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THE QUALITY STATISTICAL EVALUATION OF BAKERY FUNCTIONAL PRODUCTS FROM DIFFERENT CEREALS FLOURS MIXTURES, WITH A HIGH CONTENT OF β-GLUCANS

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Abstract

The aim of this research was the statistical evaluation of the effect of fibers rich flours addition, namely oat, barley and millet flours, in wheat flour (15% and 30%), on the dough technological parameters, as well as on the main bread quality parameters. In this regard, there have been analyzed: flours technological water absorption, dough pH after kneading, pH after fermentation, temperature after kneading, temperature after fermentation. The quality bread analyzes were: pH, moisture, porosity and volume. The results showed that water absorption increase extremely significant in oat and barley (30%) bread. Temperatures after kneading increased, especially in millet bread. Kneading and fermentation determined significant decreases of fibers rich dough pH. The Spearman correlation between the dough technological parameters (n=7) showed that the temperature after kneading correlated negative significant with pH after kneading (r=-0.821). An extremely significant positive correlation has been established between dough pH after kneading and dough pH after fermentation (r=0.955***). Water absorption influenced bread moisture by 49% (r^2=0.49). Bread with 30% millet flour, showed a significant increased porosity, against wheat bread (t=3,531*). The increase of water absorption decreased the porosity by 44% (r^2=0.44) and the increase of temperature after kneading influenced the porosity increase by 51%. Flours pH (r^2=0.41) and bread moisture (r^2=0.41) influenced most bread pH. Bread volume did not correlate with any parameter. Functional bakery products with added fibers and increased content of vitamins, proteins and minerals, from oat, barley, and millet, help to maintain the consumers health.*

Key words: *barley and oat flours, β-glucans, functional bakery products, technological and quality parameters, wheat and millet flours*

INTRODUCTION

Consumption of products derived from cereals, mainly bread, dates back more than 12,000 years, being synchronous with the beginnings of agriculture. The prevalence of these products in human food is overwhelming in most cultures, in warm and temperate areas. Thus, cereals cultivation and processing is the basis of a global economy, estimated at about 8 trillion US dollars in 2016 [13]. More and more competitive technologies, as well as the global competition, have lowered companies profit rates on classical product segments (cereals flours, usual bakery products, breakfast cereals etc.). At this point, most companies in these industries are oriented towards gaining added value, by creating and delivering functional food.

Functional food includes a range of biochemical components (especially fibers and antioxidants) associated with a number of benefits, like maintaining health and protection against diseases such as: cancer, cardiovascular and degenerative diseases [2, 4, 5, 12, 14]. Due to a large-scale consumption in society, cereals products can be the most important vectors for the dissemination of these biochemical components, namely active principles [16, 24]. Moreover, cereals products are food systems that preserve the nature and chemical-physical properties of these active principles. There is an impressive number of studies on the positive effect of β-glucans in diets, on the proper functioning of the immune system or the cardiovascular and digestive system [5, 6, 9, 10, 21]. The mechanisms by which these compounds positively influence the state of health are based on the reduction of serum and plasma cholesterol [1, 11] or on the reduction of postprandial glycemic response [3, 17, 22].

β-glucans are polycarbohydrates constituents of the cell walls in the aleuronic layer or cereal endosperm. Concerning the structure, these ones are polymers formed by glucose molecules, 70% joined by β-(1-4) glycosidic bonds and 30% by β-(1-3) glycosidic bonds [8]. The largest amounts of β-glucans are found in barley (3-11%) and oat (3-7%). For rye and wheat the values reported in the literature are significantly lower (1-2%) [5, 23].

The purpose of the paper and related research was the statistical evaluation of the effect of oat, barley and millet flours addition in wheat flour, on **dough technological parameters** obtained from mixtures of flours, as well as on the main **bread quality parameters** obtained from mixtures of flours dough.

