## Correlations between chemical and certain rheological quality parameters of wheat flour and bread

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The aim of this research was to determine existence of the correlation between chemical and certain rheological quality parameters of different wheat flour samples and quality of bread produced from them. Three samples of wheat flour type 500, which were produced as experimental samples in industrial conditions, were analyzed. The analysis of chemical composition (content of water, ash, ash on dry matter, fat, protein, starch) and farinograph parameters (farinograph water absorption, dough development time, stability of dough, softening degree of dough, quality number, quality group) of experimental samples of wheat flour has been conducted. These analyzed flour samples were used for bread production. Also, quality parameters of three produced bread samples were analyzed (volume of bread, mass of bread, overall sensory quality of bread). After that, the existence of the correlation between analyzed parameters has been examined and found as very important correlation between farinograph water absorption (FWA) and parameters of chemical composition: water content (p<0.05), fat content (p<0.05), protein content (p<0.05) and starch content (p<0.05). Also, a significant impact and positive correlation between the protein content and farinograph water absorption (FWA) on bread volume (p<0.05) has been found.

## INTRODUCTION

Bread has been a fundamental food product for many civilizations. Even today, bread and cereal-based products, in general, constitute the base of the food pyramid, and their consumption is highly recommended in all dietary guidelines (Rosell, 2011). Bread has an important role in human nutrition because it contains numerous important nutritional ingredients, providing a positive effect on human health (Dewettinck, 2008). It is produced through baking dough made of flour, water, salt and other ingredients. The global concept of bread quality could be integrated by instrumental attributes (objectively measured), sensory attributes (based on the analysis of quality parameters) and nutritional attributes (functionality and nutritive composition) (Rosell, 2011).

Wheat flour can be considered as a complex system which is used as raw material for production of numerous final products. In the production of bread and pastries, for example, the wheat flour can participate in dry mater content with over 96% (Žeželj, 2005). Chemical components in wheat flour are: starch, protein, fat, sugar, mineral matter, vitamins, enzymes, pigments, ballast material and water. Quantitatively observed, starch is main ingredient of wheat grain and wheat flour, but proteins give specific technological properties to the wheat dough. Starch has numerous roles in baking industry, and it is still the subject of scientific research. Starch forms a network of its particulates together with macromolecular gluten network, so that these two networks and their mutual interactions, give rheological characteristics to the dough. According to the Unbehend et al. (2003) and Tomić (2015), the protein content and protein structure are very important factors for baking properties and quality of the wheat flour, as the higher protein content leads to better quality of final product. Complex mechanisms in which proteins participate, during the production and forming the quality attributes of the final product, are not completely explained because of the difficulties in gluten extraction, gluten characteristics and diversity of the structure, and also because of the large number of chemical reaction which occurs during the production process of milling (Delcour et al., 2012; Tomić, 2015) and the type of food product in which it could be incorporated. Protein quality is not a simple concept and it can be observed indirectly through the strength of the dough, where the end test is baking test. Some of usual factors that can

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provide information about dough extensibility, as well as dough strength, are gluten index and rheological tests (farinograph, extensograph and alveograph tests) (Aydogan et al., 2015). It is necessary to emphasize that, for many years, farinograph has been a standard tool for the evaluation of dough properties during kneading and the amount of water which should be added to flour to achieve optimal dough consistency (Fišteš, 2009). Farinograph is an important instrument for analyzing rheological properties of dough, by measuring the dough consistency and resistance during the kneader activity (Dapčević-Hadnađev et al., 2011; Žeželj, 1995). The wheat flours with high farinograph water absorption give the best results in baking industry, because the dough from that kind of flour is stable, tension resistant, elastic, and it doesn't stick on working surfaces of used machinery and equipment. According to Žeželj (1995), development time of the dough is the time during which maximal dough consistency is achieved. Wheat and wheat flour with longer development time are considered to be stronger and to have better technological quality (Bushuk et al., 1969). According to Wang et al. (2002), dough stability (max consistency) is higher for wheat or wheat flour with better quality characteristics, and this is important in the production process. Softening degree declines in resistance after 15 minutes of the dough kneading, and strong flours have very low softening degree (Kaluđerski & Filipović, 1998).

The aim of this research was to determine the existence of correlation between chemical and farinograph quality parameters of different wheat flour samples and the quality of bread produced from them.

