USE OF COLOUR VARIETIES OF WHEAT IN THE BAKERY INDUSTRY

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Abstract: Coloured wheat represents an interesting raw material for the food industry not only in terms of new products, but also for its positive effects on human health. We have tested four varieties of coloured wheat – Konini, Rosso, Scorpion, and UC66049. From the milling fractions obtained by milling grains of coloured wheat, we have compiled 11 pastry recipes. The results of sensory analysis indicate that the best variants for preparation of pastry recipes are variants 2, 9, and 10. Variant 2 contained only flour milled from the Konini variety. Variants 9 and 10 contained an admixture of 10% of bran particles. Variant 9 was produced from the Rosso flour variety and variant 10 from the Scorpion variety.

Key Words: coloured wheat, pastry, bran, texture, sensory analysis

INTRODUCTION

In our study, we have used grain of coloured wheat with purple pericarp (Konini and Rosso varieties) and blue aleurone (Scorpion and UC66049 varieties). Different coloration of the kernels is due to the presence of colour pigments from the group of xanthophylls, carotenoids, anthocyans, and anthocyanins. In the purple wheat grain, the dominant anthocyans include cyanidin-3-glucoside and peonidin-3-glucoside. In the aleurone layer of blue wheat, the most common is delphinidin-3-glucoside (Knievel et al. 2009). Anthocyans have a high antioxidant effect and prevent many diseases. Blue-grain wheat generally has a higher content of anthocyans than wheat with purple pericarp (Martinek et al. 2012). In the whole-grain, blue-wheat flour, the content of anthocyans is about 152.6 mg · kg^{-1}, while the whole-grain purple-wheat flour contains about 92.83 mg · kg^{-1} of anthocyans (Abdel-Aal, Hucl 2003). Coloured wheat contains higher proportions of phenolic compounds represented mainly by ferulic acid, vanillic acid, p-coumaric acid, and the like (Kequan et al. 2005, Liu 2007). Thanks to the health benefits of these substances, the interest in the use of coloured wheat in food is increasing. Due to the location of colour pigments in caryopsis, in order to increase the content of anthocyans in the product, it requires the addition of bran to the dough. However, this can lead to negative influence on certain characteristics of bakery products, such as the reduction in volume. In contrast, adding bran to the dough may extend the shelf life of products and equally important is the positive effect of fibre on human health (Kurek, Wyrwisz 2015).

MATERIALS AND METHODS

For the evaluation, we have used four varieties of coloured wheat harvested in 2014 - Konini, Rosso, Scorpion, and UC 66049. The Konini variety was used from both 2013 and 2014 harvests. For all varieties of coloured wheat, we have first established the basic parameters of milling and baking qualities. Then we have milled the grain using a laboratory mill Chopin CD1. We have carried out a baking experiment (Table 1). It was used fresh yeast. Within the baking experiment, we have baked and evaluated 11 pastry recipes (Table 2).

Table 1 Recipe for the baking experiment

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

Table 2 Variants of the experiment

Var.	Recipe	
	Flour	Bran
1	500 g flour from the market	0 g
2	500 g Konini 2013	0 g
3	500 g Konini 2014	0 g
4	500 g Rosso	0 g
5	500 g Scorpion	0 g
6	500 g UC66049	0 g
7	450 g Konini 2013	50 g Konini 2013
8	450 g Konini 2014	50 g Konini 2014
9	450 g Rosso	50 g Rosso
10	450 g Scorpion	50 g Scorpion
11	450 g UC66049	50 g UC66049

We have prepared the dough via mixing of all raw materials at once. The dough was kneaded in a dough-kneader for about one minute. We let it rise in a proofer at 32 ± 1°C and humidity of 80 ± 5% for 20 minutes. After removal from the proofer, we let the dough rest for 10 minutes and weighed it. The dough was shaped into the desired pieces weighing 80 g and then it was allowed to rise again at 32 ± 1°C and humidity of 80 ± 5%, this time for 25 minutes. Before loading the pieces into the oven, we have sprinkled them with water, and baked at 230°C to 240°C in a laboratory oven with a proofer. At the beginning of the baking, the oven was steamed with 50 ml of water. The baking time was 20 minutes. Subsequently, experienced evaluators have evaluated the baked goods via sensory method (n = 10). For the sensory evaluation of the baking experiment, we have used unstructured graphic scales.