MATERIALS AND METHODS

To carry out the research, the following assortments of flours were used:

- **dark wheat flour**, with a natural high content of protein (no gluten added), produced by Farinsan SA, from harvest 2016, having the following features: pH 6.543±0.040, moisture (%) 13.950±0.050; ash content (%) 0.993±0.030; protein content (%) 17.567±0.058; wet gluten (%) 42.400±0.529; gluten index 89.660±2.081; falling number 421.667±7.637 [19];
- **whole oat flour** standardized, purchased from SC Cope SA Piatra Neamt, having the following features: pH 6.320±0.020, moisture (%) 10.263±0.032, ash content (%) 1.420±0.050, protein content (%) 11.000±0.125, fibres content (%) 4, carbohydrates content (%) 66, lipid content (%) 8, falling number 733.000±6.083, granulation characterized by an average particle size of less than 500 µ for 97% of the particles, the remaining 3% having dimensions between 500 and 1,000 µm;
- **whole barley flour** from the stone mill (according to the producer, Solaris Plant S.R.L.), having the following features: pH 5.513±0.023, moisture (%) 10.200±0.020, ash content (%) 1.000±0.025, protein content (%) 10.700±0.100, falling number 388.667±5.131) [19];
- **whole millet flour** from the stone mill (according to the producer, Solaris Plant S.R.L.), having the following features: pH 6.483±0.021, moisture (%) 10.250±0.026, ash content (%) 0.643±0.045, protein content (%) 10.500±0.135, falling number 326.667±5.773) [19].

The percentages of the flours mixtures (the tested variants) for dough preparation, as well as the performed analyzes are outlined in Table 1.

The tests were performed in trplicates (n=3), taking into account as representative, the mean values of replicates, after statistical evaluation.

Table 1. Experimental plan

No. of variant	Wheat flour (%)	Oat flour (%)	Barley flour (%)	Millet flour (%)
Control	**100**	0	0	0
1	85	15	0	0
2	70	30	0	0
3	85	0	15	0
4	70	0	30	0
5	85	0	0	15
6	70	0	0	30
Performed analyses				
Dough (obtained by the method of performing the baking test): pH after kneading, pH after fermentation, temperature after kneading, temperature after fermentation, technological water absorption **Bread** (2 hours after being removed from the oven): pH, moisture, volume, porosity.				

In order to obtain the finished bakery products, bread respectively, were followed the recipes and methodology presented in Table 2.

The analyzes were performed using the methods described below.

Moisture determination. Moisture M% was determined on crumb samples, from the center of bread, using the thermobalance Precisa XM 60.

pH determination. pH was determined using Serna-Saldivar method (2012), as follows: extraction of 10 g bread sample in 100 ml of distilled water for ½ hour [15]. Measurement was performed with a pH-meter Testo 206 pH1, after filtering the extract. Determination of dough pH was done directly in dough, using a Testo 206 penetration probe pH meter.

Table 2. The recipes and technological process used for baking tests

No. of variant	Wheat flour (g)	Oat flour (g)	Barley flour (g)	Millet flour (g)
Control	1,500	0	0	0
1	1,275	225	0	0
2	1,050	450	0	0
3	1,275	0	225	0
4	1,050	0	450	0
5	1,275	0	0	225
6	1,050	0	0	450
Recipe and technology				
Recipe: **37.5 g** dry yeast Pakmaya **22.5 g salt** **water** - variable, depending on technological water absorption%, in order to obtain a dough of normal consistency **4.5 g baking conditioner** - Pan Up T-Max (Orkla manufacturer; ingredients: wheat flour, antioxidant E300; enzymes - xylanase, lipase, amylase, oxidase, cellulase; dextrose). **Technology:** **kneading**: 12 minutes on a single-speed mixer (100 rpm) with fork stirring arm; **dough resting**: 10 min; **partition**, 355-365 g; **round modeling**; **rest**: 5 min; **long modeling**; **fermentation** under controlled conditions: 45 min at 37^{0}C, 78% humidity; **baking**: 220^{0} C for 20 minutes				

The bread mass was determined by weighing it to a technical balance (the determination of the weight of the bread is necessary to calculate the porosity).

Determination of crumb porosity was performed using the weighing method, described by STAS 91/1983. The method is based on the relationship between weight and volume of the sample [20].

Determination of bread volume was performed by gravimetric method described by STAS 91/1983, using rape seeds of known volumetric density, in order to determine the volume of bread displaced there from. The density used to determine the bread volume was 0.676 g/cm^3.

Interpretation and results processing techniques. Interpretation of results was performed using computer-assisted statistical analysis techniques. Microsoft Excel program have been used to run graphics, media and dispersion calculations. The significance of mean differences t test was performed using the QuickCalcs online software from GraphPad, Software, based on the probability of transgression: *significant p<0.05; **very significant p<0.01 and ***extremely significant p<0.001 [7, 18, 25].

