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THERMO-MECHANICAL PROPERTIES OF DOUGH ENRICHED WITH WHEAT BRAN FROM DIFFERENT WHEAT VARIETY

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ABSTRACT

Wheat bran is the by-product derived from the wheat milling and represents a good source of dietary fiber. Consumption of wheat bran is associated with many health benefits. The hydration properties (water holding, water retention and swelling capacity) and oil binding capacity of bran from various wheat variety were investigated. It was showed that the water holding capacity of bran ranged from 2.27 to 2.98 $g.g^{-1}$, which were approximately four times higher compared to wheat flour. Also, it was observed that commercial wheat bran was characterised with the highest swelling capacity (5.21 $mL.g^{-1}$) and the lowest water retention and oil binding capacities (1.38 and 1.35 $g.g^{-1}$, respectively). Mixing and pasting properties of wheat dough with addition of bran at different level (5, 10 and 15%) were studied using Mixolab. From the results it was concluded that water absorption and dough development time increased with addition of different bran, while dough stability decreased. Moreover, with increasing addition level of different bran significantly affected the thermo-mechanical properties of wheat dough. The lowest effect on protein weakening was found after addition of spelt bran. The higher starch pasting ability of enriched dough was recorded after incorporation of bran from crossbreed Lubica. Furthermore, it was found that dough enriched with the commercial wheat bran was characterized by the lowest values of C3 (lower starch pasting ability), C4 (lower stability of hot formed gel) and C5 (lower starch retrogradation) parameters.

Keywords: wheat bran; spelt bran; functional properties; dough rheology; Mixolab

INTRODUCTION

Triticum aestivum L. is one of the major crop worldwide and mainly in the Mediterranean-type temperate zones, it is used for production of staple food **(Gotti et al., 2017)**. The quality of wheat is genetically conditioned and influenced by soil conditions, climate, technology, diseases and pest attack. Therefore, in order to have the chance to harvest quality wheat it is absolutely necessary to cultivate a variety that has the potential to develop that quality and for people to provide conditions for the wheat to achieve its potential **(Constantinescu et al., 2011)**.

Interest in the development of dietary fiber enriched foods has grown significantly as a result of increasing health awareness among consumers and food industry. As a complement of wheat flour in milling, one of the most obvious sources of dietary fiber in the baking industry is wheat bran **(Jacobs et al., 2015)**. Wheat bran is mainly composed of epidermis, peel, seed, nucellus layer, and aleurone layer **(Yan et al., 2015)**. Regarding the different types of bran fraction, there are quantitative and qualitative differences among the different cereal grains. Different types of bran have a different chemical composition; it depends on grain genetics, the agricultural background, and the milling process **(Jefremova et al., 2015)**. The wheat bran is rich in total dietary fiber (36.5 – 52.4%, w/w), and >90% of that is water-insoluble, thus the wheat bran might have significant prebiotic and antioxidant activities in lowing the risk of cardiovascular diseases, and provide the best protections against tumor, cancer and neurodegenerative diseases mainly because of the phenol compounds **(Jefremova et al., 2015)**. However, addition of bran has negative consequences on bread volume and organoleptic properties, depending on wheat cultivar, particle size, and the other treatment applied to bran **(Gómez et al., 2011)**.

Rheological tests on dough can predict their behaviour in a bakery, although only if the applied stress and the extent of the deformation are in the same range as those encountered during dough processing **(Rodriguez-Sandoval et al., 2012)**. The traditional instruments, which provide practical information for the cereal industry, measure the power input during dough development caused by a mixing action (farinograph, mixograph) and determine the extensional deformation of a prepared dough (extensigraph, alveograph) **(Minarovičová et al., 2017)**. Mixing and pasting properties of wheat flour dough can be studied by Mixolab, which is a new tool capable of giving empirical rheological measurements of flour quality. The instrument allows analysing the quality of the protein network and the starch behaviour during heating and cooling **(Jia et al., 2011)**. The incorporation of wheat bran into wheat dough greatly interferes with protein association and its further aggregation during heating. Presumably, fibers occupy the space of the proteins in the gluten network. In addition, a fiber also affect pasting characteristics of starch such as peak viscosity, breakdown and final viscosity **(Xhabiri et al., 2016)**.

Scientific hypothesis

The objective of this study was to determine the effect of substituting wheat flour with different bran on pasting and mixing properties of dough. The functional properties of different bran were also evaluated.

