Possibilities of using purple wheat in producing bakery products

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Abstract: The aim of the study was to assess the possibilities of using grain mill products (flour, semolina and bran) obtained by milling purple grain wheat (variety Konini) in bakery products. The attention was focused on the use of bran with high levels of anthocyanins characterised by high antioxidant capacity. Mixtures were prepared with the mixture of bran making 10 – 30% of the total quantity of mill products. The addition of bran particles caused a negative impact on some sensory properties such as curvature of bread, crumb texture or taste. The product crust colour was significantly influenced as determined using the Konica Minolta Spectrophotometer CM-3500D unit. After adding bran, changes in texture were not only visual but also reflected in the physical analysis made using TIRAtest. It was shown that the addition of bran should not exceed more than 10% of the total mixture.

Key-Words: - wheat, purple pericarp, anthocyanins, bran, baking quality

Introduction

Currently gaining importance are the genotypes of wheat with caryopses of different colours, such as purple, blue, yellow and white. The colouring is due to the presence of colour pigments included in xanthophylls, carotenoids, anthocyans and anthocyanins. As regards the purple-coloured grain, this is mainly due to anthocyans. Found chiefly as cyanidin-3-glucoside and peonidin-3-glucoside (Knievel *et al* 2009), the substances possess a high antioxidant effect. In addition to preventing oxidative damage, they are capable of binding heavy metals (zinc, iron and copper) and acting pre-emptively against cardiovascular disease, cancer, rheumatoid arthritis, neurodegenerative disease, and diabetes mellitus, type 2 (Lutsey *et al* 2007, Fang *et al* 2002). With the content and the effect of the substances, coloured wheat grains find applications in the production of functional foods. In purple-coloured caryopses, pigments are stored in the pericarp. Due to the location of the colour pigment in the caryopsis, the addition of bran into the dough is necessary to increase the content of anthocyanins in the product which however may lead to a negative impact on certain properties of the bakery product. Other health-beneficial substances contained in purple wheat include phenolic compounds. These are usually found in the wheat grain as ferulic acid and vanillic acid. Found in wheat bran is also *p*-coumaric acid along with other free phenolic acids such as caffeic acid, chlorogenic acid, gentisic acid, syringic acid and *p*-hydroxybenzoic acid (Liu, 2007). Kequan *et al* (2005) indicate that purple wheat contains higher levels of ferulic acid in comparison with other types. Liu *et al* (2010) report a higher content of sinapinic acid. The content of phenolic acids is influenced by genetics, environmental factors and other stressors (Mpofu *et al* 2006). This study aimed at assessing the potential of mill products obtained by processing purple wheat grain (the Konini variety) for the production of bakery products.

Material and Methods

The evaluation was based on Konini, the variety of purple wheat grown in Brno-Chrlice and harvested in 2013. Konini has a purple pericarp and is a winter variety. The grains were ground using Chopin, the laboratory mill. A baking experiment was made (Rapid mix test; Tab. 1). The trial used various proportions of milling fractions sourced from the milled purple wheat grains (Tab. 2). The variant 3 differed from variant 4 in that the bran employed for variant 3 was pulverised before use. In all the variants, bran was soaked the day before. Afterwards, it was sorted out via a sifter and excess water removed by squeezing. The water absorbed by the bran was deducted from that specified in the formulation.

Table 1 Baking experiment formulation

Wheat flour	500 g
Salt	7.5 g
Sugar	5 g
Yeast	25 g
Oil	5 g
Water	300 ml

The dough was prepared from all ingredients using a straight dough process, kneaded for about 1 minute using a mixer and allowed to rise in a proofer for 20 minutes at 32 ± 1 °C and humidity of 80 % ± 5 %. After removal from the proofer, the dough was allowed to rest for 10 minutes and then it was weighed down. Loaves were shaped, the weight of each being 80 g, and allowed to rise once again at 32 ± 1 °C and the humidity of 80 % ± 5 %, which this time took 25 minutes. Before loading into the oven, the loaves were moistened with water and then baked at 230 - 240 °C. At the beginning of the baking process, the oven was steamed with 50 ml of water. The baking time was 20 minutes.