RESULTS AND DISCUSSIONS

a. Technological parameters of dough

The baking tests were performed and the technological parameters were measured during the respective technological phases. The technological parameters of dough, prepared from wheat flour and mixtures of wheat, oat, barley and millet flours are presented in Table 3 (n = 3).

Dough technological water absorption. The dough technological water absorption varied significantly, depending on the flour used. Generally, the flours enriched in fibers (oat, barley) led to an increase of dough water absorption, relative to control flour.

The increase was insignificant for variants that involved the addition of 15% of β-glucans rich flours, to control flour (t=2.343 for oat and t=0 for barley flour). The addition of larger amounts, had significant growth effects on the technological water absorption.

Thus, in the case of 30% whole oat flour addition, the technological water absorption increased very significant, with 3.333 ml/100 g of dough (t=5.574**).

In the case of 30% barley flour addition, the water absorption increased extremely significant, with 6.667 ml/100 g of dough, (t=9.17***).

In the case of 30% barley flour addition, the water absorption increased extremely significant, with 6.667 ml/100 g of dough, (t=9.17***). In the case of millet flour, the addition of a smaller amount (15%), resulted in a very significant decrease of the water absorption (-2.333 ml/100 g, t=5.293**). The addition of 30% millet flour resulted in a very significant increase of dough water absorption, compared to the 15% variant (+ 2.9 ml/100 g, t=5.705**), to a level corresponding to that of the control (60.567, t=1.18 ns).

Table 3. Technological parameters of dough

Parameter/ Flour assortment	**Technological water absorption WA (%)**	**Dough temperature (^{0}C)**	**Dough pH**	**Dough temperature (^{0}C)**	**Dough pH**
		after kneading		**after fermentation**	
Wheat	60.000±0.500	21.400±0.529	6.030±0.010	27.767±0.252	5.57±0.01
Wheat-Oat (85:15)	61.033±0.577	23.400±0.200	5.870±0.010	27.800±0.200	5.56±0.005
Wheat-Oat (70:30)	63.333±0.907	22.400±0.529	5.980±0.020	28.333±0.503	5.57±0.01
Wheat- Barley (85:15)	60.000±0.500	25.100±0.854	5.720±0.010	29.877±0.759	5.37±0.006
Wheat- Barley (70:30)	66.667±1.155	26.500±0.500	5.600±0.050	27.267±0.305	5.36±0.006
Wheat-Millet (85:15)	57.667±0.577	26.600±0.360	5.723±0.025	29.067±0.513	5.49±0.006
Wheat-Millet (70:30)	60.567±0.665	27.467±0.450	5.673±0.011	30.100±0.361	5.48±0.006

Dough temperature after kneading and fermentation. The dough temperature after the kneading phase, naturally depended on the temperature of the added ingredients, especially the temperature of the water used. The dough temperature after kneading increased significantly from 21.40° C for the control samples to 26-27° C for the wheat-millet flour samples (extremely significant variation t=14.07*** for 15% and t=15.13*** for 30%).

The dough temperature after fermentation increased extremely significant from 27° C in the control samples to 30° C in the case of 30% millet flour (t=9.17***).

Dough pH after kneading and fermentation. The dough pH after kneading, fell significant from oat, to barley and millet, regardless of the variant (t ranged from 3.87* for 30% oat, up to 41.59*** on addition of 30% millet).

The effects of fermentation and the accumulation of lactic acid in dough, were visible in the pH decrease at the end of the fermentation, as compared to the end of the kneading phase. The highest decrease in pH was observed in control samples (-0.46), followed by mixtures with oat flour (-0.31 for the 15% variant and -0.41 for the 30% variant), barley flour (-0.35 and -0.24, respectively) and millet flour (-0.23 and -0.19, respectively). The lowest dough pH values at the end of fermentation, were observed in the case of barley flour (5.36-5.37) and millet flour addition (5.49).

Practically, the dough prepared from flours mixtures with barley and millet, had after fermentation an extremely significant lower pH value, compared to the control (from t=30.74***, 30% barley to t=11.88***, 15 % millet).

Table 4 shows the Spearman correlations coefficients between the temperature after kneading, the temperature after fermentation and the pH of dough obtained from all the analyzed flours, namely wheat flour and six mixtures of flours (n=7).