## MATERIALS AND METHODS

Within the frames of this research, three samples of wheat flour type 500, experimentally produced in industrial mill with capacity of 100t/24h from three different wheat mixtures, were analyzed. Wheat mixture 1 consists of 20% improver (wheat A, with a higher level of quality) and 80% wheat with lower level of quality (wheat B). Flour sample 1 was produced from mixture 1. Mixture 2 consists of 30% improver and 70% wheat with a low level of quality, and that was raw material for flour sample 2 production. Mixture 3 consists of 40% improver and 60% wheat with a low level of quality, and that mixture is raw material for the flour sample 3 production. The results for quality parameters of wheat samples A and B, and wheat mixtures 1, 2 and 3 are given in Table 1. For bread production in industrial conditions, the following ingredients were used: wheat flour type 500, water from public supply system, fresh yeast ("Lesaffre Adriatic" d.o.o., France), sunflower oil ("Bimal" Brčko), sugar ("Agragold" d.o.o. Ljubljana), table salt ("So komerc plus", Banja Luka), additives [commercial mixture with ingredients as follows: anti-lumps agent E170, agent for flour treatment E300, wheat flour as filler, enzymes (alpha amylase, amyloglucosidase, glucose oxidase, xylase and lipase); "Ireks aroma" d.o.o., Croatia]. The quantity of ingredients used for bread production is given in the Table 2.

Water content was determined according to ISO 712:2009 method, ash content was determined according to ISO 2171:2007 method, protein content was determined according to ISO 20483:2013 method, and fat content was determined according to ISO 7302:1982 method. Starch content was determined using the Kaluđerski and Filipović method (1998). Using the farinograph (C.W. Brabender, Duisburg, Germany), and according to ICC Standard No115 method, the following information is obtained: farinograph water absorption (*FWA* %), development dough time (*DDT* min), stability of a dough (*STB* min), quality number (*QN*) and softening degree of a dough (*SD* (BU)). The results were showed as mean value and standard deviation (n=3).

The dough was prepared by mixing the ingredients in high-speed kneader (25 kg/batch), until optimal consistency of dough was achieved. The dough is then left in kneader to ferment, with one additional short mixing. The next phase implies cutting of dough and round shaping of dough pieces on work tables. After that, the dough pieces go on intermediate fermentation for 10 minutes, final shaping, and manual placing in molds with the following dimensions: upper opening 260x100 mm, bottom 250x95 mm and height 90 mm. Final fermentation was realized in controlled conditions: temperature 35-40°C and relative humidity 80%. Bread samples were produced in industrial conditions, according to the manufacturer's specifications, so information about some processing parameters is not presented in the paper, but is known to the author. After baking and cooling, the bread was cut in pieces with uniform shape, and then packed.

The sensory analysis of experimental bread samples was realized at the Faculty of Technology, University of Banja Luka, Bosnia and Herzegovina (BA), in the Laboratory for food sensory analysis, designed and equipped according to the Standard ISO 8589:2007. Individual Quantitative Descriptive Analysis (QDA) was organized with 22 panelists, students from the Faculty of Technology, University of Banja Luka (BA). They were recruited for sensory analysis, verified and trained for objective evaluation and scoring, following the standard procedures (ISO 6658:2005; ISO 8586-1:1993). The panelists evaluated selected sensory attributes for each of three experimental batches of bread (sample 1, sample 2, sample 3) using QDA scoring method with 5-point scoring system according to the similar research (Grujić et