Table 2. Trial variants

Variant	% bran	% semolina	% flour
1	0	0	100
2	10	10	80
3	20	10	70
4	20	10	70
5	30	10	60

Subsequently, the baked products were sensorially evaluated by experienced specialists (n = 10). The sensory analysis involved evaluating the following descriptors: volume, shape, colour, integrity, gloss, porosity, aroma and taste. The sensory evaluation of the baking trial was making use of unstructured graphic scales. The bread colour was measured using Konica Minolta Spectrophotometer CM-3500D. Modes chosen for the colorimetric determination of colour within the baking experiment were as follows: reflectance, d/8 geometry (*the instrument measures the reflected light at an angle of 8°*), SCE (specular component excluded - eliminating gloss), D 65 (illumination mode; 6.500 Kelvin), 30 mm slit. Statistical evaluation of colour was done by means of the UNISTAT 5.1 software and used analysis of variance (ANOVA) followed by testing for the significance level of P <0.05 (Tukey test). Evaluation of ΔE^*_{ab} (the rate of the size of the colour difference; CIE 1976) was done using MS Excel 2010 under the equations listed below; the total difference in colour was commented by Třešňák (1999).

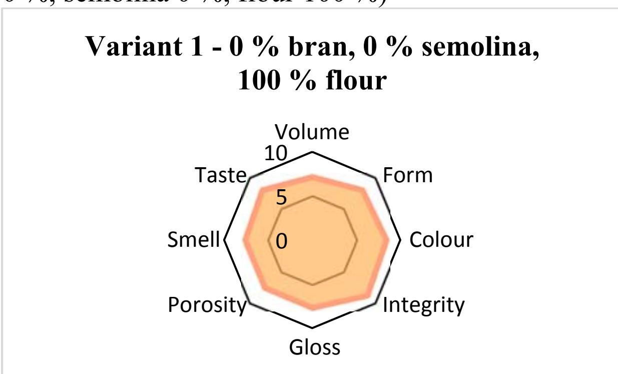
$$\Delta E^* = \sqrt{\Delta L^{*2} + \Delta a^{*2} + \Delta b^{*2}}$$
$$\Delta L^* = L^*_{sample} - L^*_{model}$$
$$\Delta a^* = a^*_{sample} - a^*_{model}$$
$$\Delta b^* = b^*_{sample} - b^*_{model}$$

A penetration test was done using the TIRAtest 27025 device. The penetration test used a probe was with a diameter of 3 mm, and a force sensor of 200 N. The test speed v_1 corresponded to 50 mm·min^{-1} and the pathway was 10 mm. A record was obtained of the force required to push the plunger to the desired depth of the baked product.

Results and Discussion

Variant 1 was used as a control for this baking experiment. The baking products possessed a large volume and regular shape. The crust was integral and of typically colour (golden-brown). The glaziness of the surface was rather low. The crumb had uniform, thin-walled pores. The aroma and taste was indicated as being characteristic, pleasant (Fig. 1).

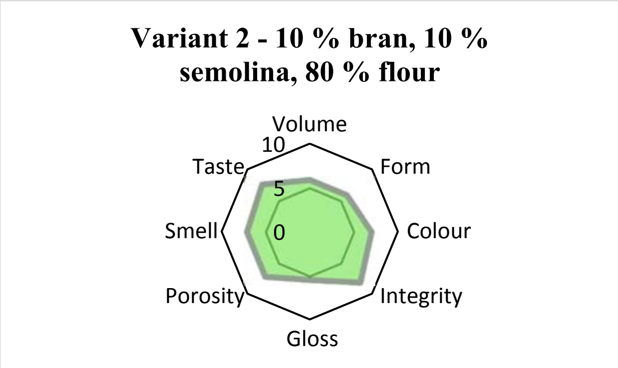
Fig. 1. Variant 1 of the baking experiment (bran 0 %, semolina 0 %, flour 100 %)



Variant 2 (Fig. 2) showed a slight decrease in the volume and a change in the shape against the control; the shape turned from regular, arched to slightly arched. Despite the above, these parameters were evaluated as the most acceptable of all the variants

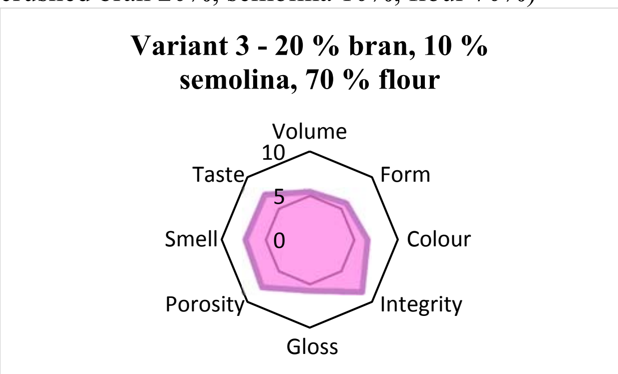
where bran was added. The same applied to the evaluation of the colour and taste. The crust was integral and rather dull. The crumb porosity was comparable to the control.