We have measured the pastry colour using the Konica Minolta Spectrophotometer CM-3500d. For colorimetric determination of colour within the baking experiment, we have chosen the following regimens: reflectance, geometry d/8 (the instrument measures the reflected light at an angle of 8°), SCE (specular component excluded - with the elimination of gloss), D 65 (illumination mode – 6,500 Kelvin), and aperture 30 mm. We have carried out statistical evaluation of colour using a programme UNISTAT 5.1. We have used analysis of variance (ANOVA) followed by testing for the significance level P <0.05 (Tukey test). Evaluation of ΔE^*_{ab} (a measure of the size of the colour difference; CIE 1976) was conducted in MS Excel 2010 using the following equations and the total colour difference was commented according to Třešňák (1999).

$$\Delta E^* = \sqrt{\Delta L^{*2} + \Delta a^{*2} + \Delta b^{*2}}$$

$$\Delta L^* = L^*_{vzorku} - L^*_{předlohy}$$

$$\Delta a^* = a^*_{vzorku} - a^*_{předlohy}$$

$$\Delta b^* = b^*_{vzorku} - b^*_{předlohy}$$

Legend: *vzorku = sample*

předlohy = control sample

To assess the integrity of pastry, we have carried out the penetration test via the TIRATEST 27025 device. For the penetration test, we have used a probe 3 mm in diameter and a force sensor 200 N. The test speed v_1 corresponds to 50 mm·min^{-1} and distance of 10 mm. We have obtained the recording of force required to push the punch to the desired depth of pastry. The measurement took place one hour after baking the samples. We have analysed the results of textures and sensory analysis using the ANOVA statistical method in the STATISTICA 12 program.

RESULTS AND DISCUSSION

The results of the baking experiment are in the Table 3. Mass values of all experimental dough variants did not distinctly differ from one another. Greater differences were apparent in the mass of baked products. These differences were caused by losses during baking. The highest loss (16.5%) was observed in variant 2 (Konini 2013), while the lowest loss (11.1%) was in variant 1 (control). Losses during baking of common pastry range between 10 and 13%, depending on the shape and weight of the product, as well as baking time and temperature, dough moisture, or kind of flour (Hampl, Příhoda 1985). In our case, it was mainly the effect of the type of flour and recipe, because all pastry variants were made under the same conditions. The most important quality parameter is the specific volume of pastry. The higher specific volume of pastry, the more suitable is wheat variety for bakery production (Müllerová, Skoupil 1988). Specific volume was the highest (291 ml/100 g) for variant 6 (UC66049). For the UC variety, the determined enzymatic activity of grain was moderate (214 s), while in all the other varieties of coloured wheat the amylase activity was evaluated as low. Amylases convert starch into simple sugars which are then converted to CO_2 by yeast. The higher activity of amylase in the UC variety caused a creation of greater amount of fermentable sugars and consequently a greater amount of air bubbles and thus even higher pastry volume. All pastry samples made from flour of coloured wheat without addition of bran, with the exception of variant 4 of the Rosso variety, showed greater specific volume relative to the control. The lowest specific volume was reported in variant 9 (Rosso + bran). Of all colourful wheat varieties, the Rosso variety had the lowest content of gluten (36.6%), which forms the supporting skeleton of pastry. Overall, the variants with added bran had lower average specific volume compared to pastry made from flour only. In addition, bran particles disrupt the gluten structure, while also bind large quantities of water, which is needed for the development of gluten. Insufficient formation of gluten and disruption of its structure in turn results in lower pastry volume (Brennan, Cleary 2007).

Table 3 Results of the baking experiment

Variant	Dough weight (g)	Pastry weight (g)	Yield of pastry (%)	Baking loss (%)	Specific volume (ml/100g)	Index number (height/average)
1	830	737	147	11.1	251	0.6
2	832	695	139	16.5	281	0.52
3	829	710	142	14.4	282	0.61
4	835	722	144	13.6	242	0.55
5	829	723	146	12	253	0.52
6	833	732	146	12.1	291	0.59
7	833	714	143	14.3	273	0.6
8	835	702	140	15.9	235	0.51
9	835	728	146	12.8	213	0.66
10	835	705	141	15.6	220	0.55
11	828	718	144	13.3	251	0.67

For sensory analysis, we have evaluated the following descriptors (Table 4): shape, colour of crust, aroma, elasticity and colour of crumb, ease of bite, sensation in mouth after brief chewing, consistency, crumb moisture, taste and overall impression. Tables 4 and 5 summarise the results of sensory analysis. Pastry should be properly proofed and should have a regular shape. According to the evaluators, variant 6 (UC66049) met these requirements best, while it also had the highest measured specific volume. Shape of pastry is related to the index number (height/average). Kučerová (2010) states that the optimum shape of pastry has index number of 0.65. This value conforms the best in pastry variant 9 (Rosso + bran), where the index number has been calculated as 0.66. Shapes of pastry in all experimental variants did not significantly differ from each other.

Crust colour of common pastry should be balanced and typically coloured in golden brown. We have identified as the lightest pastry variant 5 (Scorpion variety) and as the darkest pastry variants 6 and 11. Both variants were made from a blue-grain variety UC 66049, while the variant 11 also included its bran. Evaluators identified pastry from variant 9 (Rosso + bran) to have the most pleasant typical aroma. Similarly, they perceived the aroma of pastry in variants 1, 2, and 7. In contrast, it was identified pastry with the least pleasant aroma to be variants 6 and 11. Four evaluators have described their aroma as mushroomy or resembling champignons. Grain of this variety had an overall lower quality, as well as the lowest specific volume (70.98 $kg \cdot hl^{-1}$) and TGW (= thousand grains weight; 30 g) of all investigated varieties. According to baking quality characteristics, grain of variety UC exhibited medium amylase activity (214 s), high value of the SDS test (54.5 ml), 37.7% of gluten, and the lowest content of starch (53%) of all variants. Low quality of grain subsequently affected the final product. The grain was harvested from apparently lodged crop and we also cannot eliminate fungal infection.

Table 4 Results of sensory evaluation in pastry of colour wheat

Variant	Shape	Colour of crust	Aroma	Elasticity of crumb	Colour of crumb	Ease of bite	Sensation in mouth after brief chewing
1	8.24^{a}	5.28^{ab}	7.08^{b}	7.29^{a}	7.28^{a}	7.27^{a}	7.63^{b}
2	8.09^{a}	4.84^{ab}	6.91^{b}	7.42^{a}	6.66^{a}	7.22^{a}	7.23^{b}
3	6.90^{a}	4.76^{ab}	5.97^{ab}	7.09^{a}	6.24^{a}	7.01^{a}	7.09^{b}
4	6.17^{a}	4.26^{a}	5.67^{ab}	7.14^{a}	6.43^{a}	7.41^{a}	7.27^{b}
5	6.59^{a}	3.79^{a}	5.98^{ab}	7.47^{a}	6.88^{a}	7.68^{a}	7.3^{b}
6	8.34^{a}	6.8^{b}	4.43^{ab}	6.94^{a}	6.84^{a}	7.59^{a}	2.02^{a}
7	6.86^{a}	4.56^{ab}	6.81^{b}	6.58^{a}	8.16^{a}	7.7^{a}	7.07^{b}
8	7.63^{a}	6.09^{ab}	6.6^{ab}	6.1^{a}	7.54^{a}	7.6^{a}	7.26^{b}
9	7.19^{a}	4.64^{ab}	7.37^{b}	6.46^{a}	7.39^{a}	8.09^{a}	7.4^{b}
10	6.29^{a}	5.67^{ab}	6.39^{ab}	6.18^{a}	7.72^{a}	7.24^{a}	7.96^{b}
11	8.03^{a}	6.79^{b}	4.14^{a}	6.57^{a}	7.28^{a}	7.88^{a}	2.12^{a}

Elasticity of crumb for all variants was not significantly different. Generally, the best evaluation for elasticity of crumb received pastry with no added bran. Adding bran increases the firmness of crumb, because the bran attaches more water, making the crumb less supple and flexible (Bagdi 2015). Of products that contained only flour from coloured wheat, the best evaluated were variants 2 and 5, which showed better elasticity of crumb than the control sample. The sensory analysis assessed crumb colour in terms of whether it did or did not increase appetite for consumption. From this perspective, the best evaluated was variant 7 (Konini 2013 + bran). Products with added bran generally aroused better impression by the evaluators. Crumb colour for all experimental variants was not significantly different. Sensory evaluation also assessed sensation in the mouth after brief chewing. Variants 6 and 11 achieved lowest rating, as they were significantly differed from the other variants. Seven out of ten evaluators stated that they had a gritty feeling in the mouth. The reason could be impurities such as particles of soil, which came into grain during harvesting of lodged crops. In the other variants the feeling after a short chewing was approximately the same as they did not significantly differ from each other.

The consistency of products (Table 5) in all variants was evaluated as average. It was therefore neither too firm nor too soft. Values were not significantly different from each other. The results were similar when assessing crumb moisture. The crumb moisture should be adequate and uniform. In this case, the best evaluation received pastry made from variant 1. All other variants have achieved lower scores compared to the control. As already mentioned above, in all varieties of coloured wheat, except UC66049, we have determined low activity of α-amylase. This factor may also have played a role in the evaluation of crumb moisture, because, as indicated by Prugar (2008), flours with low α-amylase activity tend to form dry dough. Taste is an important sensory descriptor that consumers consider to be essential. According to evaluators, the best tasting pastry was the control variant which also aroused the best overall impression. However, all experimental variants, except variants 6 and 11, did not significantly different from the control variant. Among the experimental variants, the most pleasant taste had pastry from variants 4 and 2. In contrast, the worst taste has been reported for products from variants 6 and 11. These two variants have been identified in general as significantly worse of all submitted samples. Other experimental variants did not differ much from each other.

For an objective assessment of colour, we have carried out analysis using the Konica Minolta Spectrophotometer CM-3500D. One could assume that pastries made from coloured wheat varieties would have lower brightness than those made of classic flour. But for three samples of the coloured wheat (4, 5, and 7), the measured brightness was higher than in the control (not statistically significant). Variants 2, 6, 8, 10 and 11 had brightness significantly lower than the control. Colour pigments occur mainly in the casing layers of the grain. Therefore, pastries with added bran had lower brightness than those made only of flour, which was confirmed by measurement. The average measured brightness value for variants with added bran was L*(D65) = 55.86. In variants without added bran, the average brightness value was L*(D65) = 59.18. The addition of bran as a dietary fibre can also affect the amount of melanoids produced during the Maillard reaction, thereby causing the darker colour of the product (Kurek, Wyrwisz 2015).

Table 5 Results of sensory evaluation and objective determination of colour and texture

Variant	Consistency	Crumb moisture	Taste	Overall impression	Brightness	Texture
1	6.71^{a}	8.72^{a}	8.57^{b}	7.61^{b}	62.3^{de}	4.64^{de}
2	6.17^{a}	7.67^{a}	7.96^{b}	7.42^{b}	$54.9b^{cd}$	3.86^{cd}
3	6.22^{a}	7.51^{a}	7.44^{b}	6.98^{b}	59.6^{cde}	3.12^{abc}
4	6.5^{a}	7.82^{a}	8.07^{b}	7.14^{b}	66.7^{e}	2.53^{a}
5	6.99^{a}	7.66^{a}	7.46^{b}	7.43^{b}	63.9^{e}	2.23^{a}
6	6.37^{a}	7.46^{a}	3.01^{a}	2^{a}	50.8^{ab}	2.41^{a}
7	6.19^{a}	7.27^{a}	7.68^{b}	6.16^{b}	66.4^{e}	2.37^{a}
8	6.13^{a}	7.32^{a}	7.52^{b}	7.36^{b}	53.7^{bc}	3.54^{bc}
9	6.21^{a}	7.14^{a}	7.61^{b}	7.36^{b}	60.9^{cde}	2.78^{ab}
10	6.32^{a}	7.61^{a}	7.66^{b}	7.46^{b}	52.9^{ab}	5.32^{e}
11	6.29^{a}	7.19^{a}	2.86^{a}	1.18^{a}	45.4^{a}	3.79^{cd}

We have used the TIRATEST 27025 device to determine the force required to push the punch to the desired depth of pastry. In general, it was necessary to spend a higher force (3.56 N) for samples with the addition of bran in comparison with variants produced only from flour (2.83 N). With the addition of bran to the dough, not only reductions of volume and colour change take place, but also an increase in firmness of pastry (Sivam et al. 2010, Romano et al. 2011). Variant 10 had significantly better texture than other variants except control. Variants 3, 4, 5, 6, 7, 8 and 9 had significantly worse texture than control sample.

CONCLUSIONS

The aim of this study was to evaluate the possibility of using coloured wheat in the production of common bakery products. According to the characteristics of milling and baking quality, the worst evaluated variety was UC66049. The grain of this variety may have been harvested from a lodged crop or infected by a fungal disease. Poor quality of grain also affected the final product, causing the sensory analysis of the pastry to declare the variety to be the worst. Furthermore, the sensory analysis also revealed that evaluators preferred products without the addition of bran. In comparison of products from purple and blue wheat, the products from blue-grained wheat received the better evaluation.

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