Interestingly, no significant correlations (r=0.536; p=0.215 ns) were observed between the temperature after kneading and the temperature after fermentation. Since all samples were fermented under identical conditions (37 ° C, 78% relative humidity for 45 minutes) and the initial temperatures varied significantly from one sample to another, the lack of a significant correlation between the two temperatures could be an argument for the existence of different thermal conductivity of the dough, depending on the quantities and nature of the ingredients used.

This is a hypothesis to be tested in another experiment.

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Table 4. The Spearman correlation coefficients between the technological parameters of dough

Parameter		Flours pH	Temperature after kneading	Temperature after fermentation	pH after kneading	pH after fermentation
Flours pH	r	1.000				
	p	-				
Temperature after kneading	r	-0.571	1.000			
	p	0.180	-			
Temperature after fermentation	r	-0.143	0.536	1.000		
	p	0.760	0.215	-		
pH after kneading	r	0.571	**-0.821****	-0.214	1.000	
	p	0.180	**0.023**	0.645	-	
pH after fermentation	r	0.595	-0.703	-0.144	**0.955*******	1.000
	P	0.159	0.078	0.758	**0.001**	-

r - correlation coefficient; p - the probability

Table 4 shows that the dough temperature after kneading, significantly influenced the pH parameter, determined at the end of the phase. Thus, in warmer dough, acidification of pH (r= - 0.821*) was observed. There were no significant correlations between the analyzed parameters and the dough temperature at the end of the fermentation stage.

It was noted that the dough pH after kneading was not dependent on the initial pH value of the flour mixtures (r=0.571). Also, dough pH value after fermentation increased extremely significant, as pH value after kneading was higher (r=0.955***).

b. Quality parameters of finished bakery products

The main quality characteristics of bread obtained from the control flour and the flours mixtures, after the baking tests, are shown in Table 5 (n=3).

Table 5. Quality parameters of bread made from wheat flour and mixtures of flours

Parameter/ Flour assortment	Wheat	Wheat-oat		Wheat-barley		Wheat-Millet	
	100	**85:15**	**70:30**	**85:15**	**70:30**	**85:15**	**70:30**
Moisture (%)	44.863 ± 0.158	44.613 ± 0.180	45.110 ± 0.100	45.033 ± 0.950	45.600 ± 0.100	42.630 ± 0.402	43.160 ± 0.153
pH	6.220 ± 0.020	6.120 ± 0.010	6.120 ± 0.072	5.993 ± 0.025	5.950 ± 0.010	6.000 ± 0.100	5.923 ± 0.025
Volume (cm^3/g)	4.686 ± 0.080	4.140 ± 0.075	3.663 ± 0.165	3.820 ± 0.140	3.710 ± 0.210	4.010 ± 0.150	4.377 ± 0.040
Porosity (%)	79.050 ± 1.767	77.792 ± 3.321	75.493 ± 1.413	80.907 ± 0.907	77.933 ± 0.777	80.937 ± 0.645	82.907 ± 0.676

Moisture of finished products. The moisture content of wheat flour bread was not significantly different from that of wheat-oat bread, regardless of the variant (t=1,808 for 15% variant and t=2,280 for 30% variant). The moisture increase was also insignificant for the variant with 15% whole barley flour (t=0.305). In the case of bread with 30% whole barley flour, moisture increased very significant, compared the control, from 44.86% to 45.6% (t=6.827**). The millet flour bread had extremely significant lower moisture than the control sample: 42.63% on 15% millet flour bread (t=8.954***), respectively 43.16% on 30% millet flour bread (t=13 414***). The increase in whole flours content resulted in a significant increase in bread moisture, between the two variants with whole oat flour (15% vs. 30%), from 44.61% to 45.11% (t=4.180*). There were no significant bread moisture differences between the two variants (15% vs. 30%) of barley or millet flours addition.

pH of finished products. All products made from mixtures of wheat flour with whole cereals flours, had a significantly lower pH than the control sample (wheat bread). The pH decrease was very significant in the 30% millet flour sample (5.923; t=16.068***).

The closest pH to that of control sample was observed in the case of loaves with whole oat addition (6.12; t=7.746**), although the differences were however very significant.

Barley addition bread had a pH of 5.95 (variant 30%, t=20.914***) and 5.993 (variant with 15%, t=20.914***), being extremely significant lower than the control. The increase of whole flours addition in the flour mixtures, did not result in significant changes in bread pH, between the tested variants (15% vs. 30%), no matter the cereal assortment used (t=0-2,77 ns).