Parameters of wheat quality	Wheat A	Wheat B	Mixture 1	Mixture 2	Mixture 3				
TW (kg/hL)	86.3±0.09	86.2±0.19	86.10±0.15	86.20±0.08	86.20±0.10				
Water content (%)	10.48±0.13	10.29±0.04	10.33±0.05	10.46±0.03	10.45±0.04				
Ash content (%)	1.50±0.03	1.69±0.05	1.53±0.01	1.52±0.03	1.47±0.01				
Ash content on dry matter (%)	1.68±0.03	1.88±0.06	1.71±0.01	1.69±0.03	1.64±0.01				
Fat content (%)	2.05±0.02	1.74±0.04	1.83±0.09	1.74±0.05	1.83±0.05				
Protein content (%)	14.65±0.41	11.96±0.17	12.68±0.02	12.70±0.04	13.00±0.08				
Starch content (%)	57.91±0.05	62.94±0.64	62.70±0.47	62.76±0.10	62.66±0.27				
Wet gluten content (%)	30.2±0.05	24.5±0.14	24.00±0.05	25.70±0.05	26.40±0.09				
FWA (%)	64.7±0.17	62.3±0.14	62.2±0.05	64.0±0.09	64.0±0.05				
DDT (min)	3.5±0.08	2.0±0.05	2.0±0.05	2.1±0.05	2.3±0.09				
STB (min)	3.7±0.16	0.6±0.21	0.7±0.12	0.8±0.09	0.9±0.12				
SD (BU)	20±1.70	69±0.47	71.0±0.82	43.0±1.70	42.0±0.47				
QN	84.2±0.09	62.4±0.12	61.7±0.28	63.8±0.28	65.4±0.22				
QG	A <sub>2</sub>	B <sub>1</sub>	B <sub>1</sub>	B <sub>1</sub>	B <sub>1</sub>				

Table 1. Results for quality parameters of wheat samples and wheat mixtures

Results were showed as mean value ± standard deviation (n=3). Test weight (TW) has been calculated on 13% water content. TW- test weight, FWA – farinograph water absorption, DDT- Dough development time, STB – stability of dough, SD – softening degree of dough, QN – quality number, QG- quality group

Mixture 1: 20% wheat A+80% wheat B, Mixture 2: 30% wheat A+70% wheat B, Mixture 3: 40% wheat A+60% wheat B. Samples of wheat and wheat mixtures were sampled in industrial conditions.

#### Table 2. Quantity of ingredients used for bread production

	Bread sample 1	Bread sample 2	Bread sample 3
Ingredients	%*	%*	%*
Flour	100	100	100
Water	59.5	59.5	62.0
Yeast	3.0	3.0	3.0
Salt	2.0	2.0	2.0
Sugar	3.0	3.0	3.0
Additives	0.3	0.3	0.3

\*Quantity of ingredients is expressed based on the total quantity of flour needed for production

Wheat mixture 1 was used for producing the flour for bread sample 1. Wheat mixture 2 was used for producing the flour for bread sample 2. Wheat mixture 3 was used for producing the flour for bread sample 3

al., 2009a, b; Grujić, 2015) and Regulations (Official Gazette BA, No 76/10), as follows: appropriate quality (5); slight deviation (4); noticeable deviation (3); clear deviation (2); unacceptable quality (1). The bread with a total score of <40 points was of very bad quality; 40-49 points bad quality; 50-59 points poor quality; 60-69 points satisfactory quality; 70-79 points good quality; 80-89 points very good quality, and 90-100 points excellent quality (Grujić, 2015). The following sensory attributes (ISO 13299:2003; ISO 11035:1994; Pestorić, 2008; Grujić et al., 2009 a,b; Nwosu, 2014; Grujić, 2015; Official Gazette BA, No 76/10) were analyzed and evaluated: shape and volume, external appearance, appearance of cross-section, taste and the aroma of bread. Sensory analysis of the bread samples was performed 12 h after baking, and the samples were stored at room temperature (20-23°C) in closed plastic containers with lids. The bread samples were served in the individual sensory booths according to the standard procedures, at room temperature, on white plates, with white paper napkins, with water (20-23°C) in glass cups (for the mouth rinsing and cleansing the palate), containers for sputum, evaluating form and pencil.

Bread volume was determined according to a method for the evaluation of bread quality proscribed by official legislation (Official Gazette BA, No 77/10; Official Gazette SFRJ, No 74/88).

All tests were repeated in triplicate, and mean values were stated with standard deviations. Statistical analysis was performed using IBM SPSS Statistics 26.0 software. Analysis of variance (One way ANOVA) and the following post hoc Tukey test were used to determine the significant differences between the mean values (with a level of p<0.05).

As the aim of this research was to determine the existence of correlation between the quality parameters selected as independent variables (chemical and certain rheological quality parameters of different wheat flour samples), and dependent variable (quality of bread produced from them), Pearson's correlation coefficient (r) were calculated. The values of p below 0.01 and 0.05 were considered statistically significant.

Table 3. Chemical and farinograph quality characteristics of wheat flour type 500

	Sample 1	Sample 2	Sample 3
		Wheat flour type 500	
Water content (%)	13.32 <sup>b</sup> ±0.06	13.20 <sup>b</sup> ±0.06	12.66ª ±0.06
Ash content (%)	0.47ª ±0.02	0.47ª ±0.01	0.48ª ±0.01
Ash content on dry matter (%)	0.54ª±0.02	0.54ª ±0.01	0.55ª ±0.01
Fat content (%)	1.69° ±0.05	1.29 <sup>b</sup> ±0.01	0.95ª ±0.02
Protein content (%)	11.44ª ±0.15	11.70ª ±0.04	14.74 <sup>b</sup> ±0.07
Starch content (%)	69.53 <sup>b</sup> ±0.02	69.02ª ±0.13	71.12° ±0.14
FWA (%)	59.5ª±0.08	59.8 <sup>b</sup> ±0.05	64° ±0.12
DDT (min)	2.1 <sup>b</sup> ±0.00	2ª ±0.05	2.4° ±0.05
STB (min)	0.7ª ±0.08	0.5ª ±0.12	0.7ª ±0.05
SD (BU)	60ª ±0.94	66 <sup>b</sup> ±1.63	58ª ±1.41
QN	57.1 <sup>b</sup> ±0.08	52.6° ±0.09	58.5°±0.12
QG	B <sub>1</sub>	B <sub>1</sub>	B <sub>1</sub>

<sup>a-c</sup> Mean values marked with the different letter in the same row are significantly different with 95% probabilities (p<0.05). Results were showed as mean value ± standard deviation (n=3).

FWA – farinograph water absorption, DDT – dough development time, STB – stability of dough, SD – softening degree, QN – quality number, QG – quality group

Wheat mixture 1 was used for producing the flour sample 1. Wheat mixture 2 was used for producing the flour sample 2. Wheat mixture 3 was used for producing the flour sample 3.

Samples of wheat flour were produced in industrial conditions.

### **RESULTS AND DISCUSSION**

The food products quality depends on their ingredients quality and production technology. The chemical composition of wheat flour should have a strong impact on technological and sensory quality of bread and other baked products (Zhang, 2020). Water content in the analyzed wheat flour samples is acceptable (Table 3), under 15 % the referent value proscribed by legislation (Official Gazette BA, No 76/10). All three analyzed wheat flour samples can be categorized in the flour type 500, according to legislation, and if we take the ash content into consideration. The flour type 500 is primary wheat flour in baking industry. The contents of fat, protein and starch are in accordance with the data for the most common composition of wheat flour intended for bread production (Carson & Edwards, 2009; Đaković, 1969; Finnie & Atwell, 2016). Protein content in dry weight for two analyzed samples of wheat flour (sample 1 and 2) is in accordance with the results for protein content in wheat flour T-550 from the Cardoso et al. (2019) study, while protein content in dry weight for sample 3 is higher than the available data from the previously mentioned research.

There is no statistically significant difference between flour samples, for the analyzed parameters of ash content, ash content on dry matter and stability of dough, according to the results of the analysis of variance. Concerning the rest of chemical and farinograph quality parameters, there is statistically significant difference between the analyzed flour samples (Table 3).

FWA for the bread flours can vary from 50% (for weak flours) up to 65% (for strong flours), according to Kljusurić (2000). Taking that into consideration, the analyzed samples of flour in our research can be categorized in the strong flours, according to FWA values. The results of research conducted on 100 samples of wheat bread flours showed that FWA varied from 54.8% to 68.4%, with the mean value of 61.76% (Aydogan et al., 2015). Similarly, the results of research conducted on 8 samples of commercial available wheat flourT-500 showed that FWA varied from 55.5%-68.5% (Stamatovska et al., 2016). The results in our research

for FWA for the analyzed flour samples (Table 3) are similar to the results in Aydogan et al. (2015) study and in Stamatovska et al. (2016) research. Stronger flour requires longer time for dough development, compared with weaker flours. Development time, in Aydogan et al. (2015) study, varied from 1.35 to 12.17 minutes, with the mean value of 4.22 minutes. Values for DDT of analyzed flour samples are lower than the mean value in Aydogan et al. (2015) study, which indicates that analyzed flours are weaker. Similar situation occurs with the dough stability. Softening degree in strong flours is very low. The analyzed flour samples have lower values of softening degree, compared with the mean value of 100 tested samples for SD in Aydogan et al. (2015) study and also in comparison with the results in Stamatovska et al. (2016) study. Wheat flours that belong to quality groups  $B_1$  and  $B_2$  have optimal quality for bread and pastries production (Oručević, 2010). According to farinograph parameters, analyzed flour samples belong to quality group  $B_1$  (Table 3), and they are very suitable as a raw material in baking industry. However, compared with the mean value of quality number for the wheat flour in Aydogan et al. (2015) study, the analyzed flour samples have a lower quality number.