MATERIAL AND METHODOLOGY

The bran from wheat Lubica (LB) (crossbreed *Triticum aestivum* x *Triticum spelta*) and different wheat cultivars B1 and B2 (wheat variety with purple colour of grain) were obtained from Research and Breeding Station, Vígľaš Pstruša, Slovakia and Research Institute of Plant Production Piešťany, Slovakia. Commercial wheat bran (B3) (PRO-BIO, s.r.o., Staré mesto, Czech Republic), spelt bran (SB) (PRO-BIO, s.r.o., Staré mesto, Czech Republic) and wheat flour (WF) (Penam Slovakia, a. s., Nitra, Slovak Republic) (moisture 10.53%, wet gluten 31.24% and dry gluten 10.17%) were purchased in local market.

Functional properties

The Hydration properties (water holding capacity, water retention capacity and swelling capacity) of bran were determined according to the method described by **de Escalada Pla et al. (2010)** with slight modifications.

Water-holding capacity (WHC). An accurately weighed dry sample (1.000 g) was hydrated in a graduated conical tube with 20.0 mL of water for 18 h at room temperature. The supernatant was decanted and the weight of the hydrated residue was recorded. After drying at 105°C to constant weight, the residual dry weight was obtained.

WHC ($g.g^{-1}$) = (Hydrated residue weight - dry residue weight)/dry residue weight

Water retention capacity (WRC). An accurately weighed dry sample (1.000 g) was hydrated in a graduated centrifuge tube with 20.0 mL of water for 18 h at room temperature. Centrifugation for 20 min at 2500 xg was then performed into the same tube. The supernatant was separated and the weight of the hydrated residue after centrifugation was recorded. After drying at 105°C to constant weight, the residual dry weight was obtained.

WRC ($g.g^{-1}$) = (hydrated residue weight after centrifugation - dry residue weight)/dry residue weight

Swelling capacity (SC). An accurately weighed dry sample (1.000 g) was placed in a graduated conical tube and 10.0 mL of water was added. It was hydrated for 18 h and after this time, the final volume attained by the fiber product was measured. Swelling capacity was calculated using:

SC ($mL.g^{-1}$) = volume occupied by the sample / original sample weight

Oil binding capacity (OBC) of bran were determined using method reported by **Sangnark et al. (2004)** with slight modification. A dried sample (1.000 g) was mixed with vegetable oil in a centrifugal tube and left for 1 h at room temperature. The mixture was then centrifuged at 2500xg for 15 min. The supernatant was separated and the weight of the residue was recorded. OBC was expressed as follows:

OBC ($g.g^{-1}$) = (residue weight-dry weight) / dry weight

Rheological properties

Wheat flour was replaced with various brans at different levels (5, 10 and 15 %). Rheological properties of wheat

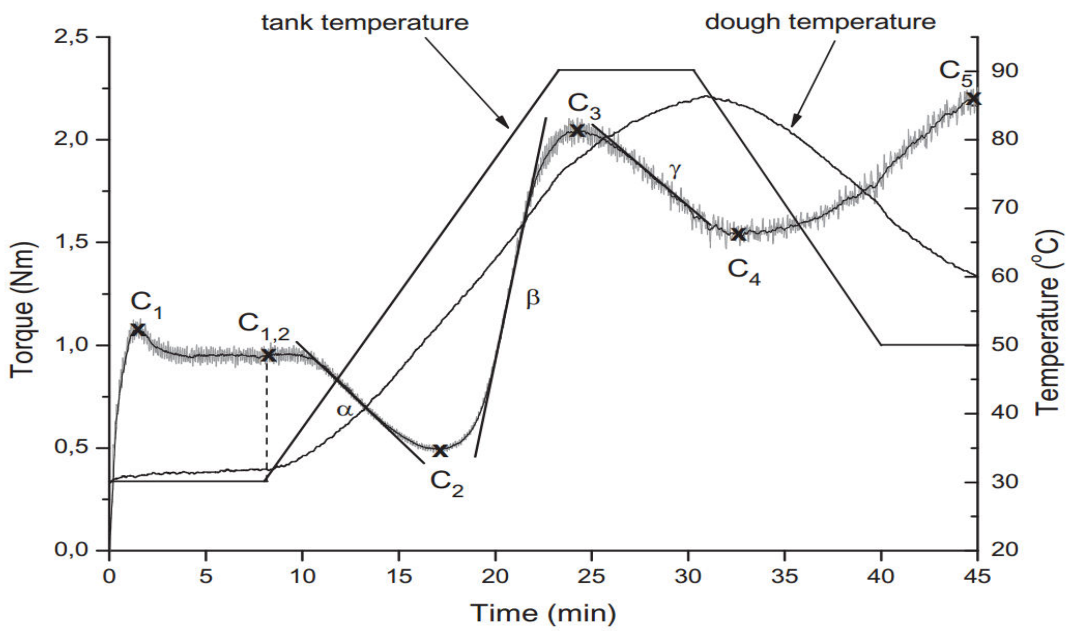

Figure 1 Typical Mixolab Curve **(Dapčević Hadnađev et al., 2011)**.

dough enriched with bran were determined using Mixolab (Chopin Villeneuve-la-Garenne, France) according to **Jia et al. (2011)**. The settings used in the test were 8 min at 30°C with a temperature increase of 4°C/min until the mixture reached 90°C. There was a 7-min holding period at 90°C, followed by a temperature decrease of 4°C/min until the mixture reached 55°C, and then 6 min of holding at 55°C. The mixing speed during the entire assay was 80 rpm.

The typical Mixolab curve (Figure 1), showing the following parameters: water absorption (%) – WA or the percentage of water required for the dough to produce a torque of 1.1; dough development time (min) – DDT or the time to reach the maximum torque at 30 °C; stability (min) S or time until the loss of consistency is lower than 11% of the maximum consistency reached during the mixing; initial maximum consistency (Nm) – C1, used to determine the water absorption; torque at the end of the holding time at 30 °C (Nm) – C1.2; mechanical weakening (Nm) – the torque difference between C1 and C1.2; minimum consistency (Nm) – C2, the minimum value of torque produced by dough passage while being subjected to mechanical and thermal constraints; thermal weakening (Nm) – the difference between the C1.2 and C2 torques; pasting temperature (°C) – the temperature at the onset of this rise in viscosity; peak torque (Nm) – C3, the maximum torque produced during the heating stage; peak temperature (°C) – the temperature at the peak viscosity; minimum torque (Nm) – C4, minimum torque reached during cooling to 50°C; breakdown torque (Nm) – calculated as the difference between C3 and C4; final torque(Nm) – C5, the torque after cooling at 50°C; setback torque (Nm) – the difference between C5 and C4 torque **(Dapčević Hadnađev et al., 2011)**.

Statisic analysis

All measurement were carried out in triplicate and the results were expressed as mean standard deviation. Significant differences between mean values at significance level p <0.05 were compared using Student`s test using MS Excel version 2010.

RESULTS AND DISCUSSION

The hydration properties of dietary fiber determine their optimal usage levels in food because a desirable texture must be retained. Usually, the hydration properties are described by three different measurable parameters such as water holding, water retention and swelling capacity **(Raghavendra et al., 2006)**. The hydration properties and oil absorption capacity of bran from different wheat variety are presented in Table 1.

WHC is defined by the quantity of water that is bound to the fibers without the application of any external force, except for gravity and atmospheric pressure **(Raghavendra et al., 2006)**. Generally, it was observed that the WHC values for bran were higher than WHC for wheat flour. The polysaccharide constituents of dietary fibers are strongly hydrophilic. Water is held on the hydrophilic sites of the fiber itself or within void spaces in the molecular structure **(Mudgil and Barac, 2013)**. The highest WHC value (2.98 g.g^{-1}) was determined for SB, while the lowest WHC value was for B2 (2.27 g.g^{-1}). Higher WHC values were reported by **Lebesi and Tzia (2012)** for oat and rice bran (3.13 – 4.53 g.g^{-1}). The high WHC values could indicate a lightness improve of food products where they were added **(Sharoba et al., 2003)**.

The WRC is the quantity of water that remains bound to the hydrated fiber following the application of an external force (pressure or centrifugation) **(Chantaro et al., 2008)**. It was concluded that WRC ranged from 1.38 g.g^{-1} (B3) to 1.92 g.g^{-1} (B1), which were similar to data presented by **Esposito et al. (2005)** for wheat bran (1.5 – 2.1 g.g^{-1}). Dietary fibres with high WRC can be used as functional ingredients which can modify the viscosity and texture of some formulated foods **(Nandi and Ghosh, 2015)**.

SC indicates how much the fiber matrix swells as water is absorbed, including loosely associated water. It is a consequence of the macromolecule relaxation during hydration, which leads to an increment in the occupied volume by the fiber product. The greater capacity to swell is the most desirable parameter for the physiological functionality of DF **(Lebesi and Tzia, 2012)**. The SC values of bran determined in this study (3.97 – 5.21 mL.g^{-1}) were higher than those presented by **He et al. (2018)** for hard white winter wheat bran (1.6 – 2.8 mL.g^{-1}).

OBC is another important property for the ingredients used in the formulation and stabilisation of food with high percentage of fat and emulsion. In fact, insoluble fibres can retain up to five times of their mass in oil. It can be beneficial for flavour retention and yield improvement technology **(Yaich et al., 2015)**. Furthermore, the OBC of fiber sources samples are also related to the particle size, overall charge density and hydrophilic nature of the individual particles **(Sharoba et al., 2003)**. From the results concluded that OBC values of different bran (1.35 – 1.79 g.g^{-1}) were higher than were reported for crude and extruded wheat bran (1 – 1.25 g.g^{-1}) **(Yan et al., 2015)**.

Table 1 Functional properties of different wheat bran.

	WHC (g.g^{-1})	WRC (g.g^{-1})	SC (mL.g^{-1})	OBC (g.g^{-1})
WF	0.65 ±0.04	0.52 ±0.02	2.21 ±0.01	0.28 ±0.02
SB	2.98 ±0.07	1.68 ±0.02	5.19 ±0.01	1.73 ±0.01
LB	2.68 ±0.02	1.71 ±0.09	4.58 ±0.02	1.79 ±0.03
B1	2.59 ±0.09	1.92 ±0.04	3.97 ±0.04	1.41 ±0.01
B2	2.27 ±0.01	1.86 ±0.02	4.38 ±0.08	1.52 ±0.02
B3	2.44 ±0.08	1.38 ± 0.01	5.21 ±0.02	1.35 ±0.01

Note: B1 – bran from new variety of wheat, B2 – bran from variety with purple colour of grain, B3 – commercial wheat bran, LB – bran from crossbreed Lubica, OBC – oil binding capacity, SB – spelt bran, SC – swelling capacity, WF – wheat flour, WHC – water holding capacity, WRC – water retention capacity.

Rheological properties of dough are very important indices for product development in terms of product quality and process efficiency **(Minarovičová et al., 2017)**. Incorporation of fiber into wheat flour interacts directly with structural elements of the three dimensional gluten network and disrupts the starch-gluten matrix, affecting the rheological behaviour of blended dough during mixing, sometime causing negative effect on the finished bread quality **(Mironeasa and Codină, 2013)**. The mixing properties of wheat dough with addition of different bran are summarized in Figure 2.

WA, which is expressed as the quantity of water needed to reach the defined dough consistency, is mainly reflected the contents of gluten protein in wheat flour **(Teng et al., 2015)**. It was observed that WA increased with addition of bran at all addition levels compared to wheat flour (55.9%). High WA is important from the economical point of view and avoiding staling **(Mosharraf et al., 2009)**. From the results also concluded that WA significantly increased with addition of SB, LB, B1 and B2 at addition level 10 and 15%, while incorporation of B3 resulted in significantly higher WA at all addition levels. This effect can be explained by the high fibre content of bran, specifically of pentosans, which have a high water-absorption capacity, as the addition of fibre had a similar effect on water-absorption. The explanation of this phenomenon is based partly on the fact that the fibre structure contains a large number of hydroxyl groups, which interact with the hydrogen bonds of water **(Gómez et al., 2011)**. Similar observations were found in case of addition of wheat bran by other autors **(Aravind et al., 2011, Xiong et al. 2017)**.

DS is related to the quality of the protein matrix, which is easily damaged by the incorporation of other ingredients, due to gluten dilution **(Minarovičová et al., 2017)**. This study also showed that DS decreased with addition of different bran. Furthemore, the highest DS values were observed after addition of SB (10.40, 10.35 and 10.18 min). Similar effect was also previously observed by **Boita et al. (2016)** and **El-Sharnouby et al. (2012)** after addition of wheat bran and mixture of wheat bran and date powder to wheat dough.

DDT is an important factor because it reflects the time between the first addition of water and the time when the dough seems to have optimum elastic and viscous properties for the retention of gas. DDT depends on the water absorption speed of flour constituents to form a smooth and homogenous appearance **(Vizittiu et al., 2011)**. It was observed that DDT values significantly prolonged with increasing addition level of different bran except of addition B1 at level 5%. This effect could be attributed to a fiber-gluten interaction, which prevents protein hydration **(Messia et al., 2016)**. These results were in agreement with those obtained by **Gómez et al. (2011)** and **Xiong et al. (2017)** after incorporation of wheat bran to wheat dough.

The thermo-mechanical properties of composed dough were presented in Table 2. Parameter C2 shows that with increase in temperature and mixing stress, the dough strength decreases as a result of protein weakening **(Sharma et al., 2017)**. From the results it was stated, that with increasing addition level of different bran parameter C2 significantly decreased except of incorporation of SB at level 5 and 10%. The lower C2 torque demonstrating greater weakening in proteins **(Gulia and Khatkar, 2014)**. The high decrease in parameter C2 may be attributed to the gluten dilution, thus losing some of its elasticity and becoming more extensible and less resistant **(Mironeasa et al., 2016)**.

After C2 the torque starts to increase and this is the stage

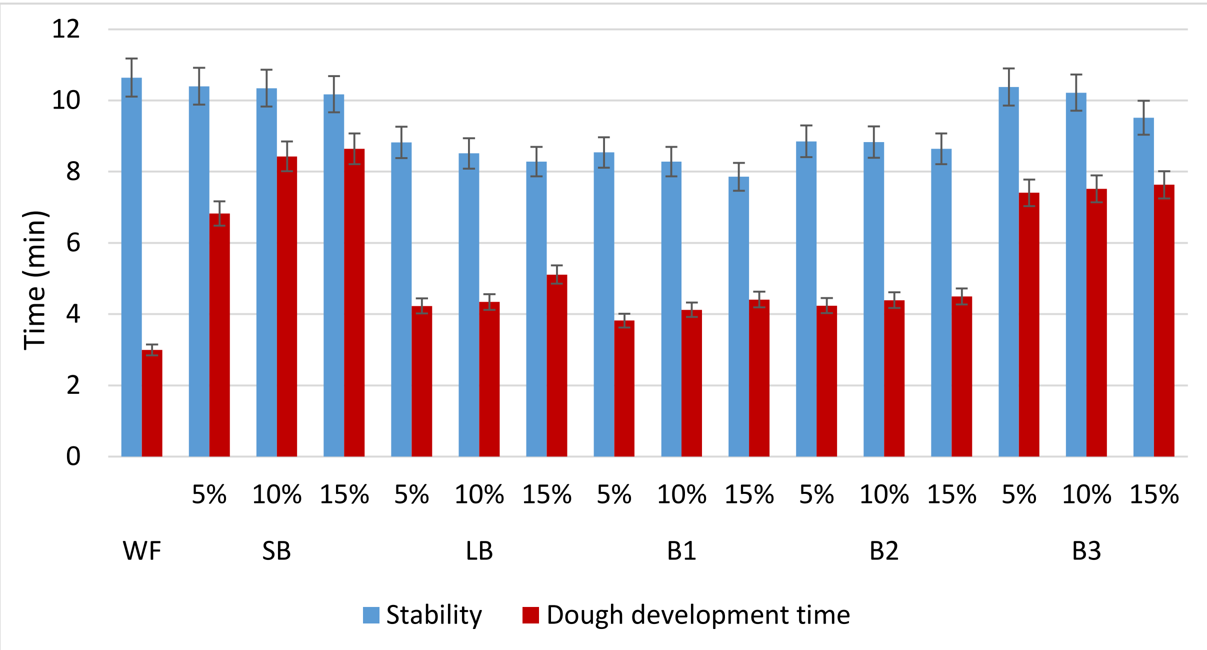

Figure 2 Dough development time and dough stability.
Note: B1 – bran from new variety of wheat, B2 – bran from variety with purple colour of grain, B3 – commercial wheat bran, LB – bran from crossbreed Lubica, SB – spelt bran, WF – wheat flour.

Table 2 Thermo-mechanical properties of dough with addition od different wheat bran.

		WA (%)	C2 (Nm)	C3 (Nm)	C4 (Nm)	C5 (Nm)
WF	0%	55.9 ±0.00	0.575 ±0.030	2.109 ±0.022	1.895 ±0.039	2.956 ±0.091
SB	5%	59.50 ±0.03	0.572 ±0.004	1.867 ±0.009*	1.599 ±0.021*	2.701 ±0.135*
	10%	61.50 ±0.00*	0.570 ±0.005*	1.841 ±0.013*	1.553 ±0.021*	2.618 ±0.045*
	15%	62.78 ±0.04*	0.569 ±0.009*	1.814 ±0.009*	1.496 ±0.022*	2.576 ±0.068*
LB	5%	56.60 ±0.00	0.458 ±0.011*	2.061 ±0.013*	1.808 ±0.065*	2.940 ±0.065
	10%	57.20 ±0.01*	0.451 ±0.016*	2.023 ±0.022*	1.753 ±0.035*	2.877 ±0.035*
	15%	57.48 ±0.05*	0.448 ±0.012*	1.992 ±0.024*	1.712 ±0.021*	2.744 ±0.021*
B1	5%	56.20 ±0.02	0.446 ±0.010*	2.010 ±0.018*	1.715 ±0.036*	2.806 ±0.089*
	10%	57.35 ±0.02*	0.430 ±0.017*	1.930 ±0.024*	1.594 ±0.025*	2.563 ±0.055*
	15%	57.75 ±0.03*	0.428 ±0.018*	1.891 ±0.028	1.507 ±0.047*	2.489 ±0.117*
B2	5%	56.33 ±0.08	0.462 ±0.013*	2.055 ±0.019*	1.833 ±0.081*	2.973 ±0.190
	10%	57.00 ±0.00*	0.455 ±0.008*	2.028 ±0.019*	1.766 ±0.020*	2.810 ±0.050*
	15%	58.00 ±0.00*	0.458 ±0.012*	1.984 ±0.013*	1.673 ±0.018*	2.742 ±0.017*
B3	5%	59.60 ±0.00*	0.563 ±0.011*	1.839 ±0.027*	1.537 ±0.039*	2.452 ±0.070*
	10%	61.40 ±0.01*	0.546 ±0.006*	1.801 ±0.003 *	1.460 ±0.026*	2.347 ±0.062*
	15%	61.87 ±0.00*	0.531 ±0.023*	1.751 ±0.045*	1.373 ±0.018*	2.300 ±0.043*

Note: B1 – bran from new variety of wheat, B2 – bran from variety with purple colour of grain, B3 – commercial wheat bran, LB – bran from crossbreed Lubica, SB – spelt bran, WA – water absorption, WF – wheat flour, * denotes statistically significant difference at p <0.05 level.

when gelatinization process starts and it keeps on increasing till C3 is reached. The C3 is the maximum torque obtained during the heating stage resulting in increase in consistency due to bursting of the starch granules (**Sharma et al., 2017**). WF contributed to a better starch performance of the samples (higher starch gelatinization, C3) than composite flour with bran. This could be ascribed to the competence for water established between the starch and the bran (**Hadnadev et al., 2011**). The C3 value for WF was 2.11 Nm. As can be seen from the Table 2, values C3 decreased with increasing addition level of bran. The lowest values were observed for dough with addition of B3.

The further viscosity reduction in C4 is the result of the physical breakdown of the granules due to the mechanical shear stress and the temperature constraint (**Hadnadev et al., 2011**). It was observed that addition of different bran significantly decreased C4 values at all addition levels. A lower torque indicates lower stability of hot-formed gel (**Gulia and Khatkar, 2014**). Bran is mainly from the grain mantle that contains also large quantity of α-amylases the cause of the reduction of the above mentioned values (**Xhabiri et al., 2013**).

The C5 is the maximum torque of the cooling stage, which reflects starch retrogradation (**Wang et al., 2017**). This study also showed, that addition of SB and B3 significantly decreased the C5 values at all addition levels. Furthermore, it was found that the lowest values were recorded after incorporation of bran B3. Lowering in starch recrystallization rate could progressively prolong a shelf-life of end product (**Švec and Hrušková, 2015**).

CONCLUSION

In this study the functional properties of different wheat bran (spelt bran, wheat bran from new wheat variety and bran from crossbreed of *Triticum aestivum* x *Triticum spelta*) were evaluated. Rheological properties of dough with addition of bran were also examined. In general, bran from different wheat variety were characterised with good hydration properties. Spelt bran was characterized with the highest water absorption value. From the results also concluded, that addition of different bran had significant (p <0.05) effect on mixing and pasting properties of wheat dough. The water absorption increased and dough development time prolonged with addition of bran, while dough stability decreased. The highest value of water absorption was observed after incorporation of spelt bran. This study also showed that increasing of addition level of different bran significantly (p <0.05) affected the weakening of protein structure (C2), stability of hot-formed gel (C4) and retrogradation of starch (C5).

REFERENCES

Aravind, N., Sissons, M., Egan, N., Felows, Ch. 2012. Effect of insoluble dietary fibre addition on technological, sensory, and structural properties of durum wheat spaghetti. *Food Chemistry*, vol. 130, no. 2, p. 299-309. https://dx.doi.org/10.1016/j.foodchem.2011.07.042

Boita, E. R. F., Oro, T., Bressiani, J., Santetti, G. S., Bertolin, T. E., Gutkoski, L. C. 2016. Rheological properties of wheat flour dough and pan bread with wheat bran. *Journal of Cereal Science*, vol. 71, p. 177-182. https://dx.doi.org/10.1016/j.jcs.2016.08.015

Chantaro, P., Devahastin, S., Chiewchan, N. 2008. Production of antioxidant high dietary fiber powder from carrot peels. *LWT - Food Science and Technology*, vol. 41, no. 10, p. 1987-1994. https://dx.doi.org/10.1016/j.lwt.2007.11.013

Constantinescu, G., Dabija, A., Buculei, A., Rebenciuc, I. 2011. Evaluation of cereal cultivar impact on bread quality. *Journal of Agroalimentary Processes and Technologies*, vol. 17, no. 4, p. 473-476.

Dapčević Hadnađev, M., Torbica, A., Hadnađev, M. 2011. Rheological properties of wheat flour substitutes/alternative crops assessed by Mixolab. *Procedia Food Science*, vol. 1, p. 328-334. https://dx.doi.org/10.1016/j.profoo.2011.09.051

de Escalada Pla, M. F., Uribe, M., Fissore, E. N., Gerschenson, L. N., Rojas, A. M. 2010. Influence of the isolation procedure on the characteristics of fiber-rich products obtained from quince wastes. *Journal of Food Engineering*, vol. 96, no. 2, p. 239-248. https://dx.doi.org/10.1016/j.jfoodeng.2009.07.018

El-Sharnouby, G. A., Aleid, A. M., Al-Otaibi, M. M. 2012. Nutritional quality of biscuit supplemented with wheat bran and date palm fruits (*Phoenix dactylifera* L.). *Food and Nutrition Sciences*, vol. 3, no. 3, p. 322-328. http://dx.doi.org/10.4236/fns.2012.33047

Esposito, F., Arlotti, G., Bonifati, A. M., Napolitano, A., Vitale, D., Fogliano, V. 2005. Antioxidant activity and dietary fibre in durum wheat bran by-products. *Food Research International*, vol. 38, no. 10, p. 1167-1173. https://dx.doi.org/10.1016/j.foodres.2005.05.002

Gómez, M., Jiménez, S., Ruiz, E., Oliete, B. 2011. Effect of extruded wheat bran on dough rheology and bread quality. *LWT – Food Science and Technology*, vol. 44, no. 10, p. 2231-2237. https://dx.doi.org/10.1016/j.lwt.2011.06.006

Gotti, R., Amadesi, E., Fiori, J., Bosi, S., Bregola, V., Marotti, I., Dinelli, G. 2018. Differentiation of modern and ancient varieties of common wheat byquantitative capillary electrophoretic profile of phenolic acids. *Journal of Chromatography A*, vol. 1532, p. 208-215. https://dx.doi.org/10.1016/j.chroma.2017.11.058

Gulia, N., Khatkar, B. S. 2014. Relationship of dough thermomechanical properties with oil uptake, cooking and textural properties of instant fried noodles. *Food Science and Technology International*, vol. 20, no. 3, p. 171-182. https://dx.doi.org/10.1177/1082013213476076

He, S., Li, J., He, Q., Jian, H., Zhang, Y., Wang, J., Sun, H. 2018. Physicochemical and antioxidant properties of hard white winter wheat (*Triticum aestivm* L.) bran superfine powder produced by eccentric vibratory milling. Powder Technology, vol. 325, p. 126-133. https://dx.doi.org/10.1016/j.powtec.2017.10.054

Jacobs, P. J., Hemdane, S., Dornez, E., Delcour, J. A., Courtin, Ch. M. 2015. Study of hydration properties of wheat bran as a function of particle size. *Food Chemistry*, vol. 179, p. 296-304. https://dx.doi.org/10.1016/j.foodchem.2015.01.117

Jefremova, O., Radenkovs, V., Kunkulberga, D., Klava, D. 2015. Technological properties of dough from wheat flour and fermented bran. *Chemical Technology*, vol. 66, no. 1, p. 13-18.

Jia, Ch., Huang, W., Abdel-Samie, M. A.-S., Huang, G., Huang, G. Dough rheological, Mixolab mixing, and nutritional characteristics of almond cookies with and without xylanase. *Journal of Food Engineering*, vol. 105, no. 2, p. 227-232. https://dx.doi.org/10.1016/j.jfoodeng.2011.02.023

Lebesi, D. M., Tzia, C. 2012. Use of endoxylanase treated cereal brans for development of dietary fiber enriched cakes. *Innovative Food Science & Emerging Technologies*, vol. 13, p. 207-214. https://dx.doi.org/10.1016/j.ifset.2011.08.001

Messia, M. C., Reale, A., Maiuro, L., Candigliota, T., Sorrentino, E., Marconi, E. 2016. Effects of pre-fermented wheat bran on dough and bread characteristics. *Journal of Cereal Sience*, vol. 69, p. 138-144. https://dx.doi.org/10.1016/j.jcs.2016.03.004

Minarovičová, L., Lauková. M., Kohajdová, Z., Karovičová, J., Kuchtová, V. Effect of pumpkin powder incorporation on cooking and sensory parameters of pasta. *Potravinarstvo Slovak Journal of Food Sciences*, vol. 11, no. 1, p. 373-379. https://dx.doi.org/10.5219/743

Mironeasa, S., Codină, G. G. 2013. Effect of citrus fibers addition on wheat flour dough rheological properties. *Food and Environment Safety*, vol. 12, no. 4, p. 322-327.