Volume of bread. It can be seen that the volume of whole flours loaves decreased significantly compared to the bread made from wheat flour.

The highest volume decrease was observed in whole barley loaves (-0, 87 ml/g at 15%, t=9.302*** extremely significant, and -0.98 ml/g at 30%, t=7.522** very significant) and whole oat loaves (extremely significant in both variants: -0.55 ml/g for 15% variant t=8.624*** and -1.02 ml/g for 30% variant, t=9.663***).

The millet flour bread samples had the closest volumes to bread made from wheat flour, however the differences were very significant. Thus, the decrease was -0.68 ml/g for the variant with 15% millet flour (t=6.887**) and -0.31 ml/g for the variant with 30% millet flour (t=5.984**).

At the same time, the increase of the whole flours amount in bread, resulted in a significant decrease of bread volume between variants. For example, in wheat-oat flour bread, 15% vs. 30%, the volume decreased significantly with -0.48 ml/g, t=4.558*.

In barley flour bread, no significant different volumes were recorded, between the variants (15% vs. 30% decrease of -0.11 ml/g, t=0.755 ns). In the case of millet flour bread volume, the 30% variant was even significant higher than the 15% variant (+0.37 ml/g; t=4.094*), unlike the whole oat and barley loafes.

Porosity of bread. Although decreases in whole oat and barley bread porosity were observed, compared to the porosity of the control sample, these decreases were not statistically significant (t=0.579-2.723).

The only significant difference, from the porosity of the control sample, was observed in the case of 30% whole millet flour bread (+3.86%, t=3.531*).

No significant porosity differences were found between variants, in whole oat bread (15% vs. 30%, t=-1.129 ns).

On the other hand, in the case of barley loafes, the difference between the porosity of the two variants was significant, in the sense of its value decreased, as the total barley flour increased (t=-4.313*).

In millet flour bread, a significant increase of porosity was recorded in 30% variant, versus 15% variant (t=+3,650*).

The overall appearance of finished products, as well as sectional layouts are shown in Fig. 1 and Fig.2.

Finished products of wheat flour

Finished products of 85% wheat flour +15% whole oat flour

Fig. 1. General appearance and sectional layouts of loaves made of wheat flour and mixture of wheat and 15% oat flour

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Finished products of 70% wheat flour +30% whole oat flour

Finished products of 85% wheat flour +15% whole barley flour

Finished products from wheat flour 70% + 30% whole barley flour

Finished products from wheat flour 85% + 15% whole millet flour

Finished products from wheat flour 70% + 30% whole millet flour

Fig. 2. General appearance and sectional layouts of loaves made of wheat flour mixtures with oat, barley and millet flours, in different proportions

Table 6 presents the main nonparametric correlations (Spearman) between the bread quality parameters, physical-chemical and technological parameters of dough (n=7).

From Table 6 we can see that the **moisture of the bread** was even higher, as the water absorption of the flour from which it came, was higher, without reaching the significance limit (r=0.703). This may be an indicator that flours with a higher water retention capacity, due to their higher fibers content, transfer to some extent this feature to finished products.

The **bread volume** did not significantly correlate with any technological parameters, however, it was most strongly influenced by the flours pH (t=0.643) and the bread moisture (t=-0.643).

As expected, the bread pH was extremely significant correlated with the dough pH, at the end of the kneading operation (r=0.955***) and significant after the fermentation (r=0.864*).

Table 6. Spearman correlations between bread quality parameters and technological parameters of flours and dough

Speci-ficații		WA (%)	T^0 after kneading (^{0}C)	Flours pH	pH after kneading	T^0 after fermentation (^{0}C)	pH after fermentation	Bread moisture (%)	Bread volume (cm^3/g)	Bread pH	Bread porosity (%)
Bread moisture (%))	r	0.703	-0.429	-0.071	-0.107	-0.536	-0.180	1.000	-0.643	0.018	-0.643
	p	0.078	0.337	0.879	0.819	0.215	0.699	.	0.119	0.969	0.119
Bread volume (cm^3/g)	r	-0.505	0.000	0.643	0.250	0.107	0.252	-0.643	1.000	0.180	0.500
	p	0.248	1.000	0.119	0.589	0.819	0.585	0.119	.	0.699	0.253
Bread pH	r	-0.164	**-0.883****	0.505	**0.955*****	-0.450	**0.864***	0.018	0.180	1.000	-0.559
	p	0.726	**0.008**	0.248	**0.001**	0.310	**0.012**	0.969	0.699	.	0.192
Bread porosity (%)	r	-0.667	0.714	-0.214	-0.429	0.643	-0.414	-0.643	0.500	-0.559	1.000
	p	0.102	0.071	0.645	0.337	0.119	0.355	0.119	0.253	0.192	.

The initial pH of flours mixtures did not contribute significant to the final pH of the bread (r=0.505). Of the technological parameters, the greatest influence on the bread pH had the dough temperature at the end of the kneading phase. The higher the dough temperature at the end of the kneading phase, the lower was the bread pH, establishing a very significant negative correlation (r=-0.883**).

The porosity of the bread crumb did not established significant correlations with the other parameters, however it is disadvantaged by the increase of the water absorption of the flours from which bread was prepared (t=-0.667). The possible explanation is an indirect effect of the increase of fibers content in the flours, as the water absorption increased. Basically, the lower porosity of the bread was due to the mechanical destabilization of the gluten films in dough, because they are involved in gases retention and formation of the crumb structure. The increase in porosity was favored by the increase in temperature after kneading (t=0.714), due to increased activity of yeast and higher gases release.

CONCLUSIONS

It was recorded a significant increase of technological water absorption in dough from fibers-rich flours (with 30% oat and barley), compared to the control (p<0.05). Millet flour, less fibers-rich, reduced the water absorption of wheat flour at 15% addition, not modifying it at 30% addition. Dough temperatures after kneading have progressively increased from 15% to 30% of whole cereals addition. The highest increases in the dough fermentation temperature were recorded in the case of millet flour addition. The kneading and fermentation operations resulted in significant pH decreases, due to the effect of the accumulation of lactic acid in dough. After kneading the dough pH dropped in order, to oat, barley and millet mixtures. The pH after fermentation decreased even more drastically, compared to the control and to the pH measured after kneading.

The Spearman correlations, performed on the 7 assortments of investigated flours, indicated that the temperatures after kneading and fermentation did not correlate with each other, as we would have expected. It had been observed that the temperature after kneading, significantly decreased the dough pH after kneading (p<0.05). An extremely significant positive correlation had been established between dough pH after kneading and dough pH after maturation (p<0.001). The addition of β-glucan rich whole flours (30% barley) significantly increased the moisture content of finished products, due to the fibers ability to absorb important amounts of water (p<0.05). The moisture content of the finished products decreased significantly on the addition of millet flour, regardless of the variant (p<0.05). The technological water absorption of the flours influenced the moisture content by 49% (r^2=0.49). The finished products with whole flours additions (oat, barley, millet) were more acidic than wheat bread. Extremely significant decreases were observed in bread with barley flour (15% and 30%) addition and in bread with millet flour (30%) addition (p<0.001).

Significant decreases in the volume of bread were observed in oat and barley variants, especially in 30% additions ($p<0.05$), but also with the addition of millet flour. Existing fibers in these flours caused damages to gluten films that retain fermentation gases, and therefore the volume of retained gases was lower.

The porosities of the finished products were similar, statistically speaking, excepting the bread with millet flour 30%, which showed a significantly increased porosity ($p<0.05$), compared to the control bread, prepared exclusively from wheat flour. Porosity varied between bread variants with 15% or 30% barley, being significant lower, as barley flour was added.

Correlations between dough technological parameters and bread quality parameters showed that bread pH correlated positive extremely significant with dough pH after kneading ($p<0.001$) and only significant with dough pH after fermentation ($p<0.05$). It was found that the higher the dough temperature after kneading was, the lower bread pH was, establishing a very significant negative correlation ($p<0.01$).

The volume of bread was not significantly correlated with any other parameter, but the parameters that most influenced the pH were the pH of the flours ($r^2=0.41$) and the bread moisture ($r^2=0.41$).

The increase of the flours water absorption influenced the decreased of the bred porosity value by 44% ($r^2=0.44$). The increase in bread porosity was also determined by the increase of the temperature after kneading, by almost 51%, as the fermentation gases were released.

In terms of consumers purchase criteria for the bread acquisition (volume, porosity), rich fibers products (up to 30%) had almost a similar appearance like wheat bread. The addition of fibers, as well as the high content of vitamins, proteins and minerals, from barley, oat, millet, is a major gain for health, as this type of bakery products are functional products.

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