmers especially for direct production activities except for decision making where they are best decision makers. The coefficient for family size was positive and statistically significant ($p \leq 0.05$) and increases inefficiency among farmers.

The coefficient for education was - 0.8899 and statistically significant ($p \leq 0.05$) and increases the technical efficiency of the respondents. Educated farmers are innovative and the transformation processes by extension agents are likely to be easier among them. This result is in agreement with the work of [20] that identified education as a catalyst in the improvement of technical efficiency of farmers in Nigeria. Education obviously will improve production efficiency as it will enable farmers to access improved technology and best practices available to them. The estimated coefficient for extension contact is -0.2454 and is statistically significant ($p \leq 0.05$). Extension contact will lead to increase in the efficiency of the farmers. The implication of this is that increasing the number of contacts with extension agents through efficient extension delivery system can bridge the gap between the efficient and inefficient maize farmers in the study area. Such approaches stimulate farmers' adoption of agricultural technologies which in the long run shifts the farmers' production frontier upward. The main function of extension agents is to disseminate the latest research results to the farmers. They provide farmers with information on improved production practices. It must be emphasized that the effectiveness of extension agents does not only depend on the frequency of their visits but also on the maize farmers' attitude and receptivity. This result is consistent with the findings of [3, 12] who found a positive correlation between extension visits and yield of maize among smallholder maize farmers in Osun State and Kwara State, Nigeria.

Allocative Efficiency of Maize Production

The Maximum Likelihood Estimate (MLE) of the parameters of the stochastic cost frontier model for maize farmers is presented in Table 4. The diagnostic statistics of the variance parameters of the stochastic frontier cost (sigma squared (δ^2) and gamma (γ) were significantly different from zero at one percent level. The gamma estimate which is 0.8024 shows the amount of variation resulting from the allocative inefficiencies among farmers which means that 80.24% of the variations among the respondents is due to differences in allocative inefficiency. The estimates of the parameters of stochastic cost frontier model of the maize farmers were all positive and imply that the variables used in the analysis have direct relationship with total cost of maize production. The estimated coefficients for the specified function can be explained as the elasticities of the explanatory variables which is typical of the Cobb-

Douglas production function. A unit increase in the cost of maize production would be increased by the value of each of the coefficients.

The estimated coefficient for cost of seeds was 0.3862 and statistically significant ($p \leq 0.01$). This implies that the variable is a positive and significant factor that influences cost of production among maize farmers. The estimated coefficient for cost of fertilizers was 0.1248 and statistically significant ($p \leq 0.01$). This implies that the variable is a positive and significant factor that influences cost of production among maize farmers. An increase of one percent in the cost of fertilizers will result to an increase in the total cost by 0.1248 percent depending on the management of maize farms. The coefficient of the variable associated with cost of herbicides was 0.1304 and is statistically significantly ($p \leq 0.05$). The estimated coefficient for was 0.1011 and is statistically significant ($p \leq 0.10$). The implication of this is that maize farmers incur more cost as output or production of maize increases. This result is in conformity with the works of [25] and [7] who found out that maize farmers incur more costs when they produce more.

Table 4. Maximum Likelihood Estimate of parameters of Cobb- Douglas Stochastic Frontier cost function for Maize farmers

Variable	Parameter	Coefficient	Standard error	t. value
Cost factors				
Constant	β_o	2.3474***	0.1185	19.81
Cost of seeds	β_1	0.3862***	0.0526	7.34
Cost of fertilizers	β_2	0.1248***	0.0362	3.45
Cost of Herbicides	β_3	0.1304**	0.0452	2.88
Depreciation on fixed cost items	β_4	0.0439	0.0327	1.34
Cost of labour	β_5	0.1011*	0.0574	1.76
Inefficiency model				
Constant	δ_0	0.0679	0.1376	0.49
Age	δ_1	-0.1425	0.1442	- 0.98
Family size	δ_2	-0.4245	0.0379	- 1.12
Education	δ_3	- 0.0269	0.1024	- 0.26
Extension Contact	δ_4	- 0.2544**	0.0965	- 2.64
Variance parameters				
Sigma squared	δ^2	0.0657***	0.0054	12.17
Gamma	Γ	0.8024***	0.1568	5.12
Log likelihood function	LLF	15.22		

Source: Field Survey, 2023 *** Significant at 1 percent ** Significant at 5 Percent

Determinants of Allocative Inefficiency among Respondents

The determinants of allocative inefficiency among maize farmers as presented in Table 4 revealed that inefficiency variables have the expected signs. The estimated coefficient for extension contact was -0.2544 and is statistically significant ($p \leq 0.01$). This implies that regularity in extension contact by farmers will lead to increase in efficiency and they will become more efficient in the allocation of resources in maize production. The finding agree with the study of [25] who observed that extension visit enhances farm productivity and efficiency in their study of Analysis of Allocative Efficiency of Small Scale Maize Production in the Guinea Savannah Region of Borno State, Nigeria.

Efficiency Measurement of Maize farmers

Table 5 shows the efficiency indices estimated from the stochastic frontier analysis (SFA).The estimated efficiency scores ranged between 0.39 and 1.00 for Technical Efficiency (TE), Allocative Efficiency (AE) and Economic Efficiency (EE) respectively. The mean, minimum and maximum TE was 0.79, 0.27 and 0.96 respectively. The mean values obtained were higher as compared to 0.52 reported by [26] but was lower to 0.98 in the case of [1].

Frequency distribution based on TE indices revealed that 18.69% of the respondents fall to the range of 0.39 – 0.69 while 81.31% were those in the range of 0.70 – 1.00.

Table 5. Efficiency Indices of Respondents

Efficiency Score	Technical Efficiency	Allocative Efficiency	Economic Efficiency
≤ 0.39	8(2.37)	15(4.45)	12(3.56)
0.40 – 0.49	13(3.86)	10(2.97)	24(7.12)
0.50 – 0.59	18(5.34)	43(12.76)	41(12.17)
0.60 – 0.69	24(7.12)	58(17.21)	69(20.47)
0.70 – 0.79	57(16.91)	192(56.97)	105(31.16)
0.80 – 0.89	95(28.19)	12(3.56)	77(22.85)
0.90 – 1.00	122(36.20)	7(2.08)	9(2.67)
Total	**337(100)**	**337(100)**	**337(100)**
Mean	0.79	0.88	0.69
Maximum	0.96	0.94	0.91
Minimum	0.27	0.33	0.26

Source: Researchers own computation 2023. Note: Figures in parentheses are percentages.

If the average farmer in the sample were to reach the technical efficiency level of its most efficient counterpart, then the average farmer could experience a cost savings of 65.82% [i.e. 1-(.27/.79)].

The result suggests that the farmers in the study area are not able to achieve optimal production as 21 % of the inputs were wasted relative to the best practiced farms producing the same output facing the same technology in the study area.

The implication is that the overall technical efficiency of the maize farmers could be increased by 21% (i.e. 1.00- 0.79) through the reduction in the wasteful use of production inputs that would occur if production was to occur at the technically efficient point in the short – run under a given technology.

The mean Allocative efficiency among respondents was 0.88 with the minimum and maximum values of 0.33 and 0.94 (Table 6). The mean value was higher as compared to 0.45 reported among maize farmers in Orlu Local Government Area of Imo State by [1]. From Table 5, 62.61 % of the maize farmers fall to the range of 0.70 – 1.00 and those in the range of 0.39 – 0.69 accounted for 37.39% respectively. This result indicates that maize farmers in the study area are fairly allocatively efficient in maize production. For the average farmer in the sample to reach the allocative efficiency level of the most efficient farmer, then the average farmer could experience a cost savings of 62.50% [i.e. 1-(.33/.88)].

In other words, 12% of the resources are inefficiently allocated relative to the best-practiced farms producing the same output and facing the same technology in the study area.

This implies that the allocative efficiency among respondents could be increased by 12% through better utilization of resources in the optimal proportions given their respective prices and given the current technology.

This would enable the farmers to equate the marginal revenue product (MRP) of input to the marginal cost of input thereby improving farm income.

The frequency distribution of respondents based on Economic Efficiency indices (Table 5) shows that 43.32% of the respondents fall to the range of 0.39 – 0.69 whereas 56.68% were those in the range of 0.70 – 1.00.

The mean, maximum and minimum efficiencies were 0.69, 0.91 and 0.26 respectively.

If the average farmer in the sample were to reach the economic efficiency level of its most efficient counterpart, then the average farmer could experience a cost savings of 62.32% [i.e. 1-(.26/.69)].

The result suggests that the farmers in the study area are not able to minimize the cost of production as 31% of the production costs were wasted relative to the best practiced farms producing the same output facing the same technology in the study area.

The implication is that the overall economic efficiency of the maize farmers could be increased by 31% (i.e.1.00 - 0.69) through the reduction in production costs that would occur if production were to occur at the allocatively and technically efficient point in the short – run under a given technology.

This would enable the respondents to minimize production costs thereby maximizing income and profit. Substantial variations were observed in farmer- specific efficiency in maize production as reported by scholars such as [1, 14, 26, 5, 21].

The results showed that farmers still have room for improvement of their efficiency in maize production in the State.

Constraints to Maize production

Analysis in Table 6 shows that high cost of inputs (94.36%), Striga infestation (89.32%), inadequate credit facilities (86.35%), drought (76.85%), pests and disease (75.37%) and flooding (71.22%) were the major constraints to maize production.

Table 6. Distribution based on Constraints of Maize Production

Constraints	Frequency	Percentage
High cost of inputs	318	94.36
Pests and diseases	254	75.37
Striga infestation	301	89.32
Adulteration of agrochemicals	239	70.92
Poor road	140	41.54
Inadequate credit facilities	291	86.35
Theft of produce	127	37.69
Drought	259	76.85
Flooding	240	71.22

Source: Field survey: 2022.

The result is in agreement with the works of [1, 22, 11, 18] who identified some of these constraints affected maize production in various parts of the country.

CONCLUSIONS

Farmers are not fully efficient in the use of resources for maize production in the State with room to improve their efficiency of production if the identified constraints are addressed by and stakeholders in the maize industry should support programmes that can lead to increase production through efficient allocation of resources.

This can be achieved through training of the farmers on resource allocation by the government and nongovernmental organization in the State. The use of early maturing and drought resistant varieties should be adopted by farmers. Formation of cooperative association by farmers will help them access credits to purchase inputs for maize production.

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QUALITY IMPROVEMENT FOR THE PRODUCT GINGERBREAD, A STUDY REGARDING THE INFLUENCE OF DOUGH MATURATION TIME AND OF THE AERATION FORMULA ON THE PRODUCT'S TEXTURAL CHARACTERISTICS

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Abstract

The processors' disposition to satisfy the customers' requirements is an essential quality management principle in the food industry. In view of offering a high-quality product to the consumer, various aspects related to the maturation time of gingerbread doughs obtained with various proportions of aeration agents (sodium bicarbonate and ammonium bicarbonate) and acidifier (sodium acid pyrophosphate) have been studied. One witness sample and 5 other samples were analysed. They were matured for 30, 60, 120, and respectively 150 minutes before the products thus obtained were processed and analysed. Maturation has a significant effect on the product's resilience, which has led to an analysis of this aspect. Maturation influences the quality of the product but, at the same time, it impacts its price; it is important to allow the space needed to achieve maturation in the flow, to organise the process flow, and to observe the parameters which need to be attained and monitored.

Key words: *gingerbread, maturation time, aeration agents, textural characteristics, quality indicators.*

INTRODUCTION

The product *gingerbread*, a long-established product in Romania, poses some challenges to the manufacturers. The difficulty consists in adapting the classical doughs to the modern technological processing, but, at the same time, in adapting the traditional product to the market's current requirements.

The crumbly, hygroscopic product of former days has been replaced with the moist, soft product, having different fillings (which must be thermostable), covered in various coatings, from the traditional glazing with a supersaturated sugar solution, to various surrogate coatings or even chocolate.

Such adjustments can only be made by studying the influence exerted by the quality of the ingredients, the aeration formula, the kneading time, maturation times and temperatures, in correlation with the textural characteristics.

Gingerbread production is tricky because of its complex recipe and difficult to process dough. For other products, such as biscuits or cookies, extensive research has been conducted related with dough rheology [4],[5],[7],[8],[9],[12].

This study analysed the influence of both the aeration formula and of the maturation time on the texturometric features of the finished product. A witness sample (P0) was prepared, starting from the basic recipe, as well as a set of 5 samples, with various proportions of sodium bicarbonate and ammonium bicarbonate, to the point of fully replacing the ammonium bicarbonate. Neutralisation was achieved using sodium acid pyrophosphate (SAPP). The effect of the aeration agents on both the texture of the finished product and on its resilience was analysed, using the texture meter.

The doughs obtained from a mixture of wheat flour and rye flour have low resilience and high plasticity, as well as high stickiness [1]. Rye flour is a very good alternative to the “dilution of gluten” in wheat flour [11], [3].

The gluten formed by the rye flour proteins is less resilient and more plastic [6].

To obtain a tender texture, a soft product, rye flour needs to be used in the recipe. It confers stickiness to the dough, which becomes less cohesive, but the end product will be of superior quality in terms of texture [2], [10].

In this context, the research aimed to produce a high quality gingerbread for consumers studying various aspects of doughs maturation and using aeration agents (sodium bicarbonate and ammonium bicarbonate) and acidifier (sodium acid pyrophosphate) in various proportions.

MATERIALS AND METHODS

In view of studying the effect of maturation time and of the aeration formula on the textural characteristics, gingerbread was prepared according to the recipes in Table 1.

Table 1. Recipes for gingerbread sample manufacturing

Raw material	P0	P1	P2	P3	P4	P5
	kg	kg	kg	kg	kg	kg
Wheat flour	1.76	1.76	1.76	1.76	1.76	1.76
Rye flour	0.95	0.95	0.95	0.95	0.95	0.95
Sodium bicarbnate	0.036	0.0334	0.0436	0.054	0.064	0.074
Ammonium bicarbonate	0.018	0.018	0.014	0.009	0.005	0
SAPP 28	0.018	0.044	0.058	0.071	0.084	0.098
Clove	0.01	0.01	0.01	0.01	0.01	0.01
Cinnamon	0.039	0.039	0.039	0.039	0.039	0.039
Salt	0.009	0.009	0.009	0.009	0.009	0.009
Lecithin	0.018	0.018	0.018	0.018	0.018	0.018
Vegetable fat	0.18	0.18	0.18	0.18	0.18	0.18
Caramel	0.29	0.29	0.29	0.29	0.29	0.29
Sorbitol	0.145	0.145	0.145	0.145	0.145	0.145
Glycerin	0.024	0.024	0.024	0.024	0.024	0.024
Inverted syrup	1.55	1.55	1.55	1.55	1.55	1.55

Source: Original.

The witness recipe was changed, considering the following requirements: the gradual replacement of ammonium bicarbonate with sodium bicarbonate and the addition of sodium acid pyrophosphate, so as to achieve a 95% neutralisation of the sodium bicarbonate in the recipe.

To analyse the influence of maturation time on the textural characteristics, after they were kneaded, the samples were left to rest for different time intervals, namely 0, 60, 120, and respectively 150 minutes, at room temperature, before division, moulding and baking.

As it has been found that gingerbread is susceptible to loss of moisture and that its textural characteristics are dependent on the moisture content, before the test, the samples were kept in vessels with H_2SO_4 solutions of various strengths (30, 35, and respectively 40%), ensuring various levels of water activity in the products.

They were kept for 14 days, enough time to balance the moisture between the samples.

To perform the tests, the TexVol TVT-300XP/XPH texture meter, manufactured by Perten, Sweden, was used. It was fitted with a 15 kg load cell. It is a sensitive, modern instrument, but empirical methods are also used in textural analysis, with relevant results for the food products covered by the study [13].

The test device employed was the blade version, a device imitating the bite, the shearing of the product between the incisors. Cutting was achieved at a speed of 1 mm/sec, down to a depth of 10 mm. As the samples kept in the presence of stronger H_2SO_4 solutions suffered more intense dehydration, they were harder, and testing with the ball device was not possible, as the specific hardness values were higher than the measurement range for the device's load cell.

The tool's software provides several parameters as textural characteristics. Such parameters are the maximum resistance force recorded upon testing (ForceA), the hardness stated as the resistance force recorded for the maximum stroke (Hardness), the working energy, as an area of the force graph - pressing distance (Area4), and the product between the force recorded at the end of the stroke and the distance covered (Hard x Dist), similar to the previous parameter - Area4. Figure 1 and Figure 2 show such parameters in relation to one another, to note where any dependencies exist between then and whether the interpretation of each parameter in part is necessary or whether the analysis of a single textural feature is sufficient.

Good correlation was noted (the linear regression coefficient R^2 is 0.9058) between hardness and the maximum force recorded. The correlation is good because, in fact, they both convey the same physical parameter, a force.

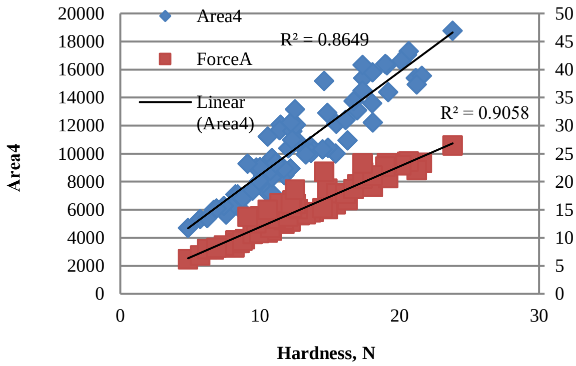


Fig. 1. The relationship between hardness, energy, and maximum force
Source: Own results in the laboratory.

The correlation between hardness and energy is smaller, R^2=0,8649.A very good correlation was also noticed between the curve area and the maximum force, R^2=0.9801. This highlighted the fact that, for the tested samples, irrespective of the recipe or the work parameters, the curves had a similar shape, and the cutting to a 1 cm depth ensured the fact that analysed texture sizes were measured at similar moments, when the analysed samples were not destroyed. This shows that the analysis of how the maximum distortion force varies is sufficient.

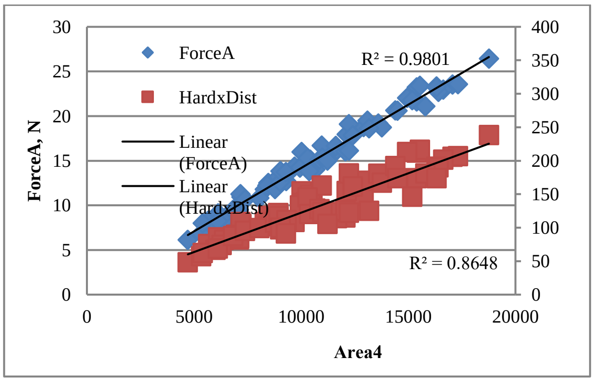


Fig. 2. Statistical ratio between the area of the force variation curve, the maximum distortion force and the result obtained upon multiplying hardness and displacement.
Source: Own results in the laboratory.

Upon analysing the statistical ratio between the area of the recorded force variation curve and the result obtained upon multiplying hardness and displacement, it was found to be significant, although not very solid.

The linear regression rate had a value identical to the linear regression rate upon correlating maximum force and hardness. This is normal, as the distortion distance was always the same, of 10 mm, it was not indicated as a percentage from the height of the sample.

Such data led to the conclusion that, for the textural characterization of gingerbread using this test type, namely cutting to a constant depth, the analysis of hardness and of the maximum distortion force is sufficient.

RESULTS AND DISCUSSIONS

Effect of maturation time on the textural characteristics of gingerbread

Figure 3 presents the variation of hardness and of the distortion energy for the samples maintained at various maturation times, namely from 0 minutes to 150 minutes.

Upon analysing the graphs, we can note that both hardness and distortion energy have a very similar variation model, demonstrated also by the very good correlation of such values.

Another aspect is the increase in hardness as water activity decreases. This mode of variation is specific for all analysed gingerbread assortments and it was also noticed in previous experiments. The lower the water activity, the lower the moisture in the samples. The decrease in the moisture of gingerbread leads to the crystallisation of sugar solutions and to the dehydration of starch and protein gels, which become more rigid and generate higher gingerbread hardness. Surprisingly, an increase in gingerbread hardness is ascertained with the increase in maturation time.

It would have been expected for gingerbread hardness to decrease as maturation time increases.

During maturation, a relaxation of the dough occurs, as well as a hydrolysis of the endogenous proteins and a hydrolysis of the granular starch, which leads to the weakening of the protein and starch gel in the finished product.

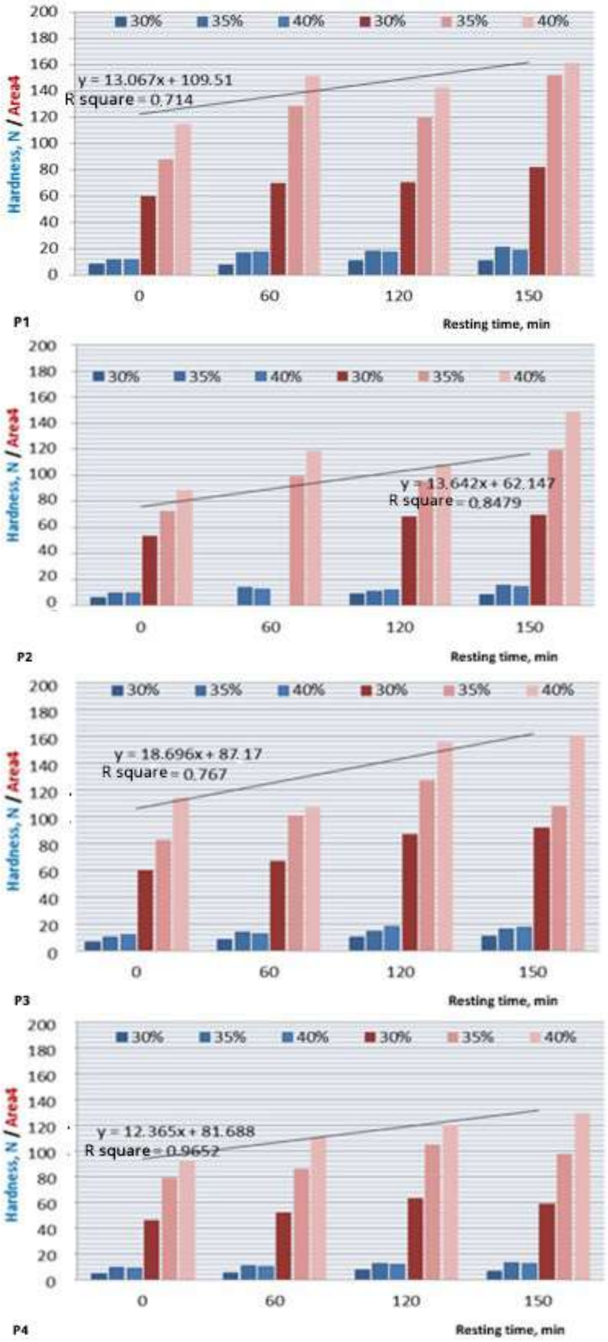


Fig. 3. Variation in hardness and in the distortion energy in conjunction with maturation time for P1, P2, P3, P4
Source: Own results in the laboratory.

This variation in hardness in conjunction with the relaxation time must be correlated with the results obtained in the rheological test. In this trial, the fact was noted that, as dough maturation time increases, its consistency also increases.

We can thus assume that the transformations occurring during dough maturation also affect the hardness of the gingerbread. It is unlikely that the physical processes of gluten or starch hydration during maturation are also the ones that lead to higher hardness.

It was concluded that short maturation times (in the order of 1-2 hours) did not influence the texture of the products in a positive way. The increase in maturation time could lead to texture improvement, but longer maturation times may be needed, of 24-48 hours, as recommended in traditional recipes for obtaining gingerbread.

Upon analysing the series of values for the gingerbread having the same water activity, it was noticed that the differences are higher for the dryer gingerbread, compared to the moister types. In the case of gingerbread with lower water activity, the increase in hardness was more pronounced as maturation time increased. To check this observation, linear trend curves were also marked (not presented in the figure, to avoid overburdening it).

We noted that the slope of hardness variation curves in conjunction with maturation time was smaller for the samples with higher water activity, and that it increased as water activity was reduced.

It was ascertained that product moisture is more important than maturation time.

For instance, the hardness of the witness sample obtained without maturation and with the lowest water activity was higher than the hardness of the sample with the maximum maturation time, but with the highest water activity. It was concluded that the preservation of gingerbread moisture is more effective for maintaining the samples tender.

Predictability in the variation of hardness also improved, as water activity increased. The linear regression rate values are higher for the series of samples with higher water activity.

There is significant-to-good correlation between maturation time and gingerbread hardness. The linear regression rates had values between 0.7000 and 0.9980. The linear regression rate had values smaller than 0.5000 in one case only. However, some reservations should be expressed regarding this observation, as the series of values were reduced to 3 cases only (3 pairs of maturation time - hardness values).

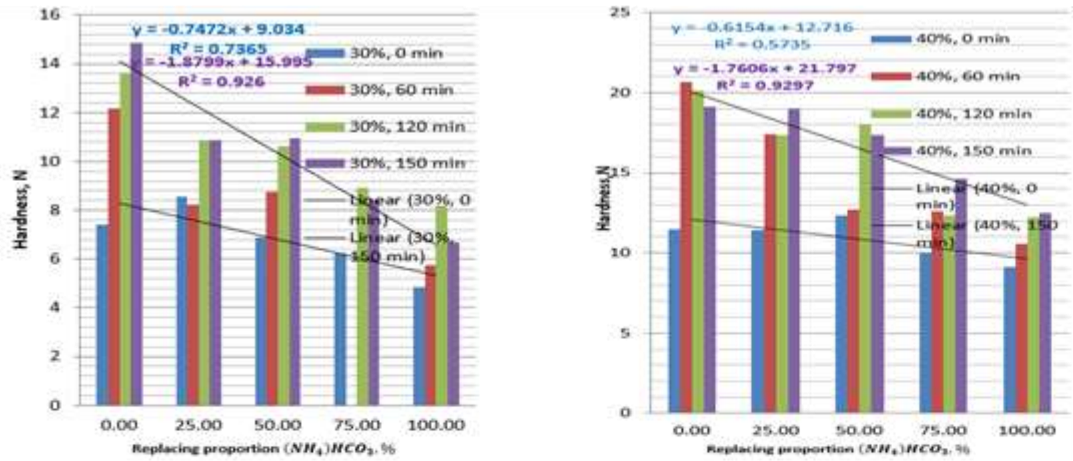


Fig. 4. Variation in gingerbread hardness, depending on the ammonium bicarbonate replacement rate
Source: Own results in the laboratory.

Figure 4 presents the variation in gingerbread hardness, depending on the replacement rate of ammonium bicarbonate.

The figure shows that, as the proportion of ammonium bicarbonate was replaced with sodium bicarbonate, gingerbread hardness decreased.

The effect became stronger as resting time increased, suggesting that the processes occurring upon maturation, which influence the texture of gingerbread imply, in one way or another, transformations of such aerating agents. We must have in view the fact that another variable existed in this system, the dose of acidifier, sodium acid pyrophosphate (SAPP). The SAPP quantity increased so as to achieve a chemical neutralisation of the sodium bicarbonate to a 95% rate.

The actual variable may in fact be the acidifier, rather than the aeration agent.

The fact was noticed that dough maturation time had a greater influence on product texture than the alternative selected for aeration. With small maturation times, the hardness decrease slope in conjunction with the ammonium replacement percentage was smaller. Linear regression rates are also smaller in conjunction with smaller dough maturation times. At 0 minutes maturation time, the decrease in hardness was of 21% and of 31% for the gingerbread cookies kept in 30% and respectively 40% sulphuric acid, and, at 150 maturation minutes, the decrease was of 35% and of 55% for the samples with the highest water activity.

Influence of the aeration formula on gingerbread texture

Hardness curve slope

The effect of ammonium bicarbonate replacement was also analysed in terms of other texturometric parameters. Thus, the effect on the variation curve slope exerted by the distortion force was monitored, depending on the extent of the distortion. The first part of the curve was selected, as distortions are small, and the possibility of product cracking is smaller. The parameter is defined as Degree 1/3.

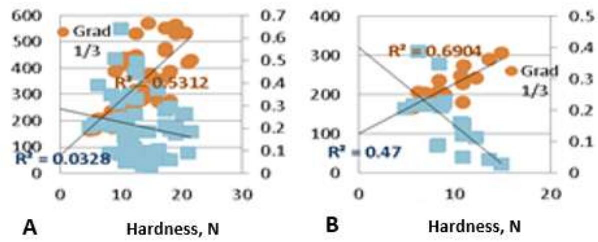
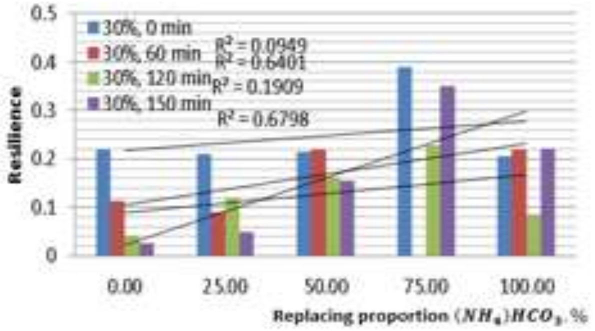
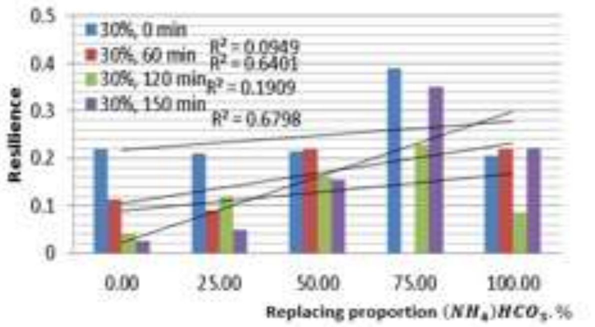


Fig. 5. Correlations between the graph's initial slope, the resilience of the gingerbread cookies and their hardness
Source: Own results in the laboratory.

A very similar variation was noted in correlation with the variation in product hardness (the data is not presented in the figure). To confirm the hypothesis, the relation between hardness and the slope of the hardness variation graph was monitored. The results are presented in Figure 5 A and B. In





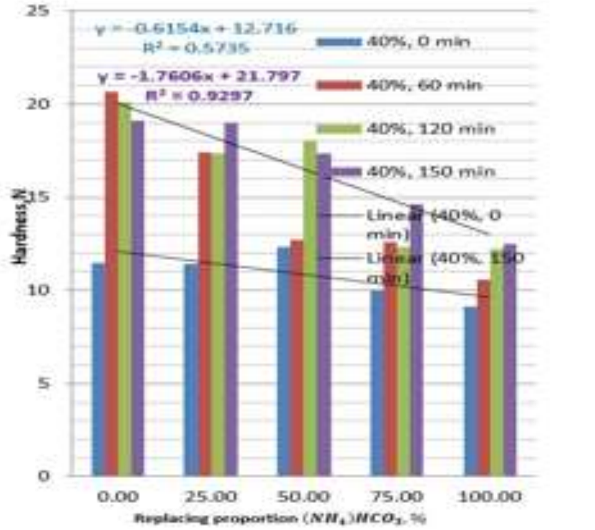


Fig. 6. Variation in gingerbread resilience in conjunction with the replaced proportion of ammonium bicarbonate
Source: Own results in the laboratory.

Figure 5A, all cases covered by the analysis are considered, and very weak correlation of parameters is noted. Upon separating the data into categories, depending on water activity, we note an improvement of such correlation. This suggests that certain particularities occur in the behaviour of the products, depending on the products' characteristics, at least depending on water activity.

Effect of the aeration formula on resilience

Resilience is the ratio between the area below the graph upon withdrawing the testing device and the area below the graph of the pressing force exerted when the device advances, if we use the single-compression test. Using this graphical representation, we can define resilience as the ratio between the energy used by the product to push the knife and the energy needed to push the knife into the product.

In Figure 5A, we note that there is no correlation between product hardness and its resilience. If the cases are selected according to the water activity criterion (Figure 5B), we note an improvement in the linear regression rate; however, its value is less than 0.5.

In Figure 6 we note that no statistical correlations can be established between such parameters.

There were only in several cases, and without following a certain model, that the linear regression rates were higher than 0.5000.

No statistical correlations can be established between resilience and dough maturation time, either.

The graphs lead to the conclusion that resilience is not a textural measure that can be used in cutting tests for gingerbread.

Moslikely, the cutting test induces permanent distortions, leading to the destruction of sample integrity.

COCLUSIONS

The study led to useful conclusions for the processors obtaining the product gingerbread with regard to maturation time, moisture, resilience, aeration formula, product hardness, in view of improving it. It was found that product moisture is more important than maturation time.

Short maturation times (in the order of 1-2 hours) do not influence the texture of the products in a positive way. The increase in maturation time can lead to texture improvement, but longer maturation times may be needed, of 24-48 hours, as recommended in traditional gingerbread recipes.

There is significant-to-good correlation between maturation time and gingerbread hardness.

Dough maturation time has a greater influence on product texture than the alternative selected for aeration.

As the proportion of ammonium bicarbonate is replaced with sodium bicarbonate, the hardness of gingerbread decreases. The effect becomes stronger as resting time increases, suggesting that the processes occurring upon maturation, which influence the texture of gingerbread imply, in one way or another, transformations of such aerating agents. We must have in view the fact that another variable existed in this system, the dose of acidifier, sodium acid pyrophosphate. The SAPP quantity increased so as to achieve a chemical neutralisation of the sodium bicarbonate. to a 95% rate. The actual variable may in fact be the acidifier, rather than the aeration agent.

For the textural characterization of gingerbread using this test type, cutting to a constant depth, the analysis of hardness and of the maximum distortion force is sufficient.

Resilience is not a textural measure that can be used in cutting tests for gingerbread. Most likely, the cutting test induces permanent distortions, leading to the destruction of sample integrity. The use of other devices and work protocols, such as compression with two or more cycles, is needed for a characterization in terms of resilience.

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MARKETING AND INNOVATION IN THE ROMANIAN WINE MARKET

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Abstract

The present research is focused on the link between entrepreneurship and rural economic growth in the direction and intensity of the net influence of farmers' entrepreneurial activities on rural economic development in Romania. This research delves into land use for grape production, a key element in Romania's wine processing industry. It examines the dynamics between consumption, production, and import in the wine market, noting in particular the increase in imports after Romania accedes to the European Union. In addition, it considers the impact of viticulture on land use amid food competition concerns. The study aims to elucidate the relationships between wine production, import, and consumption and assesses the capacity of domestic production to meet consumption demands. Using regression analysis of data on wine consumption, production, and import, the research uncovers significant findings. It reveals that a one-unit increase in wine consumption correlates with a 0.13-unit increase in both wine production and imports. This study contributes to a deeper understanding of the interaction between wine consumption, production, and import, helping predictive modeling and identifying sustainable entrepreneurial paths in the grape processing sector in Romania, given the considerable wine production potential.

Key words**:** *entrepreneurship, wine industries, products, Romania*

INTRODUCTION

As economic development enters the new normal, Romania is in a crucial period of transition from a largely agricultural country to a strong agricultural country. However, changes in the global economic landscape, the emergence of the new technological revolution, Covid-19, and the war in Ukraine, have had a huge impact on agricultural production and rural socio-economic development due to the severe employment situation from the countryside and market disruptions caused to farmers.

For this reason, the inferior position of agricultural and rural development gradually became prominent. In particular, the shortage of leading agricultural management experience, the insufficient side effects of agricultural industrialization, and the insufficient power of traditional agricultural transformation are becoming more and more complicated.

Romania is one of the main producers of wine grapes in the EU27. As Eurostat reports show, Italy, France, Spain, Germany, Portugal and Romania are the main European producers of grapes and wine grapes, as well as suppliers to the global market. This ranking has not changed since 2013. Italy, Spain, and France accounted for 78% of European grape production. interdependencies and dynamics of these markets comprehensively. This research aims to explore the intricate relationships between the grape and wine markets of five countries: Romania, Bulgaria, Hungary, Moldova, and Serbia. These nations share a significant interconnectedness in their market dynamics, with changes in one country profoundly impacting the others and reverberating throughout the global grape and wine market. Therefore, it becomes imperative to conduct a thorough investigation into these interdependencies [6, 11].

According to official data published by NIS in Romania [14], in rural areas the employment

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rate was 63.1 in 2020 (compared to the EU-27 average of 68.1) and in the case of young people (20-24 years old)) the occupancy rate is 50.3% (compared to the average of 53.6%). In addition, agricultural GDP accounted for only 4% of the country's total economic output in 2021, while labor productivity in agriculture was only a quarter of labor productivity in industry + construction and services.

Therefore, issues related to agriculture, rural areas, and rural people, represent the crucial foundation in Romania, there is an urgent need to look for new driving forces to support the high-quality development of agriculture, to promote sustained economic growth and stability in rural areas.

The Romanian wine industry plays a key role not only in the world market but also in the national economy. The interplay between the food industry, including grape production underscores the diversity and complexity of Romania's agricultural sector. Moreover, it emphasizes the interconnectedness of various sub-sectors within the broader food industry. Policies and strategies aimed at supporting and enhancing these sectors can have far-reaching implications for the overall economic growth and sustainability of Romania. Additionally, fostering innovation, improving efficiency, and promoting sustainability practices within these industries can further bolster their contributions to the economy while ensuring their long-term viability.

In Romania, the beer processing industry will generate, in 2022, 26.1% of the number of products obtained by the food industry, followed by wheat flour processing at 22% and only 12.6% goes to meat processing. Wines for consumption represented 5.9% of the total amount of food industry production in Romania [14].

The pandemic and the war in Ukraine have not left their mark on the sector and therefore increased productivity levels have been recorded. This situation can be traced through the increase in the number of both processing units and employees, while the value of production remained the same.

The results are consistent with those found in agriculture, where grape growing was not affected by the pandemic and the war in Ukraine, financial crises that have seriously affected other categories of farmers, traders, and seed processors through lower liquidity and increased financing costs. In 2021, a Romanian drank 2.6 liters more wine compared to 2020, reaching an average of 23.7 liters according to NIS data [14].

The work aims to evaluate the wine market and analyze the manifestations of producers and consumers of wine products in Romania in the last 15 years.

MATERIALS AND METHODS

In terms of research methodology, given that innovation and entrepreneurship are closely related in both temporal and spatial dimensions, it is necessary to consider spatial influencing factors. However, the existing studies do not overcome the spatial barrier and conduct a deep analysis of the effects of rural entrepreneurship in the surrounding areas, which may lead to an incorrect estimation error to some extent. Based on this perspective, this paper seeks to investigate the possible influences of rural entrepreneurship on agriculture and rural economic growth from an innovation-based perspective.

By sorting through the existing literature, this research provides three main contributions: first, this paper considered innovation and entrepreneurship in the unified analysis framework and tried to build a comprehensive indicator to identify the capacity of rural innovative entrepreneurship on "Schumpeter's theory of innovation". Second, this paper empirically discussed the relationship between rural innovation, entrepreneurial capacity, and rural economic performance based on a spatial methodological framework at the provincial level, at the same time the factors of geographic location, and economic attributes were considered in the model, market, and level of urbanization. Also, this paper deeply investigated the problem of heterogeneity in the heterogeneity of wine-growing areas, including grape-producing areas, consuming areas, production areas, and trade balance providing a new perspective for related research.

In analyzing the relationship between consumption and domestic production using a linear regression model, the goal is to identify the parameters that characterize the dependency between these variables. In this context, consumption represents the dependent variable (y), while domestic production serves as the independent or explanatory variable (x).

The linear regression model aims to establish a linear relationship between the independent variable (domestic production) and the dependent variable (consumption). The model can be expressed mathematically as:

$y=\beta_0 +\beta_1 x+\varepsilon$

Where:

y represents the dependent variable (consumption).

x represents the independent variable (domestic production).

$\beta_0$is the intercept, which represents the value of y when x is zero.

β_1 is the slope coefficient, which indicates the change in y for a unit change in x.

ε represents the error term, which captures the difference between the observed and predicted values of y.

The goal of regression analysis is to estimate the coefficients β_0 and β_1 that best fit the observed data. This is typically done using a method such as ordinary least squares (OLS), which minimizes the sum of the squared differences between the observed and predicted values of y.

Once the regression model is estimated, it can be used to make predictions about consumption based on the level of domestic production. Additionally, statistical tests can be performed to assess the significance of the estimated coefficients and the overall fit of the model.

By analyzing the quantitative relationships between consumption and domestic production using a linear regression model, researchers can gain insights into the dependency between these variables and make informed decisions regarding policy, planning, and resource allocation in the context of the food industry.

To clarify, it seems there might be a typo or formatting issue in your text. Assuming you're referring to hypotheses tested in the research, particularly Hypothesis 1 (H1), which states that consumption can be met through domestic production, here's a revised version of your statement:

This hypothesis suggests that the research seeks to investigate whether the level of domestic production is sufficient to meet the consumption demands. It aims to explore the relationship between consumption and both domestic production and imports separately to understand the extent to which domestic production contributes to meeting consumption needs compared to imported goods.

The paper investigates the grape wine market with a focused examination of its key components: supply and demand. In the context of food supply, the research considers factors such as land use and the agricultural area available for grape cultivation, as well as the quantities and yields obtained from these lands. However, it acknowledges that food products, including grapes for winemaking, are part of the global market, where local supply is influenced by various components of the trade balance, including production, stocks, demand, imports, and exports.

Specifically, the supply analysis in this paper aims to closely monitor two primary factors: production and imports. By scrutinizing these elements, the research seeks to gain insights into the dynamics of the grape wine market, particularly in terms of how local production and imports contribute to meeting the demand for wine. Understanding the interplay between production and importation is essential for assessing the sufficiency of domestic supply, identifying potential gaps, and gauging the market's responsiveness to changes in demand.

Through this supply analysis, the paper aims to provide a comprehensive view of the grape wine market, shedding light on the factors driving supply dynamics and their implications for market stability, competitiveness, and sustainability. By examining production and import trends, the research contributes to a deeper understanding of the market forces shaping the grape wine industry, thereby informing strategic decision-making and policy formulation within this sector. [11] likely refers to a source providing insights into consumer preferences and behavior regarding purchasing decisions. According to this source, quality emerges as the most critical factor influencing consumer choices, with 96% of European consumers prioritizing it over other determinants. Following quality, price ranks as the second most significant determinant, with 91% of consumers considering it important, while environmental impact is also a significant factor, with 84% of consumers taking it into account when making purchasing decisions.

In the context of the research, the demand analysis employs a quantitative approach to monitor both consumption and exports, which are identified as the main destinations for the products. Consumption patterns vary across geographical regions and countries due to diverse economic, social, and cultural factors. Additionally, factors such as population diets and the availability of food influence food consumption trends.

By examining consumption and export trends, the research aims to gain a comprehensive understanding of the demand side of the grape wine market. This analysis allows researchers to identify patterns, trends, and factors driving consumer behavior and market dynamics. Understanding consumer preferences and behaviors is crucial for businesses and policymakers in developing effective marketing strategies, product innovations, and trade policies to meet consumer demand and enhance market competitiveness.

RESULTS AND DISCUSSIONS

Indeed, the literature offers various conceptual and analytical models that aid in comprehending the intricate relationships between consumption, production, and import in the context of markets such as the grape wine industry [5]. They investigated the relationships between imports and consumption in different regions. The level and intensity of cause-effect relationships between food consumption and prices were analyzed. These analyses typically involve the use of various econometric techniques to investigate the relationships between trade (exports and imports) and consumption [1] Some prominent econometric analyses in this area include:

Gravity Models: Gravity models are widely used in international trade analysis to explain bilateral trade flows between countries. These models are based on the gravitational analogy, where trade between two countries is influenced by their economic sizes (measured by GDP), the distance between them, and other factors such as trade policies, cultural ties, and institutional arrangements. Econometric estimation of gravity models allows researchers to quantify the impact of these factors on trade flows[3].

Import Demand and Export Supply Models: These models focus on estimating the determinants of import demand and export supply for a particular country or industry. Econometric analysis of import demand models helps identify factors influencing a country's imports, such as income levels, prices, exchange rates, and domestic production. Export supply models, on the other hand, examine the determinants of a country's exports, including factors like domestic production capacity, foreign demand, and trade policies [4].

Time-Series Analysis: Time-series econometric techniques, such as vector autoregression (VAR) models, error correction models (ECM), and cointegration analysis, are used to analyze the dynamics of trade, exports, imports, and consumption over time. These models allow researchers to identify long-term relationships and short-term dynamics among these variables, as well as to assess the impact of shocks and policy changes on trade patterns [6].

Panel Data Analysis: Panel data econometrics, which combines cross-sectional and time-series data, is often employed to study trade, exports, imports, and consumption across multiple countries or regions. Panel data models, such as fixed effects, random effects, and dynamic panel models, enable researchers to control for unobserved heterogeneity and

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time-varying factors, providing more robust estimates of the relationships of interest.

Structural Models: Structural econometric models, such as computable general equilibrium (CGE) models and partial equilibrium models, simulate the effects of policy changes, trade agreements, and other shocks on trade patterns, exports, imports, and consumption. These models are often used by policymakers and international organizations to assess the potential impacts of trade policies and agreements on various economic outcomes.

The importance of rural innovation and entrepreneurial capacity has received widespread attention from all sectors of society, especially the rural workforce [5].

However, we occupy the penultimate place at the European level in terms of the sustainability of entrepreneurial initiatives: more than half of the newly established companies do not manage to survive the critical period of 42 months (they close or suspend their activity). It is without a doubt that rural entrepreneurship is conducive to stimulating the enthusiasm and creativity of farmers that provide endogenous support of the power of high talents for rural revitalization and common prosperity in Romania.

Based on the knowledge of rural reality and the complex and interconnected nature of agricultural sectors, the impact of innovative entrepreneurial activities in rural areas on economic growth is elusive. From one perspective, scholars generally agree that entrepreneurship is an important means of increasing agricultural economic performance and stimulating rural economic growth with the growth of entrepreneurial activity worldwide in recent years. Innovative entrepreneurial activities contribute to the stimulation of a thriving market, which promotes the diversification of cultures and reduces their dependence on a single market, thus increasing their incomes and business models [12].

In addition, in rural areas, innovative entrepreneurs in the agricultural sector can bring new technologies and practices to improve farm productivity and efficiency, leading to increased yields and profitability. Meanwhile, the entrepreneurial activities of farmers provide new jobs both on and off the farm, which is conducive to stopping rural migration and the development of new business forms and new models, such as the digital countryside, tourism agriculture, and rural complex.

This is beneficial for strengthening rural communities and sustaining rural livelihoods. Thus, innovative farmer entrepreneurship can play a key role in improving the well-being of rural communities to a large extent. While entrepreneurial activities can contribute to economic growth and development in rural areas, it is essential to carefully consider their potential negative impacts and adopt policies and strategies that promote sustainable and inclusive rural development. This requires balancing economic objectives with social and environmental considerations, empowering local communities, and fostering resilient and diversified rural economies. For example, excessive competition in the entrepreneurial process may hurt the development of local non-established businesses and exacerbate the pressure on the local economic environment due to the condition of limited market access.

In addition, it is worth noting that agricultural entrepreneurship can present several environmental problems and social challenges, such as soil degradation, agricultural land abandonment, water pollution, resource wastage, displacement of local communities, and other social conflicts. The first five companies in the grape wine processing industry in Romania represent 90% of the total revenues from this sector.

The impact of technological innovation on economic growth

The Schumpeterian theory of endogenous growth emphasizes that technological innovation is the fundamental source of power for long-term economic growth. In recent years, the promotion effect of technological innovation on the economy has become a hot spot for researchers. Technological innovation is also conducive to the efficiency of enterprise management and factor allocation, thereby promoting economic growth.

The impact of entrepreneurship on economic growth

The entrepreneurial phenomenon first appeared in the 18th century, with the deepening of research, the connection between entrepreneurship and economic growth was gradually confirmed by many scholars. However, the views of different scholars not only have certain similarities but also have differences to this effect.

[2] also divided entrepreneurship into innovative entrepreneurship and general entrepreneurship internationally, indicating that innovative entrepreneurship has multidimensional effects such as improving economic growth and facilitating the modernization of industrial structure, while the multidimensional effects of general entrepreneurship are very limited.

These studies highlight the multifaceted nature of the relationship between entrepreneurship and economic growth, suggesting that various factors, including public spending, access to finance, and institutional quality, interact to influence the impact of entrepreneurship on overall economic performance.

Additionally, [7] argued that entrepreneurship can spur innovation and technological advancements, leading to productivity gains and long-term economic growth. By fostering competition, experimentation, and knowledge creation, entrepreneurial activities contribute to the dynamism and resilience of economies, ultimately driving innovation-led growth.

[2] also indicated that returning home to start businesses can facilitate the modulation of the rural industrial structure and the integrated development of primary, secondary, and tertiary industries. However, some research reflects that the correlation between entrepreneurship and economic expansion is negative. For example, [2] stated that the influence of entrepreneurial activities on economic growth has an obvious heterogeneity in different provinces, some regions are significantly positive, while others are the opposite. In addition, [17]'s research concluded that opportunistic entrepreneurship has a significant impact on local regional economic development, but may inhibit the economic growth of nearby regions, while demand-driven entrepreneurship has the opposite influence. The knowledge spillover effect brought about by entrepreneurial activities is also one of the important reasons for its positive impact on economic growth.

The impact of innovative entrepreneurship on ecological development

The influences of innovative farmer entrepreneurship on sustainable agriculture and rural ecological development are also important and complex. On the one hand, the innovative entrepreneurship of farmers can lead to the creation of new and sustainable agricultural practices that can mitigate the negative impact of agriculture on the environment.

The existing literature has deeply investigated the impact of innovation or entrepreneurship on economic development, laying a solid foundation for the research of this paper. First, most studies tend to investigate the impact of innovation and entrepreneurship on economic expansion from a theoretical level and take innovation and entrepreneurship as separate individuals, rarely considering them as a unitary whole. Second, the few studies that look at innovation and entrepreneurship as a unified indicator are mostly done at the macroeconomic level, without focusing on agricultural and rural economic development. Finally, only a few studies consider the spatial effect of innovation and entrepreneurship on economic development, but they are based on the traditional geographic distance matrix and do not consider the economic level, marketization, urbanization, and other factors that may affect the effect of space. Therefore, this study took innovation and entrepreneurship as a unitary whole and tried to measure its level in rural areas. Moreover, considering the spatial effect characteristics of innovation and entrepreneurship, economic geography, market matrix, and urbanization matrix were constructed to comprehensively explore their impact on regional agricultural and rural economic development from different perspectives.

The study highlights Romania's significant potential in wine grape production, indicating favorable conditions for cultivating grapes suitable for winemaking. Moreover, it points out that Romania, along with other countries in the region, possesses sectors with high potential in various agricultural products.

The transformations of the food viticulture system and its implications on land use have been discussed by [7]. Other aspects of the influences of the production and use of secondary production as biofuels are noted in studies such as [7].

Starting from the review of specialized literature and statistical data that show the great potential of grape cultivation in Romania, we assume one of the study hypotheses:

H1: Romania possesses potential for domestic wine production.

In 2022, the number of companies working in the wine industry is 222, down from 236 in 2008. Moreover, the decline in the number of domestic wine producers has likely facilitated an increase in wine imports. This shift towards imports may have adverse effects on the Romanian economy. Importing wine from other countries could lead to a drain on foreign exchange reserves, loss of domestic market share for local producers, and reduced opportunities for employment and income generation within the domestic wine industry.

Therefore, it is reasonable to conclude that there is potential for domestic wine production to satisfy grape wine consumption in Romania. However, the decline in the number of wine-producing companies suggests a need for further examination of factors contributing to this trend, such as market dynamics, regulatory challenges, and competitive pressures. Addressing these issues could help revitalize the domestic wine industry, enhance its competitiveness, and promote economic growth and sustainability in Romania.

This is why, in this research, we test the following hypothesis:

H2: Romania may have an abundance of grapes available for winemaking, but lacks the infrastructure or capability to process these grapes into finished wine products to meet domestic demand.

As with other studies [1] Addressing the constraints in processing capacity within Romania's wine industry would require a concerted effort from various stakeholders, including government agencies, industry associations, and private sector investors. Investing in modernizing infrastructure, promoting technology transfer and innovation, streamlining regulatory processes, and supporting skills development and training initiatives could help unlock the full potential of Romania's grape supply and reduce reliance on wine imports. Additionally, fostering collaboration and partnerships between domestic producers and international counterparts could facilitate knowledge exchange and capacity building in the wine processing sector.

This leads to the need to test the following hypothesis:

H3: More significant interactions are found between wine consumption and imports compared to wine consumption and production.

Statistical data on consumption and export, as components of demand, as well as production and imports, as components of supply, are presented in Table 1.

Table 1. Trends in production, import, export, and consumption of grape wines in Romania, 2008-2022

	2008	2009	2010	2011	2012	2013	2014	2015
Production of wine for consumption (100 l)	5,369,189	4,957,315	3,287,241	4,058,168	3,310,612	5,113,232	3,749,862	3,627,609
Export	63,671,411	62,298,593	61,040,758	67,121,084	77,203,985	83,503,535	86,357,800	107,091,401
Consumption per capita	25.8	23.4	22.2	21.3	21.1	21.7	22.6	19
Import	139,136,765	68,375,785	93,226,388	217,879,612	193,366,130	175,917,999	159,791,821	198,768,426

Source: author's calculation based on data [14], [9] (2024)

Table 1. Trends in production, import, export, and consumption of grape wines in Romania, 2008-2022 (continued)

	2016	2017	2018	2019	2020	2021	2022
Production of wine for consumption (100 l)	3,266,669	4,264,144	5,088,202	3,808,430	3,959,703	4,451,149	3,787,502
Export	101,170,773	122,372,463	143,289,931	146,514,441	149,485,547	168,097,966	174,789,500
Consumption per capita	18	21.8	23.8	23.4	21.1	23.7	23.3
Import	223,500,749	271,019,671	291,995,479	298,406,696	340,871,647	457,823,276	578,415,214

Source: author's calculation based on data [14], [9] (2024)

In Romania, the grape wine market dropped in 2022, to a volume of 9.4 million hl, of which 3.7 million hl from domestic production and 5.7 million hl from import.

The relationship between grape wine production and wine consumption is direct and linear and can be expressed as: yx= 231,855x - 994,885.27 (Fig. 1).

R is the multiple correlation coefficient, in this case, the simple correlation between x and y. R recorded 0.64, which means that there is a strong relationship between grape wine production and consumption, given the data from 2008–2022.

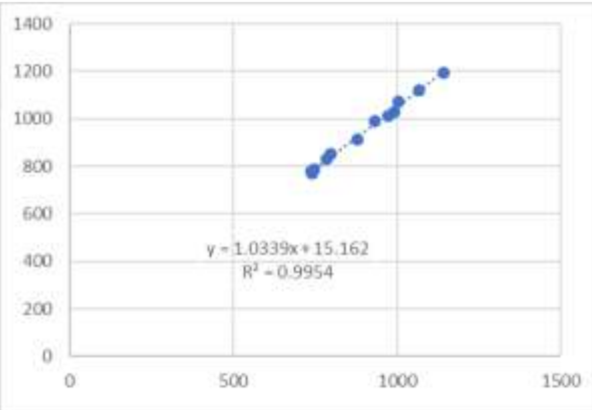

Fig. 1. Scatterplot between grape wine productions vs. grape wine consumption, 2008–2022
Source: Own determination.

R-squared is the coefficient of determination, which shows the validity of the chosen model and explains the variation of y. Its value is far from 1, indicating that the model is well chosen, final consumption, x, explains 0.41 percent of the variation in wine production, y. Adjusted R-squared is a degrees-of-freedom-corrected coefficient of determination with the same significance as R^2. The standard error expresses how much the observed average values yi deviate from the theoretical values in the expectation of the regression line y (in this case by + 15.162). Observations (n) represents the number of observations, in this case, n equals 12.

Final consumption is an extremely important factor in the evolution of wine production. It is observed that the value of the free term is very small, which allows us to say that the factors that were not taken into account in building the model have a relatively large influence on the evolution of wine production. The negative value of the free term reveals that the variables that were not included in the econometric model harm the development of production.

Once the relationship between consumption and production is established, the relationship between consumption and import is subsequently analyzed, trying to find the dependence between consumption, as a dependent variable, and import, as an independent variable. The illustration shows that the relationship between wine import and wine consumption is direct and linear and can be expressed as y = 0,0498x + 5.0494 (Fig. 2).

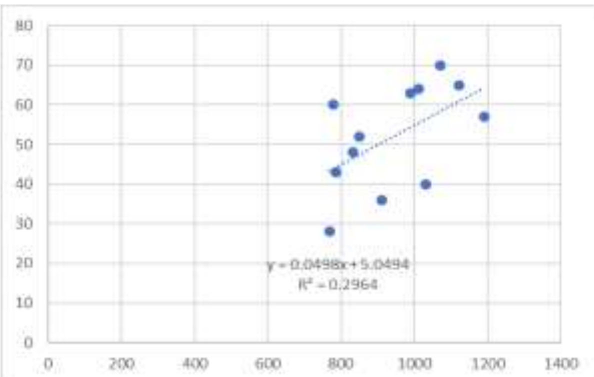

Fig. 2. Scatter diagram between wine imports vs. wine consumption, in the period 2008–2022

Source: Own determination.

Multiple R, the correlation coefficient between the value of wine imports and the final consumption recorded in Romania in the period 2008–2022, is 0.54, showing that there is a very close relationship between the two variables. R-squared, R^2 is the coefficient of determination, which shows the validity of the chosen model and explains the variation of y. In the analyzed case, it has a value far from 1, indicating that the model is well chosen, and the variable x, consumption, explains the variation of the variable y, import, in proportion to 0.29%.

The table of coefficients contains the estimated values of coefficients a and b. As a result, the estimated dependence between consumption and import can be illustrated by the model:

Consumption = 0,0498* Import + 5.0494.

The regression model is validated by the F-statistic test values (0.4198781-much higher than the reference value considered valid in the analysis of econometric models) and the near-zero degree of risk (reflected in the significance value of the F-test). The upper and lower limits of the confidence interval for the parameter are the lower 95% limit and the upper 95% limit. Threshold limits of 0.05 are calculated automatically, regardless of the regression initialization procedure.

As the data shows, wine consumption can be covered by domestic production, except for the years 2007, 2008, and 2009, when the level of production is lower than the level of consumption (Table 1).

This restricts the ability to support consumption through production alone, and consequently, imports have been needed to fill the gap. This situation began in 2007, when Romania joined the European Union, and the products of all member states competed on a single common market.

The hypothesis is supported by other studies [4] which reveal that the European food market has seen an impressive increase in import competition, coming primarily from multilateral and bilateral trade agreements, as well as from the expansion towards the Center and the East.

The year 2007 was the time when the wine produced in other member states was sold in Romania because it was more competitive in price than the wine obtained by domestic producers. This hypothesis is also illustrated by other researchers [10], who state that domestic crops have much higher production costs than imported ones.

National competition authorities have highlighted unfair competitive practices, expressing concern about the negative impact on consumer choice and product innovation in the long term. In such circumstances, as a natural reaction, certain restrictive regulations regarding the originally proclaimed freedom were implemented.

Wine grape production in Romania after 2008

Starting from 2010, wine production becomes more stable and begins to exceed consumption again. In 2014, production peaked at 454,476 tons, almost double the level of consumption. The fluctuating trend of wine production is mainly caused by fluctuations in grape production, and not by the land under vines (Fig. 3).

Along with cereals, grapevine is a species that has seen a significant expansion of plant structure on a farm. The harvested area of grapes has a constant trend of around 170 thousand hectares, in the analyzed period, while the average production of grapes reached a peak of 6,447 kg/ha in 2018, then decreased to 5,019 kg/ha in 2022 reaching the level of the 2010s.

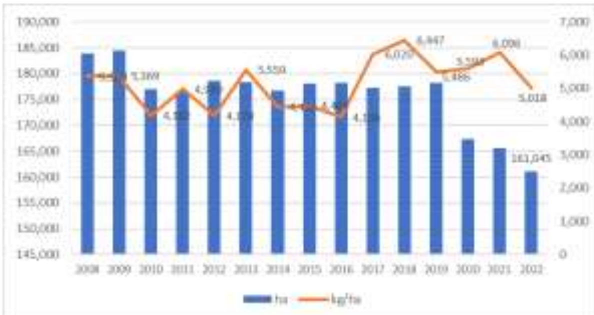

Fig. 3. The area occupied by vineyards per fruit and the average production of grapes, in Romania, 2008-2022
Source: NIS, 2024 [14].

Romania, as a wine-growing country, ranks 5th in terms of vineyard area and 6th in terms of grape and wine production in the European Union. The area cultivated with vines occupies about 1.4% of the entire agricultural area of the country. In 2014, grape production decreased by 20.8% compared to 2013, due to the decrease in yield per hectare, both in grafted vineyards (-11.7%) and in hybrid vineyards (-30, 4%) [13].

While productions and exports have seen oscillating trends, grape imports have grown steadily and slowly over the period 2010-2021 from 28 thousand tons to 78 thousand tons. Another distinctive observation is that availabilities for consumption are in step with the oscillating trend of production. This could be one reason why imports are needed to smooth out fluctuations.

In the coming period, the harvested area is expected to reach 160 thousand ha, and harvests are estimated to increase, leading to an estimated total grape production of 1,100 thousand tons in 2022.

What draws our attention in Fig. 4 is the significantly fluctuating trend of the quantities of grapes available for consumption.

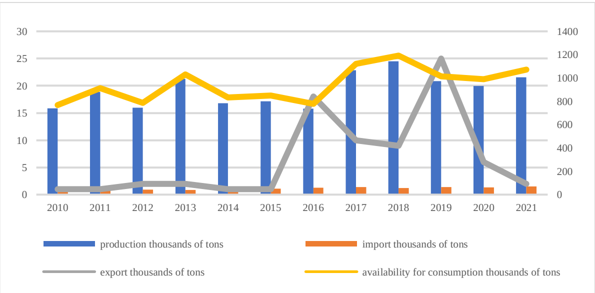

Fig. 4. Grape production, import, export, and availability for consumption, 2010–2021
Source: NIS, 2024 [14].

Their main destinations are the grape processing industry and the cannery industry. Since human consumption of grapes is stable, the quantities of grapes supplied as raw materials for the wine industry are also stable; the oscillating trend corresponds to the remaining quantities of grapes that supply the cannery industry.

These results are supported by other researchers [11] who studied the competition between food and fuel and who found that, since the beginning of 2000, the areas cultivated with fruits have increased continuously, in Romania, in competition with the areas cultivated with cereals. Romania has an agricultural area of 23 million ha, of which 209 thousand ha are vineyards and orchards (0.87%) [14]. Among European countries, Romania ranks sixth in terms of agricultural area, after Ukraine, France, Great Britain, Germany, and Poland. Arable land is mostly used for cereal crops, they occupy 72% of the arable area.

Although the areas cultivated with different crops have seen variations in their trends from 1990 to 2022, however, on average, they have increased more or less, as evidenced by statistical data. We could see that the area cultivated with canola had the most spectacular rate of change, with the area increasing by 112% per year over 26 years. The area cultivated with rape started to increase in 1999 when it tripled from 27 thousand hectares in 1998–83.6 thousand hectares in 1999. It reached a peak of 537 thousand hectares in 2010 and then stabilized around 300– 400 thousand hectares. As shown by other studies [6], the main cause of the decrease in the area cultivated with rapeseed in 2011 was the fact that Romanian farmers, after the low price obtained in 2011 for rapeseed due to the large supply, decided to rethink the production structure.

The area cultivated with vineyards and orchards has decreased at an average rate of 20% in the last 26 years. It has stabilized at around 161,000 ha. In addition to canola and sunflower, high levels of average annual rates of change were recorded for oats (4.82%), vegetables (4.43%), maize (4.22%), and wheat (3.74%). Low levels of average annual rates of change were recorded for sugar beet (0.64%), rye (0.86%), rice (1.11%), beans (1.38%) and barley (2.49%). We assume that areas under canola and sunflower have replaced areas under sugar beet, rye, rice, beans, and barley.

Consumption of grape wine

Grape wine consumption fluctuated between 25 and 19 liters per person per year (Fig. 5), which places Romania among the main wine consumers in Europe [8].

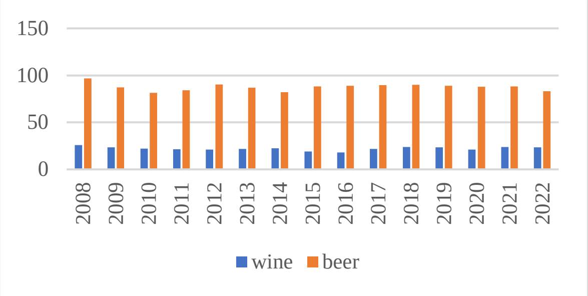

Fig. 5. Consumption of the main wine products in Romania
Source: NIS, 2024 [14]

Consumers prefer beer in consumption, respectively 83 l/person/year. However, the two major beer processors have recorded negative economic results in the last three years. We believe that this situation was generated by the rapid process of globalization. Moreover, Romania's beer processing facilities, which hold significant market shares of 40%, 27%, and 10%, are threatened by impending imports. As other studies have reported, the food market is highly concentrated.

CONCLUSIONS

Specifically, the study focuses on the grape wine market in Romania, providing an overview of its dynamics and interrelationships between key factors. It examines the relationships between consumption, representing the primary component of demand, and production and import, which are key components of supply within the grape wine market.

By analyzing these relationships, the research seeks to uncover insights into the drivers of supply and demand within the Romanian grape wine market. It aims to identify patterns, trends, and factors influencing consumption, production, and import dynamics over the study period.

Through a dynamic and spatio-temporal perspective, the research contributes to a deeper understanding of the evolving landscape of rural economic development and entrepreneurial activities among farmers in Romania. By leveraging statistical data and analytical methods, the study provides valuable insights for policymakers, stakeholders, and researchers interested in promoting sustainable economic growth and innovation in rural areas, particularly within the grape wine industry.

Overall, the empirical evidence presented in the study provides valuable insights into the spatial distribution, effects, and drivers of rural innovative entrepreneurship. By understanding the heterogeneity of entrepreneurial dynamics across regions and the interconnectedness of innovation and entrepreneurship, policymakers and stakeholders can design targeted interventions to foster entrepreneurship, promote rural development, and create a conducive environment for sustainable economic growth in rural areas. This result validates the hypothesis (H1) that wine consumption can be satisfied by domestic production in Romania.

Moreover, the study identifies heterogeneous effects of rural innovative entrepreneurship in regions with different grain production patterns and household income levels. This suggests that the impact and dynamics of entrepreneurial activities vary depending on local agricultural characteristics and economic conditions.

For example, regions specializing in grain production may experience different opportunities and challenges compared to areas with diverse agricultural activities. Importantly, the research emphasizes the importance of integrating farmer innovation and entrepreneurship deeply. It highlights the synergistic relationship between innovation and entrepreneurship in rural areas, suggesting that fostering a culture of innovation among farmers can drive entrepreneurial activities and vice versa. Furthermore, the study underscores the need for differentiated and specialized incentives to support rural entrepreneurship, especially in the context of evolving economic conditions. Tailored policies and programs that consider the unique characteristics and challenges of different regions can effectively stimulate entrepreneurial activities, promote economic development, and enhance rural livelihoods. We notice a certain tendency to decrease cultivated areas and at the same time a reduction in the number of companies working in the wine industry. The decrease in the number of wine-producing companies in Romania has indeed paved the way for an increase in wine imports into the Romanian market. This outcome supports hypothesis H2, which posits that the rise in wine imports is primarily due to Romania's insufficient processing capacity rather than a shortage of grapes.

The findings align with the NIS 2024 reports, which suggest that Romania's limited processing capacity may lead to the export of surplus grapes to other countries. This implies that while Romania may have ample grape production, the lack of adequate processing facilities constrains its ability to fully utilize its grape supply for domestic wine production

Another conclusion of the study is that consumption has a more significant influence on imports compared to its influence on production, as shown by the results of the regression model. The results of the study support hypothesis H3, indicating that there are more significant reactions between wine consumption and imports compared to consumption and domestic production. This finding helps explain the rapid increase in wine imports in Romania, driven by rising consumption levels. Importantly, these results have practical implications, particularly in identifying investment opportunities within the grape processing industry in Romania.

Traditionally, leading grape-producing countries are also major wine producers. However, countries like Moldova, France, Hungary, and Spain, which are not among the top grape producers, have significant wine industries. This suggests that a strong grape processing industry can drive wine production and competitiveness, regardless of absolute grape production levels.

Given Romania's ample potential as a grape supplier and the high demand for grape wine, the study concludes that there are substantial investment opportunities within Romania's grape processing industry. By leveraging its abundant grape resources and responding to growing consumer demand, Romania can position itself as a competitive player in the global wine market.

These findings suggest that investment in modernizing and expanding grape processing facilities, improving production techniques, and enhancing quality standards could help unlock the full potential of Romania's grape industry. Moreover, fostering innovation, promoting collaboration between stakeholders, and creating an enabling business environment is essential to capitalize on these investment opportunities effectively.

Overall, the study underscores the importance of strategic investments in the grape processing industry to harness Romania's potential as a grape supplier and meet the growing global demand for wine. By seizing these opportunities, Romania can enhance its economic competitiveness, create jobs, and contribute to the development of its rural areas

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REGIONAL COMPETITIVENESS: A KEY FACTOR FOR SUSTAINABLE ECONOMIC DEVELOPMENT IN ALBANIA

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Abstract

This study describes the effects of regional competition in the Albanian economy during the period 2005-2020. The Albanian economy is faced with numerous problems mainly related to unemployment, lack of competition in the market, the low level of foreign direct investments (FDI), the increase in consumer prices, the immoderate level of productivity and other elements with impact on the country's economy. The purpose of this paper is to identify the comparative advantages of different regions in terms of the efficient use of production resources available to them, facing the pressure of domestic production competition from imported products. To test or even measure the effects of influencing factors on regional competitiveness, econometric modelling was used in this study. The regression model in this analysis has the following form: Yt = β0 + ΣβiXit, where: with Yt the real GDP rate (used as a proxy for regional competitiveness) is identified as appropriate, and with Xt the set of variables that explain regional competitiveness. The data used were provided by: INSTAT, statistical yearbooks in years; publications of the Bank of Albania in years, for period 2005-2021. From the final results, we note that all macroeconomic variables taken into consideration have been statistically significant in their impact on GDP and automatically on Regional Competitiveness. Also, their impact seems to have followed the same sign as the raised expectations.

Key words: *competitive advantage, investment, informality, sustainable development, regional competitiveness*

INTRODUCTION

For years, regional development has attracted the attention of scholars from various fields, such as economists, geographers, urban planners, sociologists, etc., developing a series of models to explain why regions differ so much in the level of development, and how they evolve over time. International organizations over the years have developed mechanisms for achieving harmonious regional development. In the context of Albania's aspiration for EU membership, the concepts of region and regional development, according to the European legislature, are important for the country. Reducing regional disparities and strengthening institutional capacity to achieve this, it is an obligation that arises for Albania in relations with the European Union under the Stabilisation and Association Agreement between the European Communities and their Member States, of the one part, and the Republic of Albania, of the other part (SAA, Art.110) [3].

It is important to note that the classification of regions in Albania is in full coherence with the Regulation (EC) no. 1059/2003 of the European Parliament and of the Council of 26 May 2003 on the Establishment of a Common Classification of Territorial Units for Statistics (Nuts) [2].

Table 1. Definition of NUTS according to EU regulation

NUTS	Minimum number of inhabitants	Maximum number of inhabitants
NUTS 1	3,000,000	7,000,000
NUTS 2	800,000	3,000,000
NUTS 3	150,000	800,000

Source: Eurostat, 2021, Principles and characteristics, Principle 1: Population thresholds [5].

According to the DCM 1037(Decision of the Council of Ministers of Albania) [1] in 2010, Albania is classified in a NUTS 1 region, in three statistical regions NUTS II and in 12 statistical regions NUTS 3, which correspond to the level of counties.

The three statistical regions which correspond to NUTS II are: Northern Region which includes-Dibra, Durrës, Lezha and Shkodra; Central Region including Elbasan and Tirana; Southern region which includes - Berat, Fier, Gjirokastra and Vlora (DCM 1037, 2010) [1].

Based on the NUTS classification of the European Commission [4], the OECD has adopted the Regional Typology in order to provide a stable basis for the classification of the territory in the European Union (INSTAT, 2014) [8]. According to the classification of regions, the classification is based on three criteria (OECD, 2011) [13]:

(a) From the data studied for the mainly urban areas (PU), it is evident that the rural population living in these areas is less than 15%.

(b) For intermediate areas (IN), the rural population living in these areas ranges from 15% to 50% of the population of this area.

(c) while for the areas classified as mainly rural (PR), the typical rural population in these areas is greater than 50%.

The territorial division of Albania into: five regions, where we have a rural predominance; in five intermediate regions and in two predominantly urban regions.

- In the mainly rural regions, the fact that more than 50% of the population lives there, these regions are in the rural areas of municipalities that have less than 150 inhabitants per km2.

These municipalities occupy 45.8% of the territorial area of the country, representing about 23.1% of the Albanian population. The main representative districts of this region are: Dibra, Lezha, Gjirokastra, Kukësi, Korça.

-While in the intermediate regions, this figure ranges from 15% to 50% of the population living in the rural areas of the municipalities at the country level. These municipalities occupy about 45.8% of the territorial area of the country, where today about 42.1% of the population lives. in this category the representative regions are: Berat, Elbasan, Fier, Vlora, Shkodra.

- There are only two counties that have a pronounced urban predominance, which are Tirana and Durrës. In these two municipalities, which occupy only 8.4% of the territorial area, live about 34.8% of the population at the country level. Based on the typology of the OECD, we can say that our study area, based on the number of population and the characteristics of the division in Albania, can be considered as intermediate, as it includes an area with urban predominance (PU), four areas of intermediate (IN), and only two areas with rural predominance (PR).

Also, to increase the level of competitiveness, it is necessary to integrate community-oriented policies with bottom-up policies and vice versa. Proper implementation of rural and urban policies means better coordination between public, private and civil society actors who need to contribute towards knowledge transfer and fostering innovation.

Based on the analysis of NUTS, the typology of the OECD and the characteristics that each of them represents, our analysis will be based on the NUTS II classification, as it will focus and apply national and regional policies towards the economic development of the country.

In order to anticipate all the opportunities for promoting competitiveness in the central and southern area of Albania, we will first make a detailed analysis of macroeconomic indicators, based on a series of indicators defined in advance by us.

Objective of study

Through this study it is intended to achieve a high level of theoretical and practical security in order to increase competitiveness in certain regions of the Albanian territory as one of the essential elements for the design and implementation of efficient economic policies.

The study is mainly focused on the exploitation of comparative advantages according to the evaluated regions and aims to analyse the issues related to the performance of the actors and factors included in this evaluation. The methodology used and conceived in this study is in function of the object and purpose addressed above.

MATERIALS AND METHODS

For the conduct of this study, a special place is occupied by the methodology used. Data sources and their quality help in performing reliable and usable analysis for control or forecasting purposes. This study was conceived and passed through several stages:

Data selection: After reviewing the theoretical and empirical literature and the availability of data, a clearer idea has been created on the variables that should be taken into consideration for conducting the empirical analysis. At the macroeconomic level, the variables that will be worked are:

(1) Regional competitiveness, where the real rate of GDP is used as a proxy for regional competitiveness, based on several parallel studies with the same research focus [12, 14].

(2) Investments by region: The resources that determine the growth of technological processes are also determinants of regional competitiveness. Huovari et al. (2001) used investments and new patents as such determinants [7].

(3) Number of employees, as a result of new investments.

(4) Employment rate: The number of employees and the employment rate are variables that will determine aspects related to the labor market, which is certainly expected to correlate with regional competitiveness [6].

It is emphasized that the nature of the variables used in this study is only quantitative, these factors have influenced the selection of the econometric model that will be used.

Study area: In this study, we will consider he Central Region (Tirana, Elbasan) and the Southern Region (Fier, Gjirokastër, Berat, Vlorë, Korçë).

Data collection: For the study of the determining factors of regional competitiveness, the data on the variables were obtained from: INSTAT, statistical yearbooks [8, 9, 10, 11]; publications of the Bank of Albania in years, statistical register of enterprises 2016, yearbooks of the Ministry of Economy and Finance, yearbooks of the Ministry of Medicine and Social Protection. Due to the very nature of the study, no primary data obtained from questionnaires were used.

Data analysis: The statistical program SPSS version 21 and EViews were used for the descriptive and analytical analysis of the data. For the macroeconomic analysis, the variables are presented in the form of time series for a period of 17 years (2005 – 2021).

To test or even measure the effects of influencing factors on regional competitiveness, econometric modelling was used in this study. Empirical evaluation through econometric modelling is the basic approach used in the study.

The results of explaining regional competitiveness by variables that directly or indirectly affect, have been achieved through the use of regression models. The reason for using these models consists in reasoning that:

-In this study we are most interested in the relationship that exists between the number of employees, the level of investment and the employment rate, and regional competitiveness, in the face of other factors that affect the latter.

-The use of one-factor models generally eliminates the problems associated with multifactorial models (multicollinearity, heteroskedasticity).

-The amount of data available is limited. The time period covers 2005-2021, for most of the variables used in this analysis and the data are annual.

The regression model in this analysis has the following form:

$$Yt = \beta 0 + \Sigma \beta iXit \qquad ....(1)$$

where:

Yt: the real GDP rate (used as a proxy for regional competitiveness) is identified as appropriate.

Xt: the set of variables that explain regional competitiveness.

On the other hand, econometric models have also been used to assess the direction of the relationship (cause-effect) between influencing factors and regional competitiveness. Simple regression analysis that deals with the dependence of one variable on one or more other explanatory variables does not prove the existence of causality or rather the direction of impact.

RESULTS AND DISCUSSIONS

Analytical results of the study

Pearson's correlation coefficients were used to test the multiple relationship between the variables. The analysis shows that some of the variables are statistically related to each other, positively or negatively (Table 2).

Table 2. Correlation matrix for all variables included in the model

		GDP	Employment	Investments	No of employees
GDP	Pearson Correlation	1	-.751	.893	.510
	Sig. (2-tailed)		**.064****	**.019****	**.026****
	N	17	17	17	17
Employment	Pearson Correlation	-.751	1	.425	-.151
	Sig. (2-tailed)	**.064****		.178	.562
	N	17	17	17	17
Investments	Pearson Correlation	.893	.425	1	-.138
	Sig. (2-tailed)	**.019****	.178		.597
	N	17	17	17	17
No of employees	Pearson Correlation	.510	-.151	-.138	1
	Sig. (2-tailed)	**.026****	.562	.597	
	N	17	17	17	17

Note:**. Correlation is significant at the 0.1 level (2-tailed).
Source: Own results based on the data from INSTAT [8, 9, 10, 11].

In Table 2, it can be seen that there are no strong relationships between the variables and the problem of multicollinearity is not essential in this case. The values of the correlation coefficient vary from 0.019, 0.026 and 0.064 respectively, which proves a very low correlation. As long as the results show that the independent variables show no sign of deep correlation between them, we keep them all in the model.

Table 3. Correlation matrix for all independent variables included in the model

		Employment	Investments	No of employees
Employment	Pearson Correlation	1	.425	-.151
	Sig. (2-tailed)		.178	.562
	N	17	17	17
Investments	Pearson Correlation	.425	1	-.138
	Sig. (2-tailed)	.178		.597
	N	17	17	17
No of employees	Pearson Correlation	-.151	-.138	1
	Sig. (2-tailed)	.562	.597	
	N	17	17	17

Note:**. Correlation is significant at the 0.1 level (2-tailed).
Source: Own results based on the data from INSTAT [8, 9, 10, 11].

Model selection: In the next step, we set the variables that showed the relationship with the dependent variable, regional competitiveness, the GDP proxy. According to the significance results presented in Table 4, the econometric tests of the model are done.

Study hypothesis: The determining factors in regional competition are the number of employees and the level of employment, as well as the investments made.

The results of the implemented ARMAX model are presented in Table 4.

From the results obtained, we see that all three factors introduced in the model have influence and significantly affect regional competitiveness (we note the p-values in the table).

We tested the same hypothesis using the simple OLS model, as showed in Table 5.

Table 4. Model 1: ARMAX, using observations 2005-2021 (T = 17)
Dependent variable: GDP

	Coefficient	*Std. Error*	*Z*	*p-value*	
const	96109.7	9991.98	9.619	0.0001	***
phi_1	0.0987751	0.306461	0.3223	0.7472	
theta_1	1.00000	0.181524	5.509	0.0001	***
Employment	−16565.8	2334.34	−7.097	**0.0001**	***
Investments	0.737460	0.101276	7.282	**0.0001**	***
No of employees	1606.63	460.796	3.487	**0.0005**	***

Mean dependent var	123359.5	S.D. dependent var	25299.83
Mean of innovations	−65.05405	S.D. of innovations	10601.49
Log-likelihood	−183.2300	Akaike criterion	380.4599
ASchwarz criterion	386.2924	Hannan-Quinn	381.0397

Source: Own results based on the data from INSTAT [8, 9, 10, 11]

Table 5. Model 2: OLS, using observations 2005-2021 (T = 17)
Dependent variable: GDP

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
Employment	−8737.84	4374.52	−1.997	**0.0656**	*
Investments	0.689992	0.186698	3.696	**0.0024**	***
No of employees	4794.69	602.145	7.963	**0.0001**	***

Mean dependent var	123359.5	S.D. dependent var	25299.83
Sum squared resid	7.30e+09	S.E. of regression	22839.25
R-squared	0.972846	Centred R-squared	0.286923
F(3, 14)	167.1916	P-value(F)	3.38e-11
Log-likelihood	−193.0876	Akaike criterion	392.1753
Schwarz criterion	394.6749	Hannan-Quinn	392.4237
Rho	−0.258620	Durbin-Watson	2.264331

Source: Own results based on the data from INSTAT [8, 9, 10, 11].

We note that even with the second model used, the factors introduced in the model have influence and significantly affect regional competitiveness.
The work factor is significant for safety up to 94%, however, this conclusion cannot minimize the impact of this factor on the variable focused in this study, regional competitiveness (we note the p-values in the table).
From the final results, we note that all macroeconomic variables taken into consideration have been statistically significant in their impact on GDP and automatically on Regional Competitiveness. Also, their impact seems to have followed the same sign as the raised expectations.

Heteroskedasticity Test

Heteroskedasticity, otherwise known as non-constant variance of the regression error term, is another very important assumption, the presence of which does not allow us to obtain BLUE parameters.
H: Error terms do not have the same variance (heteroscedasticity)
White and Breusch – Pagan tests were used to test heteroskedasticity. In both cases, coefficient values and p-values were obtained which are statistically insignificant.
This means that we cannot reject the hypothesis of homoscedasticity by concluding that the error terms have the same variance. The assumption of homoscedasticity is met, and the parameters estimated by the Least Squares Method are BLUE.

White's test for heteroscedasticity

Table 6. OLS, using observations 2005-2021 (T = 17)
Dependent variable: GDP

	coefficient	std. error	t-ratio	p-value
const	3.34156e+09	3.55073e+09	0.9411	0.3780
Employment	−8.53835e+08	1.50649e+09	−0.5668	0.5886
Investments	45621.0	103182	0.4421	0.6717
No of employees	−2.96033e+08	2.63941e+08	−1.122	0.2990
sq_ Employment	−7.51061e+06	1.45250e+08	−0.05171	0.9602
X2_X3	−3878.83	9722.26	−0.3990	0.7018
X2_X4	7.45150e+07	6.77132e+07	1.100	0.3075
sq_ Investments	0.102921	0.133850	0.7689	0.4671
X3_X4	−3039.66	4140.55	−0.7341	0.4867
sq_No of employees	6.01456e+06	5.42119e+06	1.109	0.3039

Unadjusted R-squared = 0.359843, Test statistic: TR^2 = 6.117329,

With p-value = P (Chi-square(9) > 6.117329) = 0.728121

Source: Own results based on the data from INSTAT [8, 9, 10, 11].

Table 7. Frequency distribution for dependent variable: GDP
obs 1-17number of bins = 7, mean = 2676.23, sd = 22648.1

	Interval	midpt	frequency	rel.	Cul.
	< -30219	-36116	1	5.88%	5.88% **
-30219 -	-18427	-24323	1	5.88%	11.76% **
-18427 -	-6634.2	-12530	7	41.18%	52.94% **************
-6634.2 -	5158.4	-737.9	1	5.88%	58.82% **
5158.4 -	16951	11055	1	5.88%	64.71% **
16951. -	28744	22847	4	23.53%	88.24% ********
	>= 28744	34640	2	11.76%	100.00% ****

Source: Own results based on the data from INSTAT [8, 9, 10, 11].

Test for null hypothesis of normal distribution:

Chi-square (2) = 0.700 With p-value 0.70456

In both cases, coefficient values and p-values were obtained which are statistically insignificant. This means that we cannot reject the hypothesis of homoscedasticity by concluding that the error terms have the same variance. The assumption of homoscedasticity is met, and the parameters estimated by the Least Squares Method are BLUE.

CONCLUSIONS

The concept of competitiveness is quite broad and serves as one of the essential elements for the design, implementation of economic policies of a country. This concept plays a major role in the sustainable growth of well-being, prosperity of the population over long periods of time. The analysis of the indicators used in this study to assess regional competitiveness in the central and southern areas of Albania help us to reach the following conclusions

-At the level of gross domestic product by central and southern regions, the difference between them is noticeable. To assess the causes that have influenced these results it is necessary to analyze all the elements that affect the gross product of a region.

-The economy in the central area is growing much faster than in the southern area. Agriculture and fishing are exceptions as in the south we have two regions with rural predominance, Gjirokastra and Korça, which are known for the development of their agricultural activity (as orchards, vegetables and livestock). The southern area also consists of coastal cities, where part of the population considers fishing as a basic economic activity.

-The central region, consisting of Tirana and Elbasan counties, has a continuous population growth. Internal migration in Albania is mostly synonymous with urbanization. Most people who have changed their place of residence in the last two decades have moved to urban centers, which in most cases include the capital, Tirana, or the surrounding areas. In contrast, we note that the population level over the years in the southern region tends to decline steadily. On 1 January 2019, Gjirokastra region presented the lowest percentage of population, occupying 2.1% of it [9].

-The dynamics of gross domestic production in the central region has resulted in an upward trend and in parallel with population growth as well. Population growth in the central region is also a result of internal migration in pursuit of higher incomes enabled by the highest active enterprises in the country. As a result, the average per capita income has not decreased as the migrant population is able to work and integrates immediately into the labour market.

-We do not find the same in the southern region where although the population has shrunk mainly from the migration of active labour and we could suspect a decrease in per capita income, there is an increase in gross per capita income which is explained only by the realization of the gross product from the strategic investments of central or local governments.

-Based on the data published by [10], it results that Tirana has the lowest unemployment rate in the region although it has the highest population. Gjirokastra region results in the highest level of unemployment and the highest level of migration. This means that in this region there is an urgent need for incentive policies towards the efficient use of natural and human resources through a new economic model. We notice the increasing trend of the total number of employees in the central region. Even in this influential factor of this growing trend is undoubtedly the region of Tirana. Tirana is the only region in which the working age population can increase.

- In an analytical way, it is found that employment in the public sector, at both the local and central levels, has a downward trend, but is generally constant. Funding sources for public administration are more sustainable to create new jobs. While in the private sector, both in the field of agriculture and in other sectors, we have an increasing trend, dominating the non-agricultural sector.

In the southern region, employment is in a constant trend stabilized in recent periods. This trend also identifies the markets that provide employment in this region, where the private agricultural sector predominates, followed by the non-agricultural one, and finally the public administration of central and local government. Employment in the private sector (agricultural and non-agricultural) turns out to be the sector that affects the number of employees and the dynamics in this market. We note that the stabilization of employment in this region is created by the dynamics of this sector, where the reduction of employment in the agricultural market is associated with non-agricultural. This dynamic reflects the interest in the amount of income that these two sectors have, because the non-agricultural sector provides higher and more secure income than in the agricultural sector.

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CONCEPTUAL ASPECTS OF MANAGEMENT OF SUSTAINABLE DEVELOPMENT OF THE AGRIFOOD COMPLEX

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Abstract

*Stable development of agriculture in the context of innovative transformation of productive forces and structural changes is recognized as one of the directions of the National Security Strategy of the Russian Federation. Mechanisms for stimulating technological change and increasing efficiency should be aimed at achieving sustainable production criteria. The purpose of the study is to develop conceptual aspects of managing the sustainable development of agriculture using the example of livestock industries in conditions of structural transformation and technological changes. The article examines theoretical and methodological approaches to the study of problems of sustainable development of agriculture**.** An analysis was carried out and an assessment was made of the dynamics of crop yields and livestock production. Significant structural shifts and technological changes in the livestock subcomplex of Russia, caused by the processes of diffusion of innovations, have been identified. The authors have developed conceptual approaches to studying the problems of sustainable agricultural development in regional agricultural systems based on effective management. The main objectives of the proposed concepts are: expansion of production volumes of agricultural products, taking into account the needs of the region and export opportunities; technical and technological modernization of agricultural organizations and achieving an innovative balance of resources; compliance with the principles of rational environmental management and achieving environmental safety. The practical value of the results lies in the possibility of forming a strategy for the sustainable development of regional agricultural systems in the conditions of structural transformation and technological changes.*

Key words**:** *agri-food complex, livestock farming, innovation, technological change, sustainable development management*

INTRODUCTION

The National Security Strategy of the Russian Federation has identified the achievement of sustainable development on a neo-industrial basis as the most important condition for the successful functioning of sectors of the agro-industrial complex [11]. To achieve this task, it is necessary to use effective forms and methods of stimulating the technological transformation of the agricultural sector and the rational use of production resources by agricultural enterprises. The purpose of the study is to develop conceptual provisions for the study of problems of managing sustainable development of agriculture using the example of livestock industries in the context of structural and technological changes. The article summarizes theoretical and methodological approaches to the study of problems of sustainable development of agriculture, and explores the main directions for improving the management of sustainable development.

Theoretical and methodological approaches to research on this topic are reflected in the works of D. Pearce, J. Pezzey, William E. Rees. David William Pearce, Edward Barbier and Anil Markandya viewed sustainable development as the ability of production not only to meet current needs, but also to plan for the needs of future generations. The fulfillment of this condition predetermines the need to reserve resources for future production and introduce state control over the use of resources. Much attention in the study is paid to the problem of the impact of sustainable development on economic growth [19]. Sustainable development can be considered at the level of an individual enterprise, region, country, and also on a global scale. The Sustainable Development Goals, developed by the UN, contain recommendations for managing this process at the global level.

The implementation of the Goals largely depends on the flexibility, coordination, and maneuverability of existing national mechanisms for managing environmental and socio-economic processes [7].

J. Pezzey considered sustainable development both in a broad sense at the system level and at the level of a specific enterprise. The state must carry out the regulatory process by providing corrective subsidies to preserve non-renewable resources or by imposing taxes on inefficient management and deterioration of resources [20].

Ensuring the country's food security is largely determined by the efficient use of production resources in the agricultural sector and compliance with environmental safety. Agricultural issues of sustainable agricultural development are reflected in a number of works. For example, Bastan Mahdi used a system dynamics model to assess the level of sustainability of Iran's agriculture, noting the important role of organic farming and biological control. To reduce the consumption of water resources, it is recommended to repurpose the specialization of agricultural production [6].

The problems of increasing the efficiency of use of agricultural land are widely reflected in the scientific works of A. Popescu. Considering the features of land use in the countries of the European Union, the author emphasizes the need for a balanced ratio of production resources to obtain optimal results [21, 22].

Ali Sameh S explored the possibilities of using nanotechnology in agriculture, noting their undoubted advantages for increasing soil fertility and introducing soil protection measures, water purification and increasing stress resistance of plants. The author argued the effectiveness of using nanoelements in the technological process of production, processing and packaging of food products [2].

The problem of sustainable development in livestock farming is quite relevant, since the processes of concentration and intensification of production lead to an increase in greenhouse gas emissions [15].

According to expert estimates, food production accounts for over 30% of total greenhouse gas emissions caused by the use of pesticides, mineral and organic fertilizers [10].

Small-scale production is disproportionately affected by climate change. A sociological survey of representatives of small grain farmers in Central America showed that climate change has a negative impact on grain yields. Researchers point to the need to develop climate change adaptation programs to support small farmers, taking into account different socio-economic farming conditions [16].

A significant number of works are devoted to the study of the patterns of sustainable development of the agri-food complex of the country and regions. In her work, O. Cherednichenko substantiated the system of priorities for the sustainable development of the country’s agri-food complex and proposed measures for their implementation, using the results of a sociological survey of agribusiness representatives. Most experts highlighted the presence of such problems as climate change, limited resources for diversification of production, and rising costs of material and technical resources [9].

An important condition for compliance with the criteria for the sustainability of agricultural production is monitoring the condition of the soils of crop areas where organic products or agricultural products with improved characteristics are cultivated.

It has been proven that the production of products using new technologies helps reduce anthropogenic load. The federal budget should finance applied research programs on the problems of positive and negative externalities of using new technologies in agriculture. It is also necessary to allocate financial resources from regional budgets to compensate for the costs of agricultural producers for soil research, as well as payment for consulting services on the selection and implementation of resource-saving technologies.

It is possible to introduce a flexible system of standards for land improvement, as well as soil protection from wind and water erosion for organizations with different sustainability criteria [4, 12].

In the livestock industry, it is especially important to comply with the maximum permissible concentration of production.

Similar problems of spatial development were considered in the work of P.A. Minakir [18].

An analysis of sectoral livestock programs in Russia revealed a discrepancy between the targets and long-term development criteria presented in the programs. Based on the calculations carried out for dairy cattle breeding, strategies for the development of livestock farming in regions with different levels of production concentration are substantiated [27].

In the previous works of the authors, the topic of sustainability of the agricultural sector was studied using the methodology of modeling the impact of innovation and investment development on economic growth in order to achieve food security.

Based on cluster analysis, groups of Russian regions with differences in the scale of production and export of food products, the level of production and export efficiency, and the availability of investment resources were identified.

Recommendations for stimulating innovation and investment activities with the aim of forming an export-oriented agricultural sector are substantiated. For the identified typological groups of regions, differentiated strategies for state regulation of sustainable development of agriculture have been proposed [24].

In modern conditions, research into trends and patterns of innovation processes in the agricultural sector is quite in demand. This work explores the problems of sustainable development of livestock industries in the context of structural changes and technological transformations.

The purpose of the study is to develop conceptual aspects of managing the sustainable development of agriculture using the example of livestock industries in conditions of structural transformation and technological changes

MATERIALS AND METHODS

The theoretical and methodological basis of the study was the materials of the regulatory framework, the work of domestic and foreign scientists on the problems of development of the agro-industrial complex and its main sectors. To assess the process of diffusion of innovations in a spatiotemporal projection, the theories of technological discontinuity and diffusion of innovations were used. During the research process, monographic, abstract-logical, analytical, economic-statistical, and expert methods were used.

As an information base for the study, sources from Rosstat, line ministries, departments, business associations, materials from periodicals and expert assessments of specialists on the development of the livestock industry were used.

RESULTS AND DISCUSSIONS

The sustainable development of the country's agricultural and food complex largely depends on the rate of economic growth, improvement of the functioning conditions of the rural environment, and compliance with environmental safety requirements. In Russia, agricultural areas are not used effectively enough, which is confirmed by statistical data on grain yields (Fig. 1).

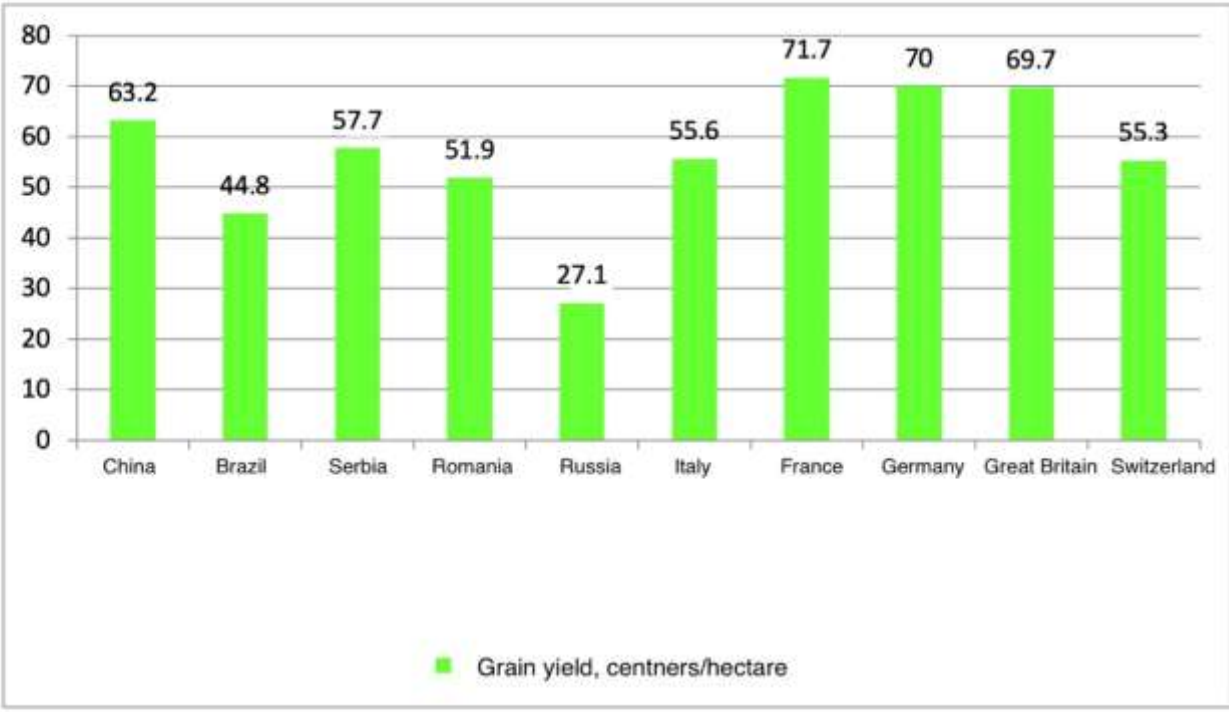

Fig. 1. Cross-country comparisons of grain yields
Source: Own calculations based on data [15].

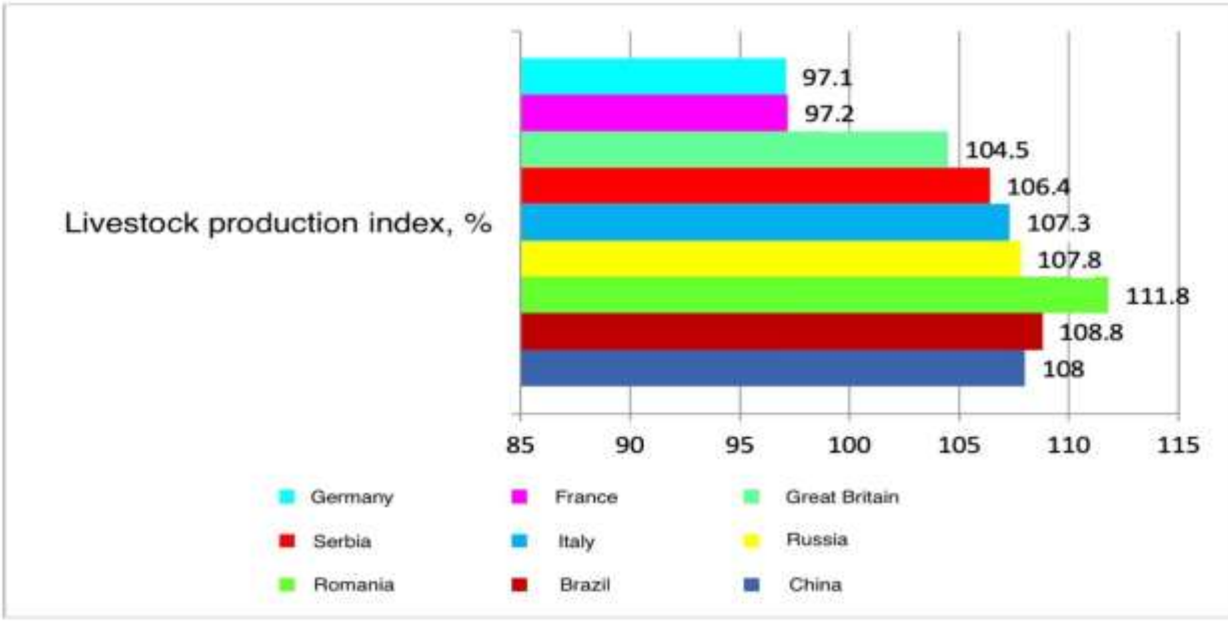

Fig. 2. Cross-country comparisons of growth rates in livestock production (2021 as a percentage of 2004-2006).
Source: Own calculations based on data [26].

A comparison of the dynamics of livestock production in individual countries of the world showed relatively high growth rates of Russian livestock production in 2021 compared to 2004-2006 (Fig.2).

A significant factor in increasing the volume of livestock production is the technological transformation of the industry. For 2017-2022 the innovative activity of organizations in the type of activity “livestock farming” has more than doubled. Large export-oriented organizations have a higher potential for the introduction and widespread use of innovative technologies. The problems of the low level of technological development of small-scale agriculture remain relevant for individual

Eastern European countries, as Popescu A. notes in his research [23].

In 2012-2022 There have been significant changes in the structure of meat production (Fig. 3).

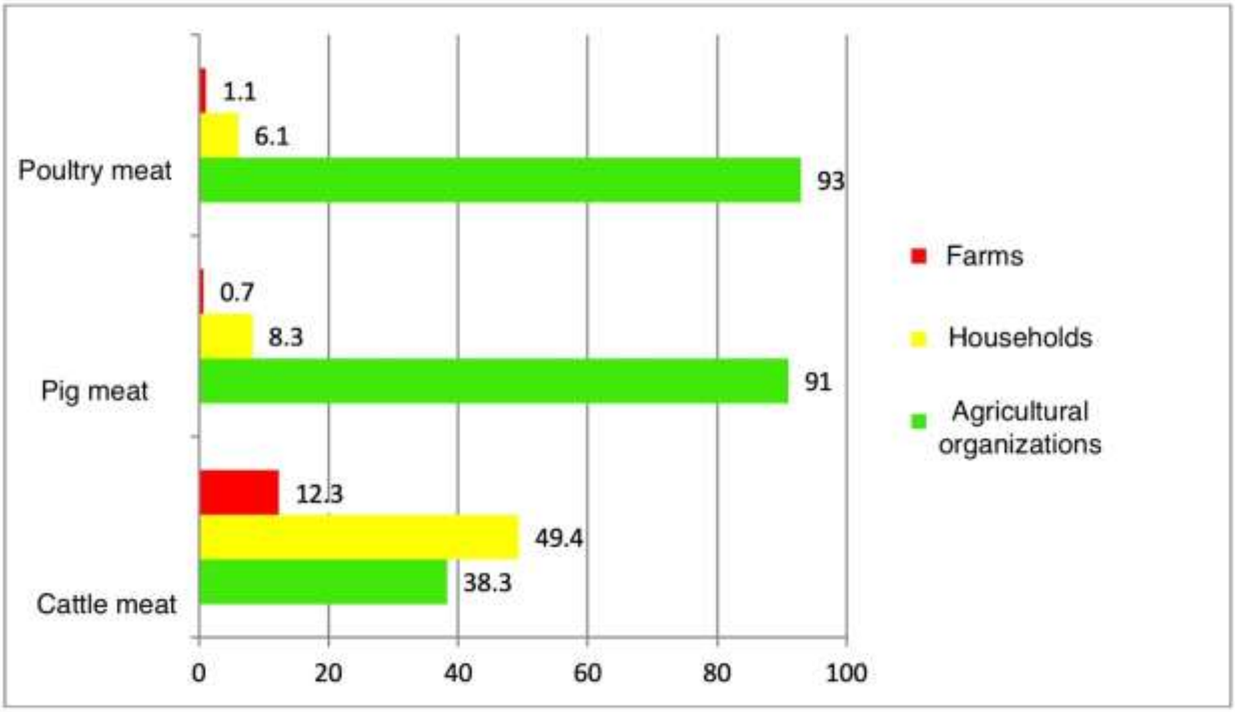

Fig. 3. Structure of meat production in Russia by farm category (2022).
Source: Own calculations based on data [8].

In 2022, the predominant share of pork and poultry production was accounted for by agricultural organizations and peasant (farm) farms. The development of pig farming on an industrial basis is explained by the rapid pace of modernization of production, as well as the development and implementation of new investment projects. The functioning of the industry is characterized by pronounced processes of business scaling: in 2022, the share of the twenty largest pig-breeding companies in the total volume of industrial pork production was about 80%. It should be noted that in terms of technical and technological development, these largest companies fully comply with international standards. The country has achieved complete self-sufficiency in pig meat; The task is to expand export positions. Increasing pork production volumes may result in increased competition in the domestic and global markets in the near future. Therefore, the most important tasks for the sustainable development of the industry are the formation of a breeding base and the construction of enterprises for slaughter and deep processing [17]. Along with achieving certain sustainability criteria, environmental problems have not been fully overcome.

In 2012-2022 In Russia, the concentration of pigs per unit of land area has increased. If in 2012 there were 78 heads per 1,000 hectares of agricultural land. pigs, then in 2022 - 124 goals. There is a need to increase the environmental responsibility of agribusiness enterprises using appropriate government regulation mechanisms [5]. In dairy farming, the impact of technological innovation on production efficiency is confirmed by a significant increase in cow productivity, which is especially typical for agricultural organizations; their share in total milk production is constantly increasing, which helps strengthen the innovative image of the industry. Along with the expansion of the agricultural sector in 2019-2022. there was a sharp increase in commercial milk resources (Fig. 4).

