BAKERY PRODUCTS WITH THE ADDITION OF SOYBEAN FLOUR AND THEIR QUALITY AFTER FREEZER STORAGE OF DOUGH

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ABSTRACT

The aim of this study was to observe the impact of adding 30% of flour from soya bean to the wheat flour T 650 on the quality of immediately baked products and products stored one, three and six months in a freezer at the temperature of -18°C and then baked. Rheological properties of wheat and composite flour by means of Farinograph, Extensograph, and Amylograph were also evaluated. Based on the farinograph evaluation of composite flour (70% of wheat flour + 30% soybean flour) it was found that the formed mixture was hydrated more slowly than the pure wheat flour, time of dough development was about 6.5 minutes longer than that for pure wheat flour, and a value of water binding was higher by 12.4% compared with wheat flour. Created dough could be characterized as strong, holding long enough optimum of its rheological properties. By means of extensographic evaluation of composite flour it was found that it has lower extensographic energy, less resistance and lower tensibility compared to wheat dough, which led to insufficient volume of products. By amylogram it was found that composite flour has higher enzymatic activity compared to wheat flour, nevertheless both flours could be characterized as suitable for leavened bakery products. Addition of gross non-defatted soy flour at 30% had a significant impact on technological quality of loaves baked during the baking experiments. Compared with loaves of wheat flour, the lower bread volume, specific volume and volume yield, and less satisfactory cambering was found. The effect of freezing on dough in the case of wheat flour showed the gradual reduction of the quality parameters of the loaves baked from such dough after freezing time lasting for 1, 3 and 6 months. In the case of the composite flour, the decrease of quality was found only after freezing lasting 3 and 6 months. One-month freeze did not cause the declination of quality, to the contrary, even a slight increase of loaf volume was observed.

Keywords: Composite flour with soy, rheology, freezing of dough, baking experiment

INTRODUCTION

In bakery production, as in other food areas the more topical question becomes not only the production of quality foods, but also the possibility of their longer-term stability and shelf-life. One of the possibilities is freezing as an anabiosis method characterized as an indirect inactivation of microorganisms (Revenue Ministry of Agriculture and Rural Development and the Ministry of Health of the Slovak Republic No 981/1996). Frozen bakery dough can be considered as semi-finished products enabling manufacturers to continuously and according to needs produce bakery products in standard quality. At the same time, these bakery products should have high nutritional value, which can be ensured by adding non-bakery raw materials containing nutritionally important components (Bojňanská, 2008; Bojňanská et al., 2008; Bojňanská et al., 2010). Legumes have a very specific place from the nutritive point of view and play an important role in nourishment of world population. Pursuant to the Alimentary Codex of the Slovak republic, (part three, chapter twelve) as legumes are understood ripe eatable seeds of legume plants: pea (Pisum sativum), lentil (Lens culinaris Med.), common bean (Phaseolus vulgaris L.), soya bean (Glycine max L.), chickpea (Cicer arietinum L.), sweet pea (Lathyrus L.) and broad beans (Vicia faba L.), which are suitable after processing for consumption. In general, legumes are a source of complex carbohydrates, protein and dietary fibre, having significant amounts of vitamins and minerals (Tharanathan and Mahadevamanna, 2003). Protein content in legume grains range from 17% to 40%, contrasting with 7 – 13 % of cereals (Bojňanská, 2004), and being equal to the protein contents of meats (18 – 25%) (Cuboň et al., 2011). Addition of legumes to cereal products increases their content of fibre, resistant starch (Utrilla-Coello et al., 2007; Angiñoloni and Collar, 2011), important minerals (Dhindra and Jood, 2001; Dalgetty and Baik, 2003; Costa de Alemidea at al., 2004) and vitamins. These products with addition of legumes have in comparison to classical bread prepared from wheat or rye higher nutritive value and lower Glycaemic index. Their consumption has positive impact on health conditions of consumers (Goni and Valentín-Gamazo, 2002; Johnson et al., 2005; Hawkins and Johnson, 2005; Pittaway et al., 2007).

