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SUSTAINABLE DEVELOPMENT AND THE BERRY SECTOR IN ROMANIA: LINKING TRADITIONAL PRACTICES TO FOOD SECURITY AND MARKET DYNAMICS

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Abstract

The berry sector in Romania represents a strategic resource for healthy nutrition, food security, and sustainable rural development, contributing to Goal 2 – "Zero Hunger" of the 2030 Agenda. This study aims to evaluate the dynamics of berry production, exports, and imports in Romania, analyzing the economic, social, and ecological impacts, as well as the role of traditional occupations in mountainous areas. Data were collected from official sources, primarily the National Institute of Statistics, including regional production, imports, and exports both within the EU and outside the EU. Statistical indicators such as standard deviation, mean, coefficient of variation, annual growth rate, and CAGR were used for interpretation. A SWOT analysis was applied to identify the strengths and weaknesses, opportunities, and threats of the sector. The results show significant regional variations, with a general national downward trend, but notable increases in the North-East and North-West regions. Romanian exports are concentrated in the EU market, while rising imports reflect domestic demand and limitations in local production. The study highlights the economic potential of the sector, the need for modernizing plantations, and the integration of traditional practices with modern technologies for sustainable development.

Key words: *berries, sustainable development, food security, Goal 2 – Zero Hunger, agricultural production, export, import, traditional occupations*

INTRODUCTION

The concept of sustainable development was internationally established throughthe Brundtland Report [21], where it is defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." This definitione mphasizes the balance between the economic, social, and environmental dimensions of development.

Sustainable Development Goal 2 of the 2030 Agenda – "Zero Hunger" – aims to eradicate hunger, ensure food security, improve nutrition, and promote sustainable agriculture [11]. This goal involves not only increasing agricultural production through modern methods but also leveraging local resources, traditional occupations, and biodiversity as tools for resilience and sustainability [5].

In the mountainous areas of Romania, the collection and utilization of medicinal plants and wild berries are traditional occupations practiced for centuries. These activities:

-contribute to food security by providing natural products rich in vitamins and antioxidants (blueberries, raspberries, rosehips, mint, St. John'swort, etc.);

-provide supplementary income for mountain households, where intensive agriculture is limited by natural conditions;

-support biodiversity and the cultural landscape through sustainable harvesting methods and the perpetuation of local knowledge [3].

The "Zero Hunger" objective is not limited to expanding industrial agricultural production but is directly linked to the protection of natural and cultural heritage and the integration of traditional products into a responsible global market [5].

Berries are a valuable resource for Romania's agricultural economy, generating income for rural households and contributing to exports. Romania produces and exports mainly

blueberries, raspberries, and currants, with a significant expansion of blueberry plantations in recent years, resulting in an increase of over 800% between 2014 and 2022 [7]. Exports are primarily directed to the EU market, but alsoto extra-EU markets, indicating economic development potential [1, 18].

Berry harvesting is a traditional occupation in mountainous and rural areas, providing supplementary income and maintaining local traditions. Harvesting and processing practices (jams, syrups, preserves) are part of the cultural heritage and ensure the continuity of traditional knowledge [10].

Berries grow mainly in mountainous and forested areas, contributing to biodiversity maintenance and soil protection. Sustainable collection and cultivation help prevent ecosystem degradation and support ecological farming practices [16].

Berries play a strategic role in ensuring access to healthy food, being key components of SDG 2 – Zero Hunger. They enable dietary diversification and offer economic opportunities for rural communities, helping to reduce vulnerability to poverty and hunger [5,11].

Globally, Mexico holds the leading position in fresh blackberry production, serving as the main supplier to the United States and European Union markets. In terms of raspberry production, the Russian Federation holds the leading position, with an annual yield exceeding 100,000 tonnes, while Serbia and Poland follow, each surpassing 80,000 tonnes [2]. In northern countries such as Norway, berry cultivation is limited by low temperatures. Nevertheless, in the past decades, Poland, the Netherlands, the United Kingdom, and Belgium have developed raspberry and blackberry production under protected systems (tunnels and plastic greenhouses) to prolong the harvesting season and better satisfy market demand [13, 19]. Furthermore, recent studies indicate that cultivating blackberries within shaded systems associated with productive forestry could generate commercially viable outcomes [6]. In Romania, the blueberry harvest season begins in early June and lasts until September, opening earlier than in several Central and Northern European countries. This provides a seasonal advantage in the regional market, further reinforced by comparatively lower labor costs than in Western Europe [7]. In countries such as Poland, the Netherlands, the United Kingdom, and Belgium, protected cultivation systems (e.g., high tunnels and plastic greenhouses) are widely implemented to extend the production period and enhance yield stability, Romanian production is still largely concentrated in open-field systems, with gradual adoption of modern technologies such as drip irrigation, frost protection, and anti-hail nets. These differences in technological strategies reflect both climatic conditions and the structural characteristics of each national berry sector [14].