The volume of the analyzed bread samples varied from 2184.33 to 2430.0 cm<sup>3</sup> (Table 4). According to the prescribed quality requirements (Official Gazette SFRJ, No 74/88) for bread with weight of 0.500 kg, the bread samples 1 and 2 have very good volume, while the bread sample 3 has excellent volume.

Sensory quality of the analyzed bread samples with the average grade for the total quality 4.47 (sample 1), 4.36 (sample 2) and 4.48 (sample 3) have achieved percentage in the maximum level of quality 89.61% (sample 1), 87.31% (sample 2) and 89.64% (sample 3) (Table 5). The analyzed bread samples had very good sensory quality, even samples 1 and 3 are between very good and excellent quality, according to the evaluation scale for bread quality level (Grujić et al., 2009 a, b; Grujić, 2015; Official Gazette BA, No 76/10). The results indicated a high level of technological and sensory quality of bread produced from selected

Table 4. Results for volume and mass of bread (n=3)

	Sample 1	Sample 2	Sample 3		
		Bread			
Volume of bread (cm <sup>3</sup> )	2184.33ª ±27,64	2267.3ª±82,56	2430.0 <sup>b</sup> ±16,33		
Mass of bread (g)	512ª±2.94	513ª±1.70	515ª±1.63		

<sup>a-b</sup> Mean values marked with a different letter in the same row are significantly different with 95% probabilities (p<0.05). Flour sample 1 was used for the production of bread sample 1. Flour sample 2 was used for the production of bread sample 2. Flour sample 3 was used for the production of bread sample 3. Samples of bread were produced in industrial conditions.

	Sample 1	Sample 2	Sample 3
Shape and volume (Coefficient of importance 4)	4.54ª±0.50	4.33°±0.49	4.31ª±0.58
External appearance (Coefficient of importance 3)	4.25°±0.68	4.25°±0.51	4.39ª±0.60
Appearance of cross-section (Coefficient of importance 5)	4.43°±0.54	4.35°±0.43	4.45°±0.52
Aroma of bread (Coefficient of importance 3)	4.50°±0.49	4.43°±0.60	4.66ª±0.44
Taste of bread (Coefficient of importance 5)	4.61ª±0.52	4.44°±0.63	4.60ª±0.62
Average value for overall quality	4.47	4.36	4.48
Percentage of max level of quality	89.61	87.31	89.64

Table 5. Results of quantitative descriptive sensory analysis of bread samples

<sup>a</sup> Mean values marked with the same letter in the same row are not significantly different with 95% probabilities (p>0.05). Results were showed as mean value ± standard deviation (n=22).

The evaluation of each sensory property and identified deviations in bread quality scored: appropriate quality (5);

slight deviation (4); noticeable deviation (3); clear deviation (2); unacceptable quality (1).

samples of flour in industrial conditions. All three bread samples had appropriate, very good quality with slight deviations and high mean scores for analyzed selected parameters: shape and volume, external appearance, appearance of cross-section, aroma, taste and average value for overall quality (Table 5). Also, there was no significant difference between mean values for the analyzed parameters for the produced bread sensory quality. The results of sensory analysis of bread samples are similar to the results in Nwosu et al. (2014) study for color of crust, taste, texture, aroma and general acceptance for bread sample made of the wheat flour. The results of the analysis of variance and post hoc Tukey test (Table 4 and 5) showed that bread volume between the analyzed samples is significantly different, while bread mass and sensory analyzed parameters didn't show any statistically significant difference.

According to Carson and Edwards (2009), as well as Mills and Bekes (2009), higher protein content can influence the increase of FWA, the potentially greater bread volume and better quality of a final product, confirming the importance of protein content for the evaluation of wheat quality. The results of correlation analysis (Table 6) for chemical and farinograph parameters of flour (independent variables) and quality characteristics of bread (dependent variables) mostly confirm previous statements, and they show that between protein content and most of the analyzed parameters (water content, fat content, starch content, FWA, DDT and bread volume) there exists a statistically significant correlation (p<0.01). That correlation is strong and negative only in relation to water and fat content.