Soybean (Glycine max (L.) Merrill) has among all grown legumes highest protein content in the seed (35-45%), with excellent composition of essential amino acids (Velíšek and Hajšlová, 1999a). The combination of soybean containing a high proportion of lysine with cereals, wherein lysine is a limiting amino acid, almost a full protein may be obtained. Soybean seeds are characterized by a content of wide range of vitamins (A, D, E, in particular group B), minerals (4% to 6%) with a significant representation of Fe, Mg, P. From the anti-nutritional substances there are trypsin inhibitors, lectins, saponins and Antivitamins in soybean, and there are eliminated and removed by heat, slicing, by acid hydrolysis or fermentation processes (Kumar et al., 2008; Velíšek and Hajšlová, 1999 b).

From soybean it is possible to obtain a wide range of grain mill products, such as enzymatically active soya flour, mill whole defatted products (grouts, meal flour and fine powder) and skinned mill products (flour, powder, technical powder, flour special) (Bojňanská et al., 2013). From soybean flour itself it is not possible to prepare bread, pastries, and other leavened bakery products because it contains a low proportion of starch and gluten producing proteins. Nevertheless, thanks to application of soybean flour in combination with wheat flour are bread and other products nutritionally enriched (Mashayekh et al., 2008; Roccia et al., 2012; Dhinda et al., 2012) and influence health of consumers (Moghaddam et al., 2014). Simmons et al. (2012) state that soy ingredients stabilize bread dough during frozen storage.
The aim of this study was to observe the impact of adding 30% of flour from soy bean to the wheat flour T 650 on the quality of immediately baked products and products stored one, three and six months in a freezer at the temperature of -18° and then baked.

MATERIAL AND METHODS

To prepare control loaves wheat flour T 650 was used. The second group of loaves was made from composite flour, based on wheat flour T 650 in an amount of 70% (Mlyn Pohronský Ruskov a.s., Hlavná 76, 935 62 Pohronský Ruskov, Slovakia) with an addition of non-defatted soybean flour at 30% (company Natural Jihlava JK s.r.o., Na Dolech 10, 586 01 Jihlava, Czech Republic). According to recipe fresh compressed yeast was used (Trenciánske droždí, OLD HEROLD HEFE, s.r.o., Bratislavska 36, 911 05 Trenčín, SR). In wheat and composite flour the moisture was determined (%) (ICC Standards No. 110/1 (1976)), as well as content of crude protein (%) (ICC Standard No. 105/2, (1994)) and content of ash (%) (ICC Standard No. 104/1, (1990)). Rheological measurements were made of prepared composite flour and wheat flour by means of Farinograph-E, Brabender ÖHg, Duisburg, Germany (ICC - Standard 115/1, 1992, AACC Method 54-10, 1995) and extensograph-E, Brabender ÖHg, Duisburg, Germany (ICC - Standard 114-1, 1992, AACC Method 54-10, 1995). Based on these measurements following characteristics were determined: farinographic flour water absorption capacity (%), dough development time (min), level of dough softening (FU), dough stability (min), farinographic quality number. By means of Extensograph-E, Brabender ÖHg, Duisburg, Germany (ICC - Standard 114-1, 1992, AACC Method 54-10, 1995) and extensographic maximum (EU) were determined. By means of Amylograph-E, Brabender ÖHg, Duisburg, Germany (ICC-Standard 126/1, AACC Method 22-10,1995) the initial gelatinization temperature (°C), the maximum gelatinization temperature (°C) amylographic maximum (AU) was determined.