Fig. 2 Variant 2 of the baking experiment (bran 10%, semolina 10%, flour 80%)



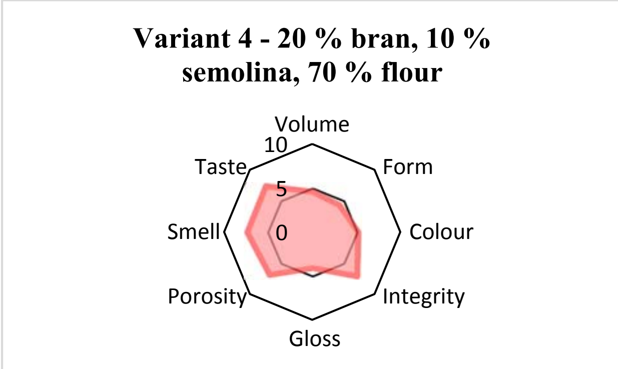
For baking products which contained 20 % of fine-crushed bran in their formulations, the crust integrity and crumb porosity were the properties evaluated the best of all experiment variants. The volume was less than with the control and variant 2, the shape was less arched. The aroma and colour of the products were comparable to variant 2. The taste was perceived by the evaluators as the second worst of all the presented samples (Fig. 3).

Fig. 3 Variant 3 of the baking experiment (fine-crushed bran 20%, semolina 10%, flour 70%)



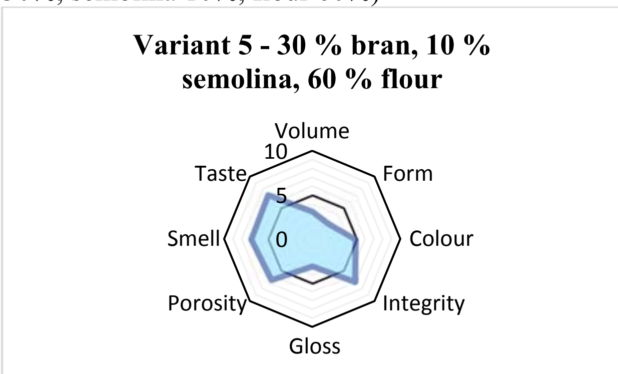
For variant 4 (Fig. 4), the same amount of bran was added as for variant 3. The exception was that the bran was not modified any further, the bran treatment before use causing the evaluators to have different perception of sensory indicators. Compared to the previous variant, the product height was low with less volume. The larger particle size of bran disrupts the gluten structure to the more extent, consequently reducing the product volume (Lai *et. al*, 1989). Sensory descriptors such as colour, integrity, product gloss and crumb porosity influenced the evaluators better in the previous variant. In contrast, the aroma and the taste were sweeter, cleaner and more distinctive.

Fig. 4 Variant 4 of the baking experiment (bran 20%, semolina 10%, flour 70%)



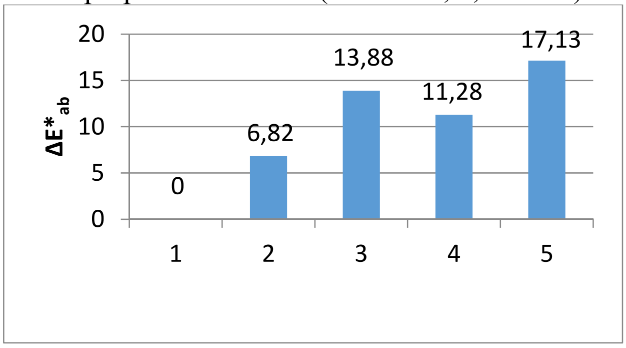
The last variant contained the highest proportion of purple wheat bran of all the test variants. All the descriptors reached the lowest values of total sensory evaluation, with the volume, shape, gloss and product colour showing the greatest difference of the evaluated parameters compared with the control (Fig. 5).

Fig. 5 Variant 5 of the baking experiment (bran 30%, semolina 10%, flour 60%)



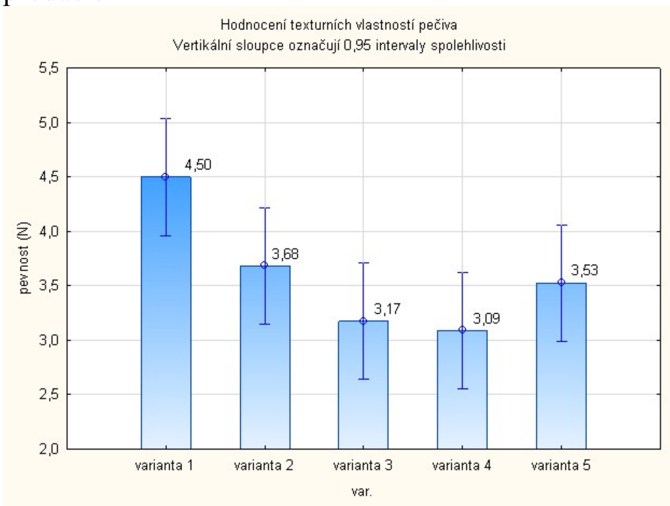
To objectively assess colour, analysis was done using the Konica Minolta spectrophotometer, with a discordant or very prominent difference found among the samples compared with the control (Tab. 3). Fig. 6 shows that there was a very prominent difference between the control and variants 3 and 5 with these two variants being significantly darker than the control, which for variant 5 was due to the largest addition of bran into the dough, while bran treatment before use was involved with variant 3. Even though variants 3 and 4 contained the same proportion of bran, for variant 4 the colour difference against the control was not so great in comparison with variant 3 (ΔE^*_{ab}= 11.3). The difference ΔE^*_{ab} between variant 3 and variant 4 was 4.2, which indicates a medium degree of colour variation. The smallest, but moderately discordant difference was found between the control and variant 2 (ΔE^*_{ab}= 6.8).

Fig. 6. The rate of the extent of the colour difference between the control (variant 1) and samples with varied proportions of bran (variants 2, 3, 4 and 5)



The TIRAtest 27025 unit was used to determine the force required to push the plunger to the desired depth of the baking product. As can be seen on Fig. 7, the greatest force required to break the crust was necessary to exert for variant 1 (control; 4.5 N). As the bran addition into the products increased, the firmness decreased. The increasing proportion of bran reduced that of flour in the dough, thus the quantity of gluten that forms the skeleton of the baking product. Bran disrupts the gluten structure. Glutenins, as components of gluten, are substances that provide strength and stability to the dough (Příhoda *et al* 2003; Noort *et. al* 2010). The lowest strength was measured for variant 4 (3.09 N). For variant 5, where the measured strength was 3.53 N, it is possible that there was an error in measurements.

Fig. 7 Evaluation of textural properties of baking products



Tab. 3. The evaluation of colour differences per baking experiment depending on the formulation

	Variant 1	Variant 2	Variant 3	Variant 4	Variant 5
L* (D65)	58.86 ± 1.37^a	55.25 ± 0.82^b	51.11 ± 0.33^c	50.73 ± 1.36^c	48.69 ± 0.21^d
a* (D65)	17.39 ± 0.12^a	14.03 ± 0.34^c	13.07 ± 0.74^c	16.01 ± 0.30^b	13.24 ± 0.21^c
b* (D65)	38.69 ± 1.23^a	33.98 ± 1.46^b	28.01 ± 0.74^c	30.99 ± 0.86^c	25.54 ± 0.27^d
ΔE^*_{ab}	-	6.8*	13.9**	11.3**	17.1***

[a, b, c, d] - The letters with different indices in the rows denote statistically significant differences ($P < 0.05$)

** - Indicates an already moderately discordant difference compared with the control*

*** - Indicates a very prominent difference compared with the control*

**** - Indicates a disturbing difference compared with the control*

Conclusion

Based on the results of the sensory analysis and the strength test it can be argued that the bran addition into the dough should not exceed 10 % of the total mill fractions in the bakery production making use of purple wheat. Products made of purple wheat are a source of health-beneficial compounds. Quantifying and evaluating the effect of these after baking should be the subject of further studies.

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