The chemical components contained in flour have great influence on FWA, and correlation analysis confirmed it, indicating that there is statistically significant correlation (p<0.01) between FWA and water content, protein content, fat content, starch content. Only in the case of ash content on dry matter that correlation is not statistically significant (p=0.278). Correlation between FWA and water content and fat content is negative, which means that with the increase of water and fat content, values for FWA decrease, and vice versa. According to the Chaddock's scale for evaluation of correlation strength (Žižić et al., 1999), the observed relations between FWA and content of chemical compounds are strong. These findings are in compliance with Tamba-Berehoiu et al. (2018) research, where a significant positive correlation has been found between FWA and protein content.

Also, the existence of positive correlation has been determined between FWA and DDT and bread volume (p<0.01). Correlation is strong between FWA and DDT and bread volume. These findings are in compliance with Aydogan et al. (2015) research, where a significant correlation has been found between FWA and protein content, DDT, bread weight and bread volume. Sahin et al. (2011) showed similar results in their research, when the correlation was determined between FWA and bread volume.

DDT is in correlation with water content, protein content, starch content, FWA, SD, QN and overall sensory quality of bread (TQ). Correlation between DDT and protein content, starch content, farinograph

	WC	ACDM	FC	PC	SC	FWA	DDT	STB	SD	QN	VOL	MAS	TQ
WC	1												
ACDM	383	1											
FC	.899**	309	1										
PC	965**	.441	870**	1									
SC	907**	.347	682*	.941**	1								
FWA	973**	.406	873**	.998**	.944**	1							
DDT	824**	.336	612	.900**	.938**	.903**	1						
STB	188	.266	.129	.256	.394	.259	.597	1					
SD	.539	.009	.226	608	823**	614	750*	413	1				
QN	529	.166	180	.625	.820**	.629	.865**	.718*	916**	1			
VOL	892**	.424	887**	.849**	.743*	.852**	.571	155	363	.268	1		
MAS	562	.475	467	.463	.390	.479	.344	.180	034	.150	.634	1	
TQ	419	.180	023	.494	.726*	.498	.753*	.778*	870**	.967**	.177	.171	1

Table 6. Correlations between chemical and farinograph parameters of flour and quality characteristics of bread

\*\* Correlation is significant at the level 0.01

\* Correlation is significant at the level 0.05

WC-water content, ACDM- ash content on dry matter., FC-fat content, PC- protein content, SC- starch content, FWA- farinograph water absorption, DDT- dough development time, STB- stability of dough, SD- softening degree, QN- quality number, VOL- bread volume, MAS- bread mass, TQ - average value for overall sensory quality of bread.

The results were showed as Pearson's correlation coefficient (r).

water absorption, quality number and overall sensory quality of bread is positive, but for water content and *SD* it is negative. According to Tamba-Berehoiu et al. (2018) study there is a very significant and positive correlation between *DDT* and protein content, which is in compliance with our research.

The results of correlation analysis showed that there is no statistically significant correlation between dough stability and the rest of the analyzed quality parameters, with the exception in case of quality number and overall sensory quality of bread (those correlations are positive and medium strong with Pearson's coefficient r=0.718and r=0.778). The softening degree, as rheological quality parameter, had statistically significant negative correlation with starch content, *DDT*, *QN* and overall sensory quality of bread (TQ).

According to the Janczak-Pieniazek et al. (2020) study, strong negative correlations were observed between the quality number and degree of softening, as well as between the dough stability and degree of softening (both values of the correlation coefficient were r=-0.94, p<0.05). Also, the correlation between QN and SD was observed in our research, and it was also strong and negative (r=-0.916, p<0.01), but the correlation between the dough stability and SD was not confirmed. Moreover, according to the previously mentioned study (Janczak-Pieniazek et al., 2020), a strong positive correlation between QN and dough stability was confirmed (r=0.96, p<0.05). The results of correlation analysis in our research showed that there is a medium strong positive correlation between QN and STB (r=0.718, p<0.05).