Experimental loaves were prepared from a mixture of flour (350 g of wheat and 150 g of soy flour), sucrose (5 g), salt (9 g), yeast (20 g) and water addition based on farinographic water absorption capacity. Bread experiment was carried out without the use of enzyme-active substances and other improvement agents. The development of dough took place in a laboratory mixer Diosna SP 12. After that the dough was elaborated and formed into loaves that stayed yeasted in ayeasting room for 20 minutes at temperature of 30°C and were baked in an oven Miwe Condo at 240°C with steaming (baking time 20 min). The baked loaves were evaluated by objective methods and the volume of products (cm³), extensographic tensibility (mm) and extensographic maximum (EU) were determined. By means of Amylograph-E, Brabender ÖHg, Duisburg, Germany (ICC-Standard 126/1) the initial gelatinization temperature (°C), the maximum gelatinization temperature (°C) amylographic maximum (AU) was determined.

RESULTS AND DISCUSSION

Based on published results it can be assumed that the addition of defatted soy flour at 3% and 7% has a positive impact on improving the rheological properties of dough and is accepted by consumers as good as wheat bread, with comparable quality of the mixture and a sign that dough from mixture of flour had a higher water absorption value compared to wheat flour (by 12.4%) and sourness of scrumb by titration (mmol.kg⁻¹). The remaining elaborated dough was immediately frozen and stored (one, three and six months) in the freezer at -18°C ± 2°C (AGF 070 AP, company: Whirlpool Slovakia spol. s.r.o., 820 09 Bratislava 29, SR). After defrosting at 22°C ± 2°C the loaves were yeasted in ayeasting room for 20 minutes at temperature of 30°C and then baked at 240°C in the steaming oven for 20 min. Baked loaves were then evaluated by the same methods as the immediately baked control products.

Table 1 Farinographic evaluation of composite flour and flour T 650

<table>
<thead>
<tr>
<th>Samples</th>
<th>Farinographic water absorption, %</th>
<th>Dough development, min</th>
<th>Dough stability, min</th>
<th>Declination of consistency, FU</th>
</tr>
</thead>
<tbody>
<tr>
<td>T 650 composite flour</td>
<td>60.1</td>
<td>9.7</td>
<td>8.0</td>
<td>58.0</td>
</tr>
</tbody>
</table>

Based on comprehensive evaluation of the results of farinographic measurements it might be noted that the addition of soy flour at 30% does not affect negatively the selected flour properties. Use of moderate and strong flours with protein content of 11% to 13% brings best results when baking bread from frozen dough as stated by Marston (1978), Wolff et al. (1984) was one of the first to point out that the production of bread from frozen dough it is the quality of the flour proteins which is very important. This has been confirmed by other authors (Neyreneuf et al., 1991, Inoue et al., 1992). Daoxastakis et al., (2002) have found that addition of 5% and 10% soybean flour to moderately strong wheat flour increased the stability and resistance of dough, although at the expense of soy flour (48.5%) on the quality of dough stored at -20°C for two to four weeks. Authors have found that soy protein prevented migration of water during storage, and therefore there have been smaller structural changes in dough as well as bread in comparison to traditional wheat bread. Baked bread was very well accepted by the consumers. Similar conclusions were also confirmed by Simmons et al. (2012).

In the context of our baking experiments we compared technological quality of loaves prepared from wheat flour T 650 and composite flour consisting of 70% wheat flour T 650 and 30% soybean flour. Used wheat flour T 650 had 13.9% moisture, 0.4% ash content and 11.5% crude protein. Soy flour had 8.3% moisture, 5.27% ash content and 38.4% of crude protein. From these results it can be assumed that from the nutritional point the addition of soy flour caused increasing of the protein content and improving of their amino acid composition. Mashayekh et al. (2008) have found that the addition of soy flour to bread increased its nutritional value in comparison to the control sample and the soybean flour thanks to its composition represented considerable nutritional enrichment of wheat flour. This view is also supported by Friedman and Brandon (2001), who published the conclusions regarding the beneficial action of soy in the human body (anti-carcinogenic effect, lowering cholesterol, preventive effects against diabetes II. type, obesity, protective effects on kidney). To objectively assess the quality of flour as the most important raw material within the baking experiment rheological measurements were used. