Biblid: 1821-4487 (2016) 20; 4; p 165 - 169
UDK: 582.542.11

Original Scientific Paper
Originalni naučni rad

POSSIBILITY OF UTILIZATION ALTERNATIVE CEREALS (MILLET AND BARLEY) FOR IMPROVEMENT TEHCHNOLOGICAL PROPERTIES OF BREAD GAINED FROM FLOUR OF POOR TECHNOLOGICAL QUALITY

MOGUĆNOST PRIMENE ALTERNATIVNIH ŽITA (PROSA I JEČMA) ZA POBOLJŠANJE TEHNOLOŠKOG KVALITETA HLEBA OD BRAŠNA LOŠIH TEHNOLOŠKIH OSOBINA

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ABSTARCT

The aim of the study was to examine does it possible to improve bread properties of the bread based on wheat flour of poor technological quality by substitution of barley and millet flour. For that purpose were examined chemical properties of raw materials (Wheat flour of extremely poor technological quality (WFPQ), dehulled wholegrain barley flour (DWBF) and decorticated millet flour (DMF)), as well as rheological properties of doughs (WFPQ flour and mixtures of DWBF and DMF with WFPQ in ratios 10:90 and 30:70) and end-use quality of control and composite breads. The substitution of the small amount of WFPQ with DMF (10%) improved most of the bread properties, whereas the sensory properties stay almost the same. Also, substitution of the high amount of DMF (30 %) neither showed effects of improvement and worsening for to the most of technological properties. On the other hand, substitution with DWBF has negative impact on the most technological properties of composite bread.

Key words: *millet, barley, wheat flour, technological properties.*

REZIME

Cilj ovog istraživanja je bio da se ispita mogućnost primene brašna od ječma i prosa za poboljšavanje tehnoloških osobina hleba proizvedenog od brašna lošeg tehnolološkog kvaliteta supstitucijom određenog procentualnog udela u osnovnoj recepturi hleba. Zbog toga je ispitan hemijski sastav sirovina (pšeničnog brašna izuzetno lošeg tehnološkog kvaliteta (WFPQ), integralnog brašna od oljuštenog ječma (DWBF) i integralnog brašna od oljuštenog prosa (DMF)), reološke osobine testa (od WFPQ i smešama od DWBF i DMF sa WFPQ u odnosu 10:90 i 30:70) i tehnološke osobine kontrolnog i mešanih hlebova (zapremina hleba, spec. zapremina hleba, visina vekne, boja kore i sredine, Texture Profile Analyses (TPA) sredine hleba i senzorna analiza hleba). Zamenom male količine WFPQ sa DMF (10%) poboljšane su tehnološke osobine hleba: zapremina, visina vekna, boja kore i TPA pokazatelji; dok su senzorne osobine hleba ostale skoro iste kao kod kontrolnog hleba. Takođe, zamenom veće količine DMF (30%) nije se dobilo niti poboljšanje niti pogoršavanje većine tehnoloških pokazatelja. Supstitucijom DWBF u osnovnoj recepturi hleba poboljšali su se neki reološki pokazatelji i boja kore, dok je većina tehnoloških pokazatelja mešanog hleba bila lošija od kontrolnog hleba. Može se očekivati da će zamenom veće količine WFPQ sa DMF i DWBF doći do boljeg poboljšavanja nutritivnih osobina hleba nego u slučaju zamene male količine DMF i DWBF jer su hemijske analize pokazale da su DMF i DWBF boljih nutritivnih osobina od WFPQ.