Mironeasa, S., Codina, G. G. 2016. The mixolab rheological properties and dough microstructure of defatted mustard seed–wheat composite flours. *Journal of Food Processing and Preservation*, vol. 41, no. 5, e13130. https://dx.doi.org/10.1111/jfpp.13130

Mosharraf, L., Kadivar, M., Shahedi, M. 2009. Effect of hydrothermaled bran on physicochemical, rheological and microstructural characteristics of Sangak bread. *Journal of Cereal Science*, vol. 49, no. 3, p. 398-404. https://dx.doi.org/10.1016/j.jcs.2009.01.006

Mudgil, D., Barak, S. 2013. Composition, properties and health benefits of indigestible carbohydrate polymers as dietary fiber: A review. *International Journal of Biological Macromolecules*, vol. 61, p. 1-6. https://dx.doi.org/10.1016/j.ijbiomac.2013.06.044

Nandi, I., Gosh, M. 2015. Studies on functional and antioxidant property of dietary fibre extracted from defatted sesame husk, rice bran and flaxseed. *Bioactive Carbohydrates and Dietary Fibre*, vol. 5, no. 2, p. 129-13. https://dx.doi.org/10.1016/j.bcdf.2015.03.001

Raghavendra, S. N., Ramachandra Swamy, S. R., Rastogi, N. K., Raghavarao, K. S. M. S., Kumar, S., Tharanathan, R. N. 2006. Grinding characteristics and hydration properties of coconut residue: A source of dietary fiber. *Journal of Food Engineering*, vol. 72, no. 3, p. 281-286. https://dx.doi.org/10.1016/j.jfoodeng.2004.12.008

Rodriguez-Sandoval, E., Sandoval, G., Cortes-Rodríguez, M. 2012. Effect of Quinoa and Potato Flours on the Thermomechanical and Breadmaking Properties of Wheat Flour. *Brazilian Journal of Chemical Engineering*, vol. 29, no. 3, p. 503-510. https://dx.doi.org/10.1590/S0104-66322012000300007

Sangnark, A., Noomhorm, A. 2004. Chemical, physical and baking properties of dietary fiber prepared from rice straw. *Food Research International*, vol. 37, no. 1, p. 66-74. https://dx.doi.org/10.1016/j.foodres.2003.09.007

Sharoba, A. M., Farrag, M. A., Abd El-Salam, A. M. 2013. Utilization of some fruits and vegetables waste as a source of dietary fiber and its effect on the cake making and its quality attributes. *Journal of Agroalimentary Processes and Technologies*, vol. 19, no. 4, p. 429-444.

Švec, I., Hrušková, M. 2015. The Mixolab parameters of composite wheat/hemp flour and their relation to quality features. *LWT – Food Science and Technology*, vol. 60, no. 1, p. 623-629. https://dx.doi.org/10.1016/j.lwt.2014.07.034

Teng, Y., Liu, C., Bai, J., Liang, J. 2015. Mixing, tensile and pasting properties of wheat flour mixed with raw and enzyme treated rice bran. *Journal of Food Science and Technology*, vol. 52, no. 5, p. 3014-3021. https://dx.doi.org/10.1007/s13197-014-1366-y

Vizitiu, D., Danciu, I. 2011. Evaluation of farinograph and mixolab for prediction of mixing properties of industrial wheat flour. *Acta Universitatis Cibiniensis Series E: Food Technology*, vol. 15, no. 2, p. 31-38.

Xhabiri, G. Q., Durmishi, N., Idrizi, X., Ferati, I., Hoxha, I. 2016. Rheological Qualities of Dough from Mixture of Flour and Wheat Bran and Possible Correlation between Bra Bender and Mixolab Chopin Equipments. *MOJ Food Processing & Technology*, vol. 2, no. 4, p. 1-7. https://dx.doi.org/10.15406/mojfpt.2016.02.00042

Xiong, L., Zhang, B., Niu, M., Zhao, S. 2017. Protein polymerization and water mobility in whole-wheat dough influenced by bran particle size distribution. *LWT - Food Science and Technology*, vol. 82, p. 396-403. https://dx.doi.org/10.1016/j.lwt.2017.04.064

Yaich, H., Garna, H., Bchir, B., Besbes, S., Paquot, M., Richel, A., Blecker, Ch., Attia, H. 2015. Chemical composition and functional properties of dietary fibre extracted by Englyst and Prosky methods from the alga Ulva lactuca collected in Tunisia. *Algal Research*, vol. 9, p. 65-73. https://dx.doi.org/10.1016/j.algal.2015.02.017

Yan, X., Ye, R., Chen, Y. 2015. Blasting extrusion processing: The increase of soluble dietary fiber content and extraction of soluble-fiber polysaccharides from wheat bran. *Food Chemistry*, vol. 180, p. 106-115. https://dx.doi.org/10.1016/j.foodchem.2015.01.127

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