Bread volume showed significant correlation with chemical quality parameters (water content, fat content, protein content, starch content), and with *FWA*. The overall sensory quality of bread showed significant correlation with starch content and farinograph quality parameters (*DDT*, *STB*, *SD*, *QN*), and that implies that with increasing the value for starch content, *DDT*, *STB* and *QN*, and with decreasing the value of SD, better overall quality of baked bread as final product can be expected.

## CONCLUSIONS

The analyzed wheat flour samples, produced in industrial conditions after milling three mixtures of wheat with a different technological quality, showed high quality for application in the baking industry. Chemical and farinograph quality parameters of wheat flour as raw material provide information about technological suitability and possibility of achieving optimal quality of bread. The results of our research pointed out the fact that farinograph parameters FWA, DDT and to a certain extent SD and QN are in correlation with the parameters of chemical composition of flour, more precisely with water content, protein content, fat content and starch content. Furthermore, already mentioned parameters of chemical composition of flour, as well as FWA, have a significant influence on the bread volume. Sensory evaluated overall bread quality is in correlation with starch content, DDT, STB, SD and QN. Farinograph analysis justified its reputation as a widely used test in the prediction and control of flour quality and flour impact on the final product bread quality. All three bread samples had appropriate, very good quality, with very slight deviations and high mean scores for analyzed selected parameters: shape and volume, external appearance, appearance of crosssection, aroma, taste and average value for overall sensory quality. Choosing the instruments, methods and parameters for analysis, especially parameters which are in correlation with other quality characteristics, can provide valuable data for the prediction of product quality, and the selection of the best available, within a relatively shorter period of time.

Identified high quality of wheat, flour and bread, based on the analyzed technological and sensory parameters, confirmed that the selected mixtures of cereals and flours can be used, in industrial conditions, as raw materials for the production of high quality bread. The identified high quality of flour for bread production opens perspectives for further research regarding its use in manufacturing other appropriate products.

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# Korelacija između hemijskih i određenih reoloških parametara kvaliteta pšeničnog brašna i hljeba

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Ključne reči: reološki kvalitet brašna, hljeb, korelacija.

Hljeb i proizvodi na bazi žitarica, čak i u današnje vrijeme, čine osnovu piramide namirnica, i njihova konzumacija je preporučena prema svim smjernicama za ishranu jer obezbjeđuju pozitivan efekat na ljudsko zdravlje. Cilj rada je da se utvrdi postojanje korelacije između hemijskih i određenih reoloških parametara kvaliteta različitih uzoraka pšeničnog brašna, te kvaliteta hljeba proizvedenog od njih. Za potrebe rada ispitivana su tri uzorka brašna tip-500, koja su proizvedena kao eksperimentalna u industrijskim uslovima od pšenica različitog tehnološkog kvaliteta. Provedena su ispitivanja hemijskog sastava eksperimentalnih uzoraka pšeničnog brašna: sadržaj vode, pepela, pepela na suvu materiju, masti, proteina i skroba; te farinografskih parametara: moć upijanja vode, vrijeme razvoja tijesta, stabilitet tijesta, stepen omekšanja tijesta, kvalitetni broj i kvalitetna grupa. Prethodno pomenuti uzorci pšeničnog brašna su pokazali visok kvalitet i upotrebljeni su kao osnovna sirovina u proizvodnji hljeba. Takođe, provedena je i ocjena kvalitetnih parametara tri uzorka eksperimentalnog hljeba. Sva tri analizirana uzorka hljeba su imala odgovarajući i vrlo dobar kvalitet, sa malim odstupanjima i visokom srednjom ocjenom za analizirane parametre: oblik i volumen, spoljašnji izgled, izgled presjeka, miris, ukus i prosječna ocjena za ukupni senzorni kvalitet. Nakon toga, ispitivalo se postojanje korelacija između analiziranih parametara i nađena je, kao vrlo bitna, veza moći upijanja vode sa parametrima hemijskog sastava: sadržaj vode (p<0.05), sadržaj masti (p<0.05), sadržaj proteina (p<0.05) i sadržaj skroba (p<0.05), kao i značajan uticaj i pozitivna korelacija sadržaja proteina, te moći upijanja vode na volumen hljeba (p<0.05). Odabir adekvatnih instrumenata, metoda i parametara za ispitivanja, posebno parametara koji su u korelaciji sa ostalim kvalitetnim karakteristikama, može da pruži vrijedne podatke u predviđanju kvaliteta finalnog proizvoda, u kraćem vremenskom periodu.