Ključne reči: *proso, ječam, pšenično brašno, tehnološki kvalitet.*

INTRODUCTION

Disorders in temperature and climatic regime of earth have reached such levels and scientists think that global climate changes are the most influential on the agriculture and world food production. Also, plants are in direct relation with temperature and climatic regime and respond to greenhouse effect caused by CO_2 and temperature (*Kersebaum and Nendel 2014*), which will not only affect at crop biomass production but also on crop quality (*Erbs et al., 2015*). Survey of *Howden et al.,* (*1999*) showed that synergistic effects of climate change and CO_2 increased yields of Australian wheat, whereas kernel protein contents decreased. Also, *Borghi et al.* (*1995*) found that temperature has influence on gluten content and composition and these gluten proteins are regarding viscoelastic properties of dough, the most responsible for baking quality. Temperatures which are responsible for heat stress and deterioration of the quality in wheat are ≥ 32 °C (*Pradhan and Prasad 2015*) whereas these temperatures in pearl millet (≥ 40 °C (*Gupta et al., 2015*)) and sorghum (≥ 38 °C (*Prasad et al., 2015*)) are higher. Since predicting that average daily temperature in Serbia will increase by 4.0–4.4 °C until 2100 year that will result in a possible decline of wheat end-use quality, one of the main interests of the baking industry in Serbia will become improvement of bread quality.

Wheat bread, in all its existing shapes and forms, is the one of the most widely consumed staple food all around the globe. Although, technology of making bread was known in ancient, improvement of bread quality is possible to fulfil in a various sophisticated ways. Several studies have been conducted to examine how different enzymes or different breadmaking process influence the quality of the bread (*Cabalerro et al., 2007; Jiang et al., 2005; Rossel et al., 2009*). Using of new processing technologies or enzymes could raise the price of the final products, especially if baking industry dispose with large amount of raw material of poor technological quality. Therefore, better and cheaper solution for solving this problem could present using of different new available raw materials to correct technological quality of bread. As a only positive result of many studies, which examined replacing wheat flour with some extent of cereals raw materials (*Iglesias-Puig et al., 2015; Koletta et al. 2014; Sanz-Penella et al., 2013*) was gained improvement of nutritive quality of bread. On the other hand, there exist only a few studies, which examined different flour mixtures of wheat and other cereals flours (*Izydorczyk et al., 2001*), where was gained improvement technological properties of bread.

Barley (*Hordeum vulgare*) is a crop that has ability to be grown in almost every region such as summer crop and winter crop regions, and possesses relative tolerance to abiotic stress such as soil salinity and drought (*Sharma and Chauhan, 2000*). Similar to barley millet possess tolerance to drought and it is resistant to some pests and diseases (*Devi et al., 2011*). Therefore these two cereals became very interesting for production and utilization as food. Also, barley contains moderate levels of dietary fibre, minerals and antioxidants, which indicate that it could be implemented as functional food supplement (*Ragaee and Abdel-Aal, 2006*). Millet is important source of dietary fibres and its amino acid compositions is well balanced except for its lysine deficiency (*Chung and Pomeranz, 1985*).

The aim of this work is to examine does it possible to improve properties of bread based on wheat flour of poor technological quality by substitution of barley and millet flour since reformulation can have great impact on bread appearance, texture and consumer acceptability.

MATERIAL AND METHOD

Material

Wheat flour of extremely poor technological quality (WFPQ), dehulled wholegrain barley flour (DWBF) and decorticated millet flour (DMF) were commercial samples.

Method

Chemical methods

Raw materials (WFPQ, DWBF and DMF) were determined for moisture (*method 44-16*), protein (*method 46-10*) and total sugar (80-60.01) using the American Association of Cereal Chemists (*AACC, 2000*) methods. Fat (*method 945.16*), and dietary fibres (*method 991.43*) were analyzed according to *AOAC* (1999) method, whereas the starch (*method 1.28*) were determined using *Serbian official methods* (*1988*). All analyses were implemented in duplicate.

Rheology test

Empirical rheology test of doughs (WFPQ, and mixtures of DWBF and DMF with WFPQ in ratio in ratios 10:90 and 30:70) was determined by 10 g Farinograph (C.W. Brabender, Duisburg, Germany) (*method MSZ 6369/6*) according to *Hungarian Standard* (*1988*).