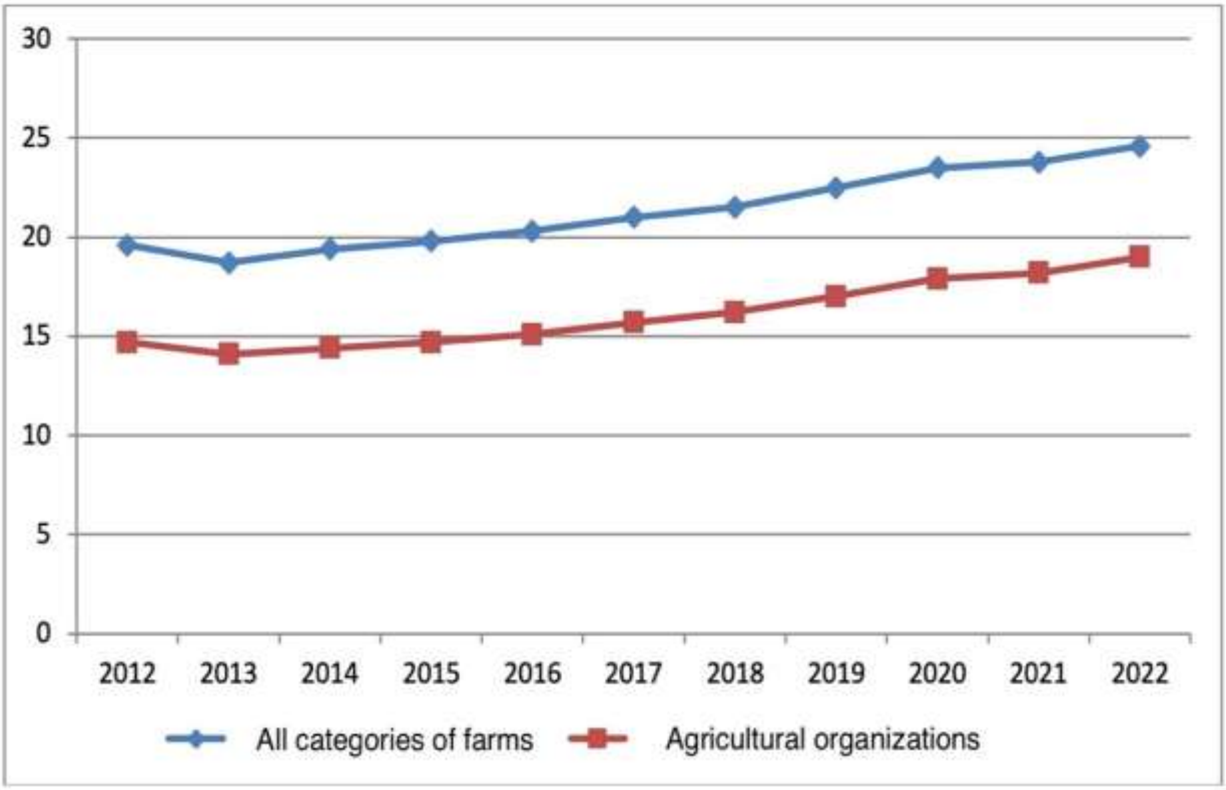

Fig. 4. Commodity milk resources in various categories of farms in Russia, million tons
Source: Own calculations based on data [1].

Increase in commercial milk volumes in 2018-2022. associated with increased government support and the introduction of new subsidies for the modernization of production. In 2023, additional measures were introduced to subsidize capital costs for the modernization of dry milk formula processing facilities; Part of the costs of product labeling is reimbursed. Further increase in the innovative potential of dairy cattle breeding is possible by improving selection and genetic work, maintaining feed balance and introducing advanced technologies for keeping cows. It is expected that the next stage of development of dairy farming will be influenced by the transfer of agricultural production to a fundamentally new technological basis. This will make it possible to build new patterns of interaction between participants in the innovation process and more actively use new technologies in small businesses.

The study showed that the processes of innovation diffusion have significant differences at the inter-industry and intra-industry levels. The relatively low rate of spread of technological innovations in dairy farming is explained by insufficient government support for small forms of farming. A similar point of view is expressed by R. Andergassen, Fr. Nardini, M. Ricottilli. When studying the process of diffusion of innovations, the authors proved the existence of an inverse relationship between the technological gap and the degree of diffusion of innovations, noting the need to use appropriate government regulation measures in order to reduce technological differences [3].

Overcoming differences in the technological level within groups of regions is possible by optimizing the structure of the volume of government support and developing appropriate mechanisms for increasing innovative potential. The most important area of stimulating innovative development of the agro-industrial complex is the creation of technological platforms [13,14].

Table 1. Conceptual approaches to managing sustainable development of regional agricultural systems

The goal of the concept is to manage the sustainable development of the agri-food complex in conditions of structural transformation and technological changes				
Objectives of theconcept				
Increasing the volume of agricultural products taking into account the needs of the region and export opportunities	Technical and technological modernization of agricultural organizations and achievement of innovative balance of resources	Formation of innovative personnel potential and development of new competencies by employees	Increasing the financial stability of agricultural organizations	Compliance with the principles of rational nature management and achieving ecological safety
Main activities of the concept				
-Timely delivery to agricultural producers of funds from the federal budget and budgets of constituent entities of the Russian Federation allocated for the implementation of the activities of the State Program for the Development of Agriculture and Regulation of Markets for Agricultural Products, Raw Materials and Food				
-Monitoring the condition of winter grain crops and the condition of perennial fruit and berry plantings				
-Organization of work to increase the reliability of the level of forecast and actual production indicators provided to the Ministry of Agriculture of Russia and securing at the regional level personal responsibility for maintaining and filling out information systems of the Ministry of Agriculture of Russia				
-Implementation of the supply plan for agricultural machinery and mineral fertilizers				
-Financing of retraining programs and development of new specialties in accordance with the requirements of the digital economy				
-Increasing the number of selection and seed-growing centers, forming a seed production plan				
-Organization of planting and monitoring of seed crops				
-Providing fire-fighting measures and preventing fires on agricultural lands				
-Assessing the consequences of using new technologies and their impact on the environment in order to maintain the optimal level of production concentration				
Expectedeffects				
Economic (achieving food security in countries and creating an innovative segment of food exports)	Social (successful development of the rural environment and rural areas based on increasing the level of employment of the population and their development of new competencies)	Technological (the process of innovative resource substitution as a result of the use of advanced technologies and updating the material and technical base)	Institutional (improving state regulation of the process of disseminating innovations and increasing the profitability of agricultural producers)	Environmental (achieving positive spillover effects from the use of new technologies as a result of reducing anthropogenic load)

Source: Own determination.

The formation of new technological foundations for the Russian agri-food complex predetermines the need to develop conceptual provisions for managing sustainable agricultural development at the regional level. The authors proposed methodological approaches to the formation of regional management concepts (Table 1).

The purpose of the proposed concept is to manage the sustainable development of the agri-food complex in conditions of structural transformation and technological changes.

The developed concept contains scientific approaches to managing the sustainable development of the Russian agri-food complex in the context of structural shifts and technological transformations. To achieve the country's food security, it is necessary to increase the volume of agricultural products, taking into account industrial and personal consumption, as well as export opportunities.

The presence of a significant technological gap between different categories of farms and the unsatisfactory state of the material and technical base predetermined the need to highlight the task of technical and technological modernization of agricultural organizations and achieve an innovative balance of resources.

Of great importance for the innovative transformation of the agro-industrial complex is the formation of the innovative potential of labor resources and their development of new competencies of the digital economy (third task).Improving the financial performance of agricultural organizations in the region is an indicator of the effectiveness of government support and indicates the possibility of more active implementation of technological innovations. The threat of environmental deterioration due to increased anthropogenic pressure makes it necessary to highlight the conceptual task of observing the principles of rational environmental management and achieving environmental safety.

CONCLUSIONS

The study of the issues of sustainable development of agriculture in Russia was carried out on the basis of a study of theoretical and methodological approaches of scientists from the world community.

Based on cross-country comparisons and analysis of individual agricultural indicators, a conclusion was made about the sustainable pace of development of Russian livestock sectors and the need for more efficient use of agricultural land to increase grain yields.

Using the example of the Russian livestock subcomplex, an assessment was made of the compliance of its functioning with the principles of sustainable development. Structural shifts and technological changes, to a certain extent caused by the processes of diffusion of innovations, have been identified. At the intersectoral level, differentiation of innovative development is observed: an industrial sector has been formed in pig farming, and dairy farming is characterized by uneven innovative development.

A forecast assessment of meat production by type for the period up to 2030 was carried out. It is concluded that the transfer of agro-industrial production to a new technological basis in the conditions of the fourth industrial revolution will significantly increase the efficiency of using innovations in various categories of farms.

Problems of insufficient level of state support and innovative development of small agricultural business organizations have been identified, which requires strengthening state support and improving mechanisms for managing sustainable development.

The authors have developed conceptual approaches to managing the sustainable development of agriculture in the region. The main points are identified: increasing the volume of agricultural production, taking into account consumption and export opportunities; technical and technological modernization of agricultural organizations and achieving an innovative balance of resources; compliance with the principles of rational environmental management and achieving environmental safety.

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TECHNICAL-ECONOMIC COMPARISONS AND HYBRIDIZATION OF GANJA-110 COTTON VARIETY WITH DIFFERENT COTTON VARIETIES: A CASE STUDY FROM AZERBAIJAN

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Abstract

The main purpose of this research is to compare the bio-morphological properties, fiber properties, technological quality indicators and net return levels of different cotton varieties, to include different varieties in hybridization and to use the obtained hybrids as a starting material in selection. The research was carried out in the experimental area of the Plant Protection and Technical Plants Scientific Research Institute in Samukh district in 2017-2020. Research material consisted of the local Ganja-110 cotton variety and some cotton varieties S-6524 (Uzbekistan), BA-440 (Turkey), Akala Beret (Israel), Selekt (Greece), Tashauz-68 (Turkmenistan) brought from cotton growing countries. The results of this research revealed that cotton varieties differ from each other in terms of raw cotton yield, this yield indicator was 4,380 kg/ha in Ganja-110 cotton variety against lower yields in the other varieties. The raw cotton mass of the Ganja-110 cotton variety was 6.3 g in a boll while it varied 5.2-6.0 g in a boll for the other different cotton varieties. It has been determined that the net return of other cotton varieties was also lower than Ganja-110 variety. It is recommended to use hybrids with enhanced heterosis effect obtained from crossbreeding between different cotton varieties.

Key words**:** *cotton growing, cotton breeding, hybridization, economic analysis.*

INTRODUCTION

One of the most valuable crops among field crops is cotton. It is cultivated in 53 countries of the world grace to its economic importance for the producing countries, where it contribute to the creation of jobs, raw materials for processing industry, income for farmers and value added helping the economic development [19, 8].
The creation of new intensive varieties and their dissemination in production is a decisive factor in the dynamic development of cotton growing. The aim of the breeders is to develop new theoretically based synthetic methods to obtain new plant varieties, and to develop various genetic selection methods to create a rich gene pool. Intensifying selection efforts, obtaining starting material for hybridization, improving the individual characteristics of existing varieties, and developing methodical approaches for the creation of new cotton varieties are pressing issues.
Increasing the amount and quality of the product obtained from the unit area constitutes the primary goal of cotton breeding programs. However, success in the breeding program, besides determining the purpose well, choosing the method to be used in the breeding study and the rootstocks to be used in these methods; It is possible with a good combination of genetic structures in hybrid combinations of rootstocks. For this reason, for the breeder to be successful, it is important to determine the breeding methods that can be followed by creating a wide variability in the early generations, as well as being careful in the selection of parents by determining the purpose well [10].
Many studies have been carried out on the morphological characteristics, genetic variation and breeding of cotton varieties in different countries of the World [5, 34, 16,

33, 15, 11, 41, 29, 28, 30, 38, 13, 23, 7, 40, 21, 42].

In these studies, it is seen that new hybrid varieties suitable for the conditions of the country and region are created, and new varieties are obtained in terms of durability and quality. However, in a period when climate change is on the agenda, it would be beneficial to set targets in this direction for improvement studies.

On the other hand, it is seen that there are many studies that reveal only the economic aspects of cotton cultivation in different countries [20, 4, 6, 26, 19, 2, 39, 24, 47, 46, 1, 14, 48].

However, interdisciplinary studies that evaluate technical and economic aspects together need to be continued [32].

Cotton growing, which is one of the strategic and important areas of the agricultural sector that brings foreign currency to the country, draws attention with its high labor intensity and total production volume indicators. In Azerbaijan, the measures taken to restore cotton to its former glory, including the "Cotton Growing Law" adopted on May 11, 2010, are very important. It has been tried to obtain higher yields in cotton planting by applying innovative technologies of countries such as China, Greece and Turkey. Comparing the quantitative and qualitative indicators of cotton varieties grown domestically and imported from other countries, and creating and applying options for preference will make significant contributions.

Some studies have been carried out on the technical aspects and development of cotton cultivation in Azerbaijan [18, 43, 27, 35, 36, 17, 31, 44, 37, 45, 49]. However, there is also a need for research that evaluates the issue from interdisciplinary technical and economic aspects and can develop varieties suitable for farmer conditions.

As a result of the comparative examination of the bio-morphological and economically valuable characteristics of other cotton varieties and the technological quality indicators of the fiber, the selection of more promising cotton varieties for cotton growing farms can be determined. Bio-morphological, productivity, quality, sustainability, etc. database of cotton varieties introduced for the first time in Azerbaijan should be created based on adaptation characteristics. For this purpose, examining the features and determining the adaptive characteristics with comparative studies will make important contributions. For this purpose, economically important, scientifically based perspective characteristics should be determined for the first time by evaluating the economic and perspective indicators of the varieties. If locally and other cotton varieties are used in hybridization to create new cotton varieties, promising hybrids with various positive signs and characteristics such as quantitative and qualitative indicators, productive, high fiber yield, long fiber, coarse, can be produced. In this way, bolls and fast-growing perspective hybrids can be obtained.

The main purpose of this research is to compare the bio-morphological properties, fiber properties, technological quality indicators and net return levels of different cotton varieties, to include different varieties in hybridization and to use the obtained hybrids as a starting material in selection.

MATERIALS AND METHODS

As the research area, the experimental area belonging to the Scientific Research Institute of Plant Protection and Technical Plants in the Ganja-Kazakh region was chosen. The region belongs to the administrative division of the Samukh region. The soils of the experimental areas of the Azerbaijan Cotton Growing Scientific-Research Institute (currently the Plant Protection and Technical Plant Scientific-Research Institute) are light chestnut coloured and belong to irrigated soils, humus content of 2.5%, carbonates 4.6-12.0%. The total nitrogen is 0.08-0.18%, the amount of silicic acid is 56.0% in the transition layers, 57.8% in the alluvial layers, the soil reaction is weakly alkaline (pH 7.5-8.2%)1. Groundwater is located at a depth of 10-30 m from the soil surface and is suitable for irrigation. The water permeability of the soil is moderate. Therefore, the soils of the Plant Protection and Technical Plants

Scientific Research Institute are considered suitable for growing high cotton crops due to both their chemical and water-physical properties [3].

The research was carried out and completed in 2017-2020 in the experimental area of the Plant Protection and Technical Plants Scientific Research Institute in Samukh district. Analyzes and evaluations were made in the department of General Agriculture, Genetics and Selection in Azerbaijan State Agricultural University (Photo 1).

Photo 1. Research area
Source: Original photo (taken by authors)

Research material consisted of the local Ganja-110 cotton variety and other cotton varieties Akala Beret (Israel), BA-440 (Turkey), S-6524 (Uzbekistan), Selekt (Greece), Tashauz-68 (Turkmenistan) brought from cotton growing countries. According to Mauer's systematics, these cotton varieties belong to the genus Gossypi-um, subgenus Eugossypium, G. hirsutum L., and have 52 chromosomes in their somatic cells [25].

Sowing was done by hand considering 60 cm x 20 cm, each variety was carried out in 4 rows, each row was 15 meters and was repeated 4 times. Field inspections were made 3-4 times in different growth periods of the plants. To clarify the height and growth rate of the plants and to determine the rod collecting ability, the sympodial branches and rod organs were determined by measuring the height of 25 plants in each replicate. Laboratory analyzes were carried out for raw cotton properties using test samples. To create selectable material, hybridization was made between cotton varieties as follows. For each combination, 50 flowers were washed and powdered according to the method.

Ganja-110 x BA-440
Ganja-110 x Selekt
Ganja-110 x Akala Beret
Ganja-110 x S-6524
Ganja-110 x Tashauz-68

Each number obtained is indicated by statistical calculations. The main characteristics of the plants in F_1 and F_2 were analysed, and the dominance of phenotypic characteristics was determined by the following formula [9].

$$H_p = [(F_1 - M_p) / M_p] \times 100 \qquad ....(1)$$

where:
H_P =Heterosis, M_p = Average of plant parent, F_1= Hybrid.

In addition, the indicators obtained from the experiment were calculated using the Dospekhov method by biological and statistical methods as follows [12].

$$m = \frac{\sqrt{\sum L^2}}{\sqrt{n-1}} \qquad ....(2)$$

where:
m = Average fiber production per plant, n= Number of plants, L= The sum of the squared differences from the average.

Bio-morphological characteristics of different cotton varieties were investigated. Phenological observations were made to determine the vegetation and interphase periods of different cotton varieties.

During the research, objectives and targets were analyzed by using traditional and modern methods used in cotton cultivation. For this, bio-morphological, economic indicators, technological quality indicators of fiber, phytopathological, selection (individual selection, sample, numbered parents) were examined, USTER HVI-1000 technological device was used, mathematical and statistical calculations were made.

In the research, the selection of suitable cotton varieties for cotton-growing farms was determined because of the comparative examination of the bio-morphological and economically valuable properties of different cotton varieties and the technological quality indicators of the fiber.

Adaptation characteristics of cotton varieties introduced in Azerbaijan for the first time were created by considering the bio-morphology, productivity, quality, and sustainability.

By evaluating the economic and perspective indicators of the varieties, economically important, scientifically based perspective forms were determined for the first time.

The equations presented below were used in the calculations of gross and net return of cotton production by different varieties [22].

Gross Return (AZN/ha) =
Cotton Production (kg/ha) x Cotton Price (AZN/kg) .... (3)

Net Return (AZN/ha) =
Gross Return (AZN/ha) – Production Costs (AZN/ha) .... (4)

RESULTS AND DISCUSSIONS

According to the results of the research, 2-3 days for seed germination of Ganja-110 cotton variety, 6-8 days for germination-blooming period, 6-9 days for flowering-maturity period, 14-18 days for vegetation period are required.

At the maturation stage of plant development, the height of the main stem of the plant was highest in different cotton varieties compared to local variety. Plant height is 120 cm in local cotton variety, 135 cm in cotton variety BA-440, 128 cm in Selekt variety, 130 cm in Akala Beret variety, 125 cm in S-6524, and 130 cm in Tashauz-68 variety (Table 1).

The amount of raw cotton obtained from a boll is one of the important indicators in increasing productivity.

Although there are many bolls in the bushes, the mass of the bolls is small compared to the local cotton varieties. In other words, while the weight of raw cotton obtained from a single boll in Ganja-110 cotton variety is 6.3 g, it is 5.4 g in BA-440 variety, 5.1 g in Selekt variety, and 5.5 g in Akala Beret variety.

The raw cotton weight obtained from a boll was determined as 6.1 g in S-6524 variety imported from Uzbekistan and 6.0 g in Tashauz-68 variety imported from Turkmenistan (Table 1).

Although the number of sympodial branches was 15 to 18 in different cotton varieties, the number of sympodial branches is 20 in Ganja-110 variety, which is superior to other cotton varieties. The number of bolls per plant was 17 in the local cotton variety Ganja-110, 16 in Selekt, Akala Beret and Tashauz-68, and 15 in BA-440 and S-6524 cotton varieties (Table 1).

Table 1. Average technical results of different cotton varieties

Varieties	Plant height (cm)	The number of bolls per bush	Raw cotton obtained from a boll (g)	Raw yield (kg/ha)	Fiber yield (kg/ha)	Fiber length (mm)
Ganja-110	120	17	6.3	4,380	1,580	35.2
BA-440	135	15	5.4	3,300	1,250	33.3
Selekt	128	16	5.1	3,460	1,380	33.8
Akala Beret	130	16	5.5	3,100	1,110	32.7
S-6524	125	15	6.1	3,620	1,300	34.0
Tashauz-68	130	16	6.0	3,320	1,220	34.2

Source: Results of this research.

Ganja-110 cotton variety differs from domestically introduced cotton varieties with its early maturation, high opening rate of raw cotton and high yield. The yield value of Ganja-110 cotton variety was 4,380kg/ha. S-6524 variety took the second place in terms of productivity value (3,620kg/ha). The productivity values of other cotton varieties are 3,300kg/ha for the BA-440 variety, 3,460kg/ha for the Selekt variety, 3,100kg/ha for the Akala Beret variety, and 3,320kg/ha for the Tashauz-68 variety. Among the different cotton varieties, S-6524 variety has the highest yield value with 3,620kg/ha, while Akala Beret variety has the lowest yield value with 3,100kg/ha. The yield of Ganja-110 cotton variety was found to be 760-1,280kg/ha higher than the different cotton varieties (Table 1).

The fiber yield of cotton varieties is one of their economically valuable basic characteristics. The creation of new cotton varieties with high fiber yield has both theoretical and practical importance. The fiber yield of cotton varieties was 36.0-40.0%. Selekt and BA-440 cotton varieties have high fiber yield (39.5-40.0%). Ganja-110 cotton variety's fiber yield was determined as 36.0-38.5%. According to the research, it is concluded that the fiber yield of BA-440 and Selekt is higher than the different cotton varieties. The fiber yield of locally and different cotton varieties varied between 1,110-1,580 kg/ha. The fiber yield in the local Ganja-100 cotton variety was 1,580 kg/ha. Fiber yield of imported cotton varieties is 1,250 kg/ha for BA-440 variety, 1,380 kg/ha for Selekt variety, 1,110 kg/ha for Akala Beret variety, 1,300 kg/ha for S-6524 variety and 1,220 kg/ha for Tashauz-68 variety (Table 1).

Ganja-110 cotton variety had 35.2 mm longer fiber length, while Akala Beret variety had 32.7 mm shorter fiber length. Among other different cotton varieties, 33.3 mm in BA-440 variety, 33.8 mm in Selekt variety, 34.0 mm in S-6524 variety and 34.2 mm in Tashauz-68 cotton variety. S-6524 imported from Uzbekistan and Tashauz-68 imported from Turkmenistan are closer to Ganja-110 cotton variety according to the economic value of fiber length (Table 1).

According to the research, it has been determined that Ganja-110 cotton variety is superior to the other cotton varieties introduced in terms of fiber length and is more compatible with the soil and climatic conditions of the country.

In the first-generation hybrids, in almost all combinations, in addition to their slightly stronger growth than the parental forms, at the same time individual indicators of economic value are characteristic of the first-generation hybrids, and the strength of heterosis is more pronounced (Table 2).

Table 2. First generation hybrid (F_1) results obtained by crossing

Hybrids	Vegetation period (day)	Fiber yield (%)	Amount of raw cotton obtained from a boll (g)	Fiber length (mm)
Ganja-110 x BA-440	118	39.5	6.3	34.8
Ganja -110 x Akala Beret	128	38.0	6.0	33.7
Ganja-110 x Selekt	125	40.0	5.8	34.0
Ganja -110 x Tashauz-68	128	37.5	6.2	35.0
Ganja -110 x S-6524	125	37.0	6.1	34.6

Source: Results of this research.

Table 3. Second generation hybrid (F_2) results obtained by crossing

Hybrids	Vegetation period (day)	Fiber yield (%)	Amount of raw cotton obtained from a boll (g)	Fiber length (mm)
Ganja-110 x BA-440	121	41.0	6.1	36.0
Ganja -110 x Akala Beret	130	39.0	5.8	34.0
Ganja-110 x Selekt	128	39.5	6.0	34.5
Ganja -110 x Tashauz-68	125	38.0	6.0	34.8
Ganja -110 x S-6524	128	37.5	6.0	35.0

Source: Results of this research.

Hybrids of all combinations are more diverse in the second generation than hybrids of the first generation due to individual characteristics. In conclusion, it was concluded that this is due to the strong crossing's characteristic of the second generation of quite diverse forms (Table 3).

The selected hybrid forms were evaluated as rich starting forms for practical selection due to their drought resistance, disease resistance, strong fiber properties, economic value indicators and fiber technological quality characteristics.

It is considered legitimate that the average number of individual economic indicators is higher in third-generation hybrids than in second-generation indicators (Table 4). As a result, stable forms with individual and sometimes several positive characteristics were chosen.

Table 4. Third generation hybrid (F_3) results obtained obtained by crossing

Hybrids	Vegetation period (day)	Fiber yield (%)	Amount of raw cotton obtained from a boll (g)	Fiber length (mm)
Ganja -110 x BA-440	120	40.0	6.0	35.0
Ganja -110 x Akala Beret	128	38.5	6.0	34.0
Ganja -110 x Selekt	124	40.0	6.1	34.8
Ganja -110 x Tashauz-68	127	37.0	6.0	34.0
Ganja -110 x S-6524	126	38.0	6.2	34.5

Source: Results of this research.

Thus, a large proportion of individuals selected from the third-generation hybrid field have been considered promising starting forms to study in the later stages of the selection process because of some useful bio-morphological signs and traits, yield indicators.

To determine the effect of heterosis, it was tried to cross the Ganja-110 cotton variety with different cotton varieties.

In the research, the heritability of the early trait of hybrids obtained by crossing Ganja-110 cotton variety with different cotton varieties was also investigated.

In the F_1 hybrid generation, the vegetation period in the hybrid combination "Ganja-110 x BA-440" was accelerated. Similar results were seen in the F_2 and F_3 generations. F_1 generation hybrids showed positive dominance (Table 5).

Table 5. Vegetation period characteristics of hybrids obtained by crossing

Hybrids	Parent couples characteristics		Hybrid characteristics (day)			
	♀	♂	F_1		F_2	F_3
			M	h_p		
Ganja -110 x BA-440	122	142	118	-1.40	121	120
Ganja -110 x Akala Beret	122	140	128	0.42	130	128
Ganja -110 x Selekt	122	138	125	-0.62	128	124
Ganja -110 x Tashauz-68	122	137	128	0.20	125	127
Ganja -110 x S-6524	122	136	125	-0.57	128	126

Source: Results of this research.

Fiber yield of F_1 hybrids is dominant and heritable in hybrid combinations of "Ganja-110 x Select" and "Ganja-110 x Akala Beret" (Table 6). The raw cotton mass obtained in F_1 is larger than in all combinations and close to the main form.

In the second (F_2) and third (F_3) hybrid generation, an increase in raw cotton mass was observed during hybrid generation selection (Table 7).

Table 6. Fiber yield characteristics of hybrids obtained by crossing

Hybrids	Parent couples characteristics		Hybrid characteristics (%)			
	♀	♂	F_1		F_2	F_3
			M	h_p		
Ganja -110 x BA-440	38.5	40.0	39.5	0.33	41.0	40.0
Ganja -110 x Akala Beret	38.5	36.0	38.0	0.20	39.0	38.5
Ganja -110 x Selekt	38.5	39.5	40.0	2.00	39.5	40.0
Ganja -110 x Tashauz-68	38.5	37.0	37.5	0.33	38.0	37.0
Ganja -110 x S-6524	38.5	36.0	37.0	0.20	37.5	37.0

Source: Results of this research.

Table 7. Characteristics of raw cotton mass obtained from boll in hybrids obtained by crossing

Hybrids	Parent couples characteristics		Hybrid characteristics (g)			
	♀	♂	F_1		F_2	F_3
			M	h_p		
Ganja -110 x BA-440	6.3	5.4	6.3	1.00	6.1	6.0
Ganja -110 x Akala Beret	6.3	5.5	6.0	0.25	5.8	6.0
Ganja -110 x Selekt	6.3	5.1	5.8	1.00	6.0	6.1
Ganja -110 x Tashauz-68	6.3	6.0	6.2	0.50	6.0	6.0
Ganja -110 x S-6524	6.3	6.1	6.1	0.10	6.0	6.2

Source: Results of this research.

The fiber length differs in different combinations of the F_1 hybrid. In terms of fiber length, hybrid dominance was obtained in crossing Tashauz-68 variety with Ganja-110 variety. It was determined that the F_1 hybrid obtained by crossing Select and S-6524 with Ganja-110 showed intermediate inheritance. In the F_2 hybrid generation, all combinations are close to the main form with high fiber length.

Individual samples collected at F_3 have high form and are close to the parent form with high fiber length. It was concluded that individual samples collected from the hybrid parents studied in the study were sufficiently effective (Table 8).

Table 8. Fiber length characteristics in hybrids obtained by crossing

Hybrids	Parent couples characteristics		Hybrid characteristics (mm)			
	♀	♂	F_1		F_2	F_3
			M	h_p		
Ganja -110 x BA-440	35.0	32.5	34.8	0.80	36.0	35.0
Ganja -110 x Akala Beret	35.0	32.0	33.7	0.13	34.0	34.0
Ganja -110 x Selekt	35.0	33.0	34.0	0.00	34.5	34.8
Ganja -110 x Tashauz-68	35.0	34.0	35.0	1.00	34.8	34.0
Ganja -110 x S-6524	35.0	34.2	34.6	0.00	35.0	34.5

Source: Results of this research.

In the research, the seeds of the hybrids obtained because of crossing the cotton varieties introduced with the Ganja-110 cotton variety were sown in the first selection field. To continue the selection study, directional selection was made in the 1st selection area in hybrid forms.

Morphological and economic indicators of hybrid parents and the same sex of plants in the selection areas were carefully examined. Relevant phenological observations were also made in this area.

The economic results of growing the Ganja-110 cotton variety and other cotton varieties were found to be consistent with the activities carried out in the field during the growing season.

In the research, the cost items such as seeds, fertilizers, pesticides, fuel, electricity, labor, etc. that can be paid by the farmers as cotton production costs were considered.

Cotton production costs were calculated as 1,140 AZN/ha, and 1 kg of raw cotton was marketed as 0.65 AZN. The yield of the local Ganja-110 cotton variety was determined as 4,380 kg/ha. The net return after growing and harvesting the Ganja-110 cotton variety is AZN 1,707/ha and the profitability level is 150% (Table 9).

Table 9. Average economic results of different cotton varieties

Varieties	Yield (kg/ha) (1)	Production cost (AZN/ha) (*) (2)	Gross return (AZN/ha) (*) (3)	Net return (AZN/ha) (*) (4=3-2)	Comparative net return of varieties (%)	Profitability level (%) (4/2x100)
Ganja-110	4,380	1,140	2,847	1,707	100	150
BA-440	3,300	1,140	2,145	1,005	59	88
Selekt	3,460	1,140	2,249	1,109	65	97
Akala Beret	3,100	1,140	2,015	875	51	76
S-6524	3,620	1,140	2,353	1,213	71	106
Tashauz-68	3,320	1,140	2,158	1,018	60	89

(*) AZN = Azerbaijan Manat, 1 AZN = 0.59 USD
Source: Results of this research.

When the economic results of Ganja-110 cotton variety and different cotton varieties were compared, it was determined that the economic results of other cotton varieties were lower. For this reason, the income increases to be achieved by using the Ganja-110 cotton variety will be more.

CONCLUSIONS

Forms suitable for the soil and climatic conditions of the country were selected from different cotton varieties, with different economic values, with different ecological characteristics according to many biological signs and indicators, evaluated according to their reproductive potential, and these forms were used as a starting point. As a result of the research, it has been determined that the hybrids obtained from the hybridization of locally and different cotton varieties have economically valuable features (high yield, rapid growth, high fiber yield, long fiber, large cones, etc.) and are encouraging to purchase. These are dense type varieties, and they are successful in selection studies.

Among the different cotton varieties studied in the research, local Ganja-110 cotton variety is early (vegetation period 122 days), introduced S-6524, Tashauz-68 medium early (134-136 days), BA-440, Selekt and Akala bere medium-early cotton varieties. It is divided into 3 groups that mature in the late period (138-142 days).

While the raw cotton mass of the Ganja-110 cotton variety is 6.3 g in a boll, the raw cotton mass of the different cotton varieties varies between 5.2-6.0 g in a boll, especially the Selekt and BA-44 cotton varieties, small raw cotton with bolls has a lower mass (5.9-5.4 g, respectively). The varieties BA-440 from Turkey and Selekt from Greece had high fiber yields (40-42%), resulting in higher fiber yields (1,320 and 1,380kg/ha, respectively). Since the Ganja-110 cotton variety is better adapted to the climatic and soil conditions of the country, the economic value characteristics of the variety were higher. The study of the inheritance of trait transfer in hybrids of different cotton varieties showed that the hybrids exhibit different levels of phenotypic dominance depending on the extent to which the traits studied are represented in their parental forms.

Different cotton varieties differ from each other in terms of raw cotton yield, this yield indicator is 4,380kg/ha in Ganja-110 cotton variety, 3,300 kg/ha in BA-440 variety and

3,460kg/ha in Selekt cotton variety. According to the three-year figures, 3,100 kg/ha in the Akala Beret variety, 3,620kg/ha in the S-6524 variety and 3,320kg/ha in the Tashauz-68 cotton variety. It has been determined that Ganja-100 cotton variety, which can achieve higher yields than other varieties, can also obtain higher net returns.

Examination of the level of transgression in second generation (F_2) cotton hybrids showed a negative transgression with respect to vegetation time and a positive violation with respect to cone mass, fiber yield and fiber length. The results of the study show that combinations showing high dominance and heterosis in F_1 lead to positive transgressive traits in F_2. Thus, the study of high dominance and heterosis in F_1 allows to predict the evolution of reproductive efficiency at baseline.

Recombinants of cotton varieties BA-440, Selekt, Akala Beret, S-6524, Tashauz-68 and hybrids of cotton of the second generation (F_2) differ from combinations obtained with Ganja-110 and its participation. These varieties can be used for breeding purposes due to their yield elements. As a result of selection evaluation of hybrids of introduced different cotton varieties, families with complex positive traits because of directional selection (vegetation period 120 days, raw cotton mass in a boll 65-7.0 g, fiber yield 42%, fiber length 36.5 mm) selected and used in breeding practice.

In the light of these results, some suggestions can be made. It is not suitable to plant and grow different cotton varieties in the cotton regions of the country, and as a result, it is not possible to obtain products with high stability. While the cotton varieties are regionalized, the suitability of the cotton growing regions of the republic to the soil and climatic conditions should be investigated.

In Azerbaijan, it is recommended to plant the local Ganja-110 cotton variety, which is more suitable for soil-climatic conditions, and the highly productive BA-440 cotton varieties, which are adapted to these conditions and are more suitable for growing. Since the introduced cotton varieties are selected because of their high fiber yield, their fiber quality that meets the requirements of the textile industry, and their resistance to diseases, pests, and drought, it is appropriate to use them as a starting material in selection.

Increasing genetic diversity in cotton hybrids increases heterosis to some extent. In breeding practice, it is recommended to use hybrids with enhanced heterosis effect obtained from crossbreeding between different cotton varieties.

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