This study aims to evaluate and interpret the dynamics of the berry sector in Romania from economic, social, and ecological perspectives of sustainable development. The main objective is to identify the factors influencing the production, export, and import of berries, as well as their role in ensuring food security and promoting traditional occupations in mountainous areas. The analysis is based on official statistical data, specialized literature, and recent studies on market evolution and valorization strategies, providing a framework for reflection on sustainable agricultural policies and local economic development.

MATERIALSAND METHODS

The data used in this study were obtained from official sources, primarily from the National Institute of Statistics of Romania, including databases on the production, imports, and exports of berries. The analysis focused on berry production in Romania and its regions, as well as on the international trade of berries, both within the European Union (intra-EU) and with countries outside the EU (extra-EU).

To interpret the collected data, the following statistical methods were applied:

Time series analysis was used to examine the evolution of berry production, imports, and exports over the analyzed period, calculating annual growth rates and variation ratios.

Calculation of *the growth index* (%) was performed using the formula:

$$I_t = \frac{X_t}{X_{t-1}} \times 100 \quad \text{.....(1)}$$

where:
I_t= growth index for year t,
X_t = indicator value in year t,
X_{t-1} = indicator value in the previous year.
The coefficient of variation (CV) was used to assess the fluctuations in production, imports, and exports, according to the formula:

$$CV=\sigma/\mu \quad \text{.....(2)}$$

where:
σ = standard deviation,
μ= arithmetic mean of the data series.
A CV below 0.2 indicates low variability, and a CV above 0.5 indicates high variability.
The Compound Annual Growth Rate (CAGR) was calculated to analyze the long-term trends in the production, imports, and exports of berries. CAGR is a valuable tool in long-term analysis because it allows for the comparison of growth or decline over different periods, taking into account market or data fluctuations. It is useful for:
-Evaluating investment performance – it provides a clear picture of how an investment or economic sector has developed, such as berry production or trade.
-Estimating long-term growth – based on historical data, it can help forecast the future development of a sector or market.
-Comparing sectors or regions – it allows for the comparison of growth rates across different agricultural sectors or geographic regions.

$$CAGR = \left(\frac{V_f}{V_i}\right)^{\frac{1}{n}} - 1 \quad \text{.....(3)}$$

where:
V_f= the final value of the indicator,
V_i = theinitialvalue of the indicator,
n = thenumber of yearsunderreview.
The *SWOT analysis* was applied to provide a clear overview of Romania's berry sector, highlighting its strengths and weaknesses, as well as existing opportunities and threats. This approach enables a comprehensive assessment of the internal and external factors influencing production and market dynamics, offering a valuable tool for strategic planning and decision-making.

RESULTS AND DISCUSSIONS

Berries play a strategic role in Romania, contributing both to healthy nutrition and food security. Cultivated or wild-harvested species – such as blueberries, raspberries, and currants – provide vitamins and antioxidants, being essential foods for preventing malnutrition and diversifying the diet, in line with Sustainable Development Goal 2 – "Zero Hunger" of the 2030 Agenda. The analysis of berry production in Romania for the period 2014–2023 reveals contrasting trends between the national level and the development regions. Table 1, which present sstatistical indicators such as standard deviation, mean, coefficient of variation, and compound annual growth rate (CAGR), highlights both notable fluctuations and an overall declining trend.
At the national level, average annual production reached 2,495 tons, accompanied by a standard deviation of 876 tonsand a coefficient of variation of 0.35, suggesting moderate variability between years. Nevertheless, the compound annual growth rate of –9.67% confirms a pronounced downward trajectory. This decline can be associated with factors such as aging plantations, low yields, lack of modern infrastructure (storage facilities, irrigation), and the impact of climate change on crops [20].
Regional disparities are notable:
-The North-East has the highest average production (822 t/year), with an almost negligible decline (–0.63%), suggesting a relatively stable core of the sector.
-The North-West remains significant (547 t/year), with a moderate decrease (–4.04%).
-The Center, South-East, South-Muntenia, and Oltenia show dramatic declines (between –17% and –21% annually), accompanied by high variability, reflecting unstable and vulnerable production.
-Bucharest–Ilfov and the West have almost disappeared from statistics (CAGR –100%), suggesting abandonment or insignificance of cultivated areas.