Preparation of bread and breadmaking properties

The breads were prepared according to next formulations consisting of: 100 % WFPQ or by replacing of wheat flour DWBF or DMF at 10 and 30 % (w/w), salt (2 % of flour weight) and brewer yeast (2 % of flour weight). The total volume of water required for dough consistency of 200 BU is calculated on the basis of farinograph data: water absorption and the degree of softening according to *Serbian official methods* (*1988*). All ingredients were mixed with a Diosna spiral mixer (DIOSNA, Dierks & Söhne, GmbH, Germany) at low speed for 5 min and obtained dough was fermented for 120 min (60+30+30) at 30 °C and a relative humidity of 80 %. After mixing, the dough was divided into 130-g portions and placed in baking pans (9.5 x 7.5 cm^2 upper extent, 7.5 x 5.5 cm^2 lower extent and 6.5 cm deep). After proofing of 70 min the loaves were baked at 220 °C for 17 min. The specific volume of bread was measured by displacement method with oil seeds, whereas calliper was used for measuring a maximal loaf height from three breads. Colour was determined on bread crust and crumb using a Minolta (Chroma Meter CR–400, Minolta Co., Ltd., Osaka, Japan). Texture Profile Analyses (TPA) of bread crumb samples were examined after 1 h of baking by a TA-XT2 texture analyzer (Stable Microsystems, Surrey, UK) using a load cell of 30 kg. For penetration of 12.5 mm four slices a 100 mm diameter cylindrical probe were used, whereas a strain was 50 % at test speed of 5 mm/s and with pause of 30 s between first and second compressions. Sensory evaluation of bread loafs were conducted using five-point hedonic scale and six trained panelists from Institute of Food Technology in Novi Sad were selected for this analysis.

Statistical analysis

The analysis of variance (ANOVA) was used for comparison of chemical content of raw materials and technological properties of composite breads, whereas the means were compared by the Duncan test at significance level of 0.05 using the STATISTICA 12.0 software (StatSoft Inc., USA, 2015).

RESULTS AND DISCUSSION

The values of chemical parameters (Tab. 1) show that DWBF and DMF flours are more nutritious than WFPQ since the protein and fat content of DWBF and DMF flours are significantly higher than WFPQ. Also, the DWBF showed the significantly highest content of total dietary fibre. The reason for this may lie in the fact that DWBF is flour made from whole kernel, whereas the WFPQ is refined wheat flour and the DMF flour is made from decorticated kernel.

Table 1. Chemical properties of WFPQ, DWBF and DMF flours

	WFPQ	DWBF	DMF
Moisture content (g/100 g)	8.72^a	9.44^b	9.57^b
Protein content (g/100 g)	6.55^a	11.60^c	9.48^b
Fat content (g/100g)	1.00^a	1.87^c	1.62^b
Total sugar content (g/100g)	2.65^b	2.89^b	0.48^a
Starch content (g/100g)	78.32^c	66.94^a	77.77^b
Total dietary fibre content (g/100g)	4.38^a	15.21^b	4.64^a

Generally, the results of rheological properties showed that the water absorption (WA), degree of softening and Farinograph Quality Number were improved with substitution of DWBF and DMF to WFPQ, except for degree of softening in case of substitution of 10% DMF (Fig. 1). The increase in WA of dough with substitution of DWBF could be attributed to high content of dietary fibre in DWBF (*Gómez et al., 2003*).

Although *Shouk* (*2007*) considers that addition of dietary fibre to wheat flour leads to increase of development time and stability substitution of DWBF did not show such effect (Fig. 2). Also, substitution of 30 % DMF improved development time and stability (Fig. 2).

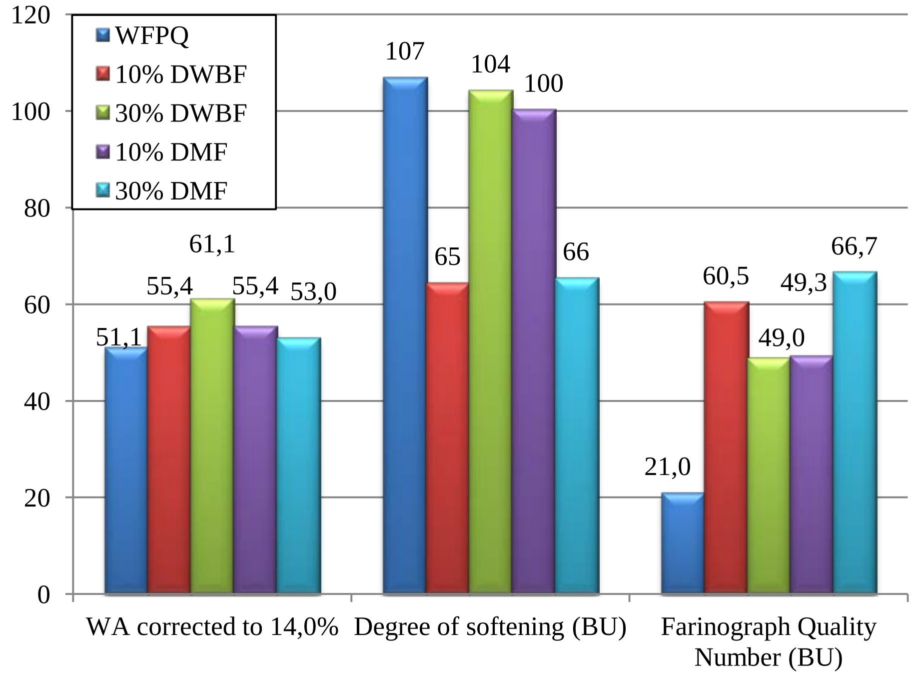

Fig. 1. Farinograph propeties of doughs (WA, Degree of softening and Farinograph Quality Number)

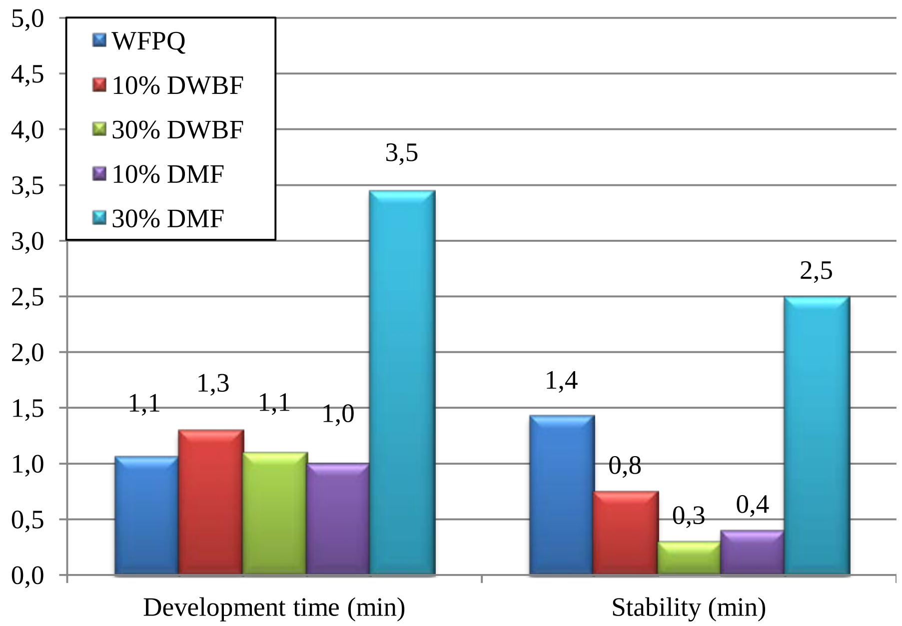

Fig. 2. Farinograph propeties of doughs (Development time and Stability)

Table 2. Tehnological porperties of control and composite breads

	Bread volume (cm^3)	Spec. bread volume (cm^3/g)	Loaf height (mm)
WFPQ	392.4^{c}	3.37^{c}	67.23^{c}
10 % DWBF	365.3^{b}	3.13^{b}	65.17^{b}
30 % DWBF	297.2^{a}	2.57^{a}	55.36^{a}
10 % DMF	442.9^{d}	3.82^{d}	75.90^{d}
30 % DMF	376.2^{bc}	3.23^{bc}	65.10^{b}

One of the most important parameter for estimation of bread quality is loaf volume as a quantitative measure of baking process (*Tronsmo et al., 2003*). Usually considers that high volume of bread is in correlation with softer texture and high porosity, which is a consequence of high quality of the flour, while high density of bread crumb impacts to harder texture of bread. ANOVA analysis showed that Bread volume, spec. bread volume and loaf height of 10 % DMF composite bread were statistically the highest. These results are contrary to the study *Patil et al.* (*2016*) which gained that increasing amount of millet flour (10, 20 and 30 %) decreased bread volume and loaf height. The reason for that could lie in the fact that *Patil et al.* (*2016*) used wheat flour of standard quality with higher ash and protein content (0.91 % and 13.3 %, respectively), whereas in this study was used wheat flour of extremely poor technological quality.

The crust colour of bread is a very important parameter for consumers (*Hathorn et al., 2007*) because of acceptability of the product. The crust colour of control and composite breads showed variation because the bread colour reflected the colour of the grain that was used for producing raw material for breads production. The values of L*, a* and b* of crust colour of control and composite breads are shown in Table 3. The lightness (L*) decreased with substitution of DWBF and DMF, whereas red tone (a*) and yellow tone (b*) increase. These results indicate that crust colour of composite breads are more similar to golden brown colour (the colour which is acceptable for bread consumer) than crust colour of control bread. The values of lightness of bread crumb were similar as crust colour of control and composite breads, whereas the differences among red and yellow tone were less pronounced (Tab 3).

Hardness is often used as a parameter of bread quality since it is changed with losing resilience during bread aging (*Spices, 1990*). Expectedly considering the results of baking tests, substitution of 10 % DMF the most significantly improved Hardness (Tab 4). These results are contrary to the study *Patil et al.* (*2016*) which gained that addition of millet flour increase Hardness of control bread. The reason for that could be in differences in the quality of the flour which *Patil et al.* (*2016*) used in their study in comparison to quality of the WFPQ. Increase in Hardness with increase in percentage of DWBF is consequence the fact that DWBF contain the highest content of dietary fibre. Similar findings showed *Blandino et al.* (*2013*) with substitutions of pearled fractions to refined wheat flour. Differences of Springiness were less pronounced and only substitutions of 10 % DMF significantly increase this parameter in comparison to control bread. Values of Cohesiveness changed in opposite trend to Hardness. Since Gumminess present multiplication of Hardness and Cohesiveness these values were very close to Hardness. Similar situation was with Chewiness which is gained by multiplying Gumminess and Springiness, whereas values of Resilience did not differ significantly among themselves.

Table 3. Crust and crumb colour of control and composite breads

	L*(D65) crust	a*(D65) crust	b *(D65) crust	L*(D65) crumb	a*(D65) crumb	b *(D65) crumb
WFPQ	82.43^{c}	0.55^{ab}	17.54^{a}	73.05^{c}	-2.65^{a}	18.94^{c}
10 % DWBF	73.69^{b}	0.16^{a}	24.01^{b}	67.17^{b}	-1.46^{b}	16.50^{b}
30 % DWBF	71.46^{b}	1.38^{ab}	22.50^{b}	63.51^{a}	0.13^{c}	13.73^{a}
10 % DMF	73.17^{b}	1.74^{b}	26.87^{c}	66.20^{b}	-2.70^{a}	16.58^{b}
30 % DMF	66.37^{a}	6.44^{c}	31.95^{d}	64.91^{ab}	-2.65^{a}	17.49^{b}