Table1. Berry production in Romania, total and by region

Specification	Standard deviation	Mean	Coefficient of variation (%)	Annual growth rate (%)
TOTAL	876.22	2495.13	0.35	-9.67
NORTH-WEST	184.85	546.99	0.34	-4.04
CENTER	149.37	249.04	0.60	-18.76
NORTH-EAST	245.48	821.99	0.30	-0.63
SOUTH-EAST	153.36	251	0.61	-21.17
SOUTH-MUNTENIA	184.07	353.89	0.52	-20.11
BUCHAREST-ILFOV	24.29	18.88	1.29	-100.00
SOUTH-WEST OLTENIA	149.39	241.99	0.62	-17.19
WEST	16.19	11.33	1.43	-100.00

Source: own calculations based on data collected from www.insse.ro [9].

Table 2. Exports of berries from Romania

Category	Standard deviation	Mean	Coefficient of variation (%)	Annual growth rate (%)
Total	11.24	20.9	0.54	11.6
Intra-UE	8.41	18.2	0.46	10.7
Extra-UE	2.77	2.3	1.20	17.3

Source: Own calculations based on data collected from www.insse.ro [9].

Table 2 provides a synthetic overview of Romanian berry exports, based on four indicators: standard deviation, mean, coefficient of variation, and annual growth rate. These indicators allow for the evaluation of stability, volatility, and growth trends in exports.

The average exports (20.88) indicate a significant share of berries in Romanian agri-food trade, while the standard deviation of 11.24 highlights large annual variations, driven by seasonality and climatic conditions [15]. The coefficient of variation of 0.54 shows moderate-to-high variability, signaling structural instability. However, the annual growth rate of 11.64% confirms an upward trend in exports, aligned with the increasing demand for berries within the EU and international markets [4].

The average level of intra-EU exports (18.2) shows that the majority of Romanian berries are directed toward the European market, which ensures a relatively stable outlet [18]. The comparatively low standard deviation (8.41) and coefficient of variation (0.46) indicate greater predictability within the European market than in total exports. The annual growth rate of 10.74% indicates sustainable, though more moderate, growth compared to extra-EU markets, where there is still room for expansion. The average extra-EU exports (2.3) are muchlower, indicating a marginal role of these markets for Romanian producers.

The high coefficient of variation (1.20) highlights significant volatility and an opportunistic character of exports to non-EU markets. Nevertheless, the annual growth rate of 17.25% shows high potential for market diversification, especially toward the Middle East and Asia, where there is demand for premium berries [15].

Concentration of exports in the EU market provides short-term stability but limits diversification and exposes Romania to regional competition [4]. Rapid expansion into extra-EU markets could be an effective strategy for growth and risk reduction but requires investment in infrastructure, international certifications, and branding [8]. Overall export volatility indicates the sector's vulnerability to exogenous factors, such as climatic conditions and price fluctuations [17].

Table 3. Imports of Berries in Romania

Category	Standard deviation	Mean	Coefficient of variation	Annual growth rate (%)
Total	34.3	39.9	0.86	36.49
Intra-UE	29.6	33.2	0.89	36.62
Extra-UE	4.9	6.8	0.71	35.82

Source: Own calculations based on data collected from www.insse.ro [9]

The data presented in Table 3 highlight several important characteristics regarding the dynamics of berry imports in Romania. The overall mean of 39.96, accompanied by a high standard deviation (34.32) and a coefficient of variation of 0.86, suggests that the market is characterized by pronounced volatility and a lack of medium-termstability. The same trend is observed for intra-EU imports, where a mean of 33.15 and a coefficient of variation of 0.89 indicate significant dependence on European trade partners, as well as increased vulnerability to fluctuations in production and prices within the common market.

In contrast, imports from extra-EU countries, although much smaller in volume (mean of 6.85), exhibit a lower standard deviation (4.89) and a coefficient of variation of 0.71, reflecting a more stable trend and serving as a diversification of supply sources. This relative stability is important in the context of risks associated with seasonality and variability in European production.

Another remarkable aspect is the high annual growth rate, both for intra-EU imports (36.62%) and extra-EU imports (35.82%), confirming an accelerated trend in Romania's dependence on external sources of berries. This dynamic can be explained by rising domestic demand, driven by changing consumer preferences toward healthy products [15], the development of the HoReCa industry and the processing sector, as well as the insufficiency of domestic production, affected by farm fragmentation and technological limitations [8].

In conclusion, the analysis highlights Romania's increasing dependence on berry imports, especially from the European area, while also exhibiting high volatility that implies economic and commercial risks. Additionally, the diversification of extra-EU sources contributes to relative stability but does not offset the general upward trend in imports. This situation underscores the need for agricultural and trade policies aimed at stimulating domestic production and reducing vulnerabilities in the external market.

SWOT Analysis

Strengths

Favorable climate andbiodiversity

Romania benefits from favorable climatic and pedoclimatic conditions for berry cultivation, especially in mountainous and forested regions. This ecological diversity allows for both commercial production and the maintenance of wild-harvested berries, contributing to biodiversity conservation and supporting local ecosystems [16].

Seasonal window

Romania's harvest window, from early June through September for blueberries, is earlier than that of some Central and Northern European countries, providing a competitive seasonal advantage. Labour costs are also generally lower compared to Western EU countries [7].

Significant increase in cultivated areas

Between 2014 and 2022, the area planted with berry crops grew from approximately 470 hectares to over 1,700 hectares, an expansion of more than 250%. This reflects growing interest among producers and the economic potential of the sector [18].

Traditionand local knowledge

Berry harvesting and processing are traditional occupations passed down through generations in mountainous and rural areas. These practices preserve local traditions and support sustainable rural development through ecological harvesting methods and utilization of local natural resources [3].

European financial support

Berry producers have access to EU funds that facilitate plantation modernization, development of processing and storage infrastructure, and implementation of modern technologies. This support enhances competitiveness and integration of Romanian production into European and international markets [8].

Weaknesses

Unstable and low production

The average annual production of berries is approximately 2,495 tonnes, with a negative average annual growth rate of –9.67%, indicating structural decline and medium-term instability.

Lack of modern infrastructure

Many plantations face deficiencies in cold storage, irrigation, and mechanized harvesting

equipment, limiting yields and product quality [20].

Fragmentation of farms

The sector is dominated by small and semi-subsistence farms, reducing efficiency and competitiveness [12].

Variable product quality

Products may exhibit significant quality differences between seasons and regions, affecting uniformity and appeal on external markets.

Opportunities

Growing demand on external markets

Romanian berry exports have an annual growth rate of 11.64%, with opportunities to expand to extra-EU markets, including the Middle East and Asia, where demand for premium products is high [18].

Product diversification and added value

There is potential for developing processed products such as jams, juices, frozen berries, or organic products, increasing added value and profitability.

Agrotourism and ecological tourism

Promoting eco-tourism and berry-picking experiences can generate additional income and support environmental conservation.

Implementation of modern technologies

Optical sorting, packaging, and mechanized harvesting technologies can increase productivity and quality while reducing post-harvest losses.

Threats

Climate change and extreme events

Droughts, late frosts, or excessive rainfall negatively affect production and may cause significant losses.

International competition

Countries such as Poland, Serbia, and Hungary produce berries at large scale and lower costs, potentially affecting Romania's competitiveness on external markets.

Price and demand fluctuations

Market volatility, driven by seasonality and international demand, may impact local producers' revenues.

Lack of qualified personnel

Shortages of seasonal workers and lack of specialized training can limit harvesting and processing efficiency [17].

CONCLUSIONS

Berries play a strategic role in Romania, contributing to healthy nutrition, food security, and the economic development of rural communities, in alignment with Sustainable Development Goal 2 – "Zero Hunger" of the 2030 Agenda.

The analysis of production (2014–2023) shows a structural decline at the national level (CAGR –9.67%), with significant regional variations. The North-East and North-West regions remain relatively stable, while the southern regions and Bucharest–Ilfov experience dramatic decreases.

Berry exports have recorded sustained growth (11.64% annually), primarily concentrated on the EU market, with potential for expansion to extra-EU markets, where high volatility is observed alongside opportunities for market diversification.

Imports are increasing rapidly (over 36% annually), indicating a growing dependence on external sources, driven by rising domestic demand and insufficient internal production, affected by farm fragmentation and technological limitations.

The SWOT analysis highlights strengths such as favorable climate, biodiversity, local tradition, and access to European funds; weaknesses include unstable production, insufficient infrastructure, and fragmented farms; opportunities include increasing external demand, product diversification, agrotourism, and modern technologies; threats comprise climate change, international competition, price fluctuations, and shortages of qualified personnel.

To strengthen the sector and reduce import dependence, public policies are needed to support plantation modernization, increase domestic production, promote traditional products, and integrate modern technologies.

Overall, Romania's berry sector presents significant economic potential, but long-term success depends on balancing domestic production with international demand and adapting to climatic and technological challenges.

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