Table 4. Texture Profile Analyses of control and composite breads

	Hardness	Springiness	Cohesiveness	Gumminess	Chewiness	Resilience
WFPQ	1032.17^{b}	1.011^{a}	0.886^{cd}	915.38^{b}	926.21^{b}	0.533^{a}
10 % DWBF	1354.41^{b}	1.015^{a}	0.882^{c}	1194.07^{c}	1213.09^{c}	0.542^{a}
30 % DWBF	2490.27^{c}	1.032^{ab}	0.862^{b}	2144.13^{d}	2162.30^{d}	0.542^{a}
10 % DMF	476.12^{a}	1.063^{b}	0.904^{d}	428.76^{a}	455.52^{a}	0.532^{a}
30% DMF	1183.79^{b}	1.009^{a}	0.839^{a}	992.80^{bc}	1023.40^{bc}	0.526^{a}

Loaf Appearance, Crumb Appearance, Flavour of Crust and Crumb and Mouthfeel of Crust and Crumb of control and composite breads are presented at Figure 3. Although control bread according to grades of Crumb Appearance, Flavour of Crust and Crumb and Mouthfeel of Crust and Crumb possess the best scores; the 10% DMF composite bread succeed to posses similar sensory properties, whereas it grade of Loaf Appearance was even better to control bread.

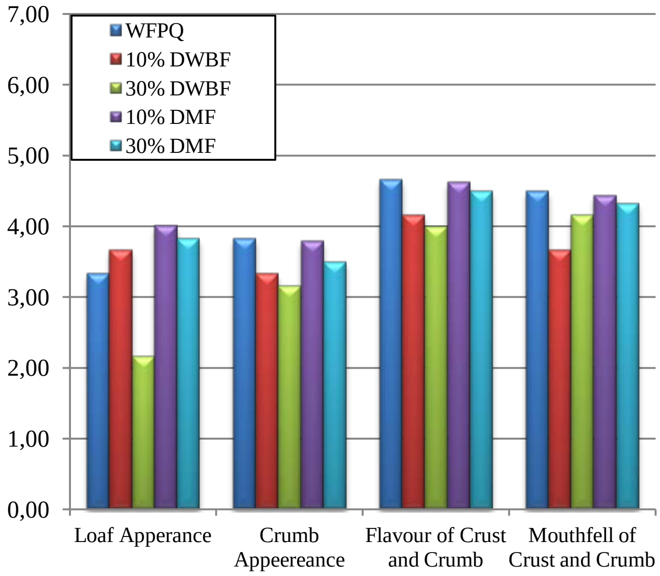

Fig. 3. Sensory results of control and composite breads

CONCLUSION

The substitution of the small amount of WFPQ with DMF (10 %) improved bread properties such as bread volume, loaf height, parameters of crust colour and TPA parameters, whereas the sensory properties stay almost the same. Also, substitution of the high amount of DMF (30 %) neither showed effects of improvement and worsening for to the most of technological properties. On the other hand, substitution with DWBF improved some rheological properties and crust colour, whereas it has negative impact on the most technological properties of composite bread. Furthermore substitution of high amount of WFPQ with DMF and DWBF should more improve nutritive properties of bread than substitution with small amount of WFPQ with DMF and DWBF since DMF and DWBF are more nutritious than WFPQ.

ACKNOWLEDGEMENT: The present study was financed by Ministry of Education, Science and Technological development who supported this work as a part of Project No. TR 31007 (2011-2016). Authors would like to express their gratitude to Provincial secretariat for science and technological development of Vojvodina, project "Technological potential of less represented cereals of Vojvodina".

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Received: 14. 10. 2016. Accepted: 30. 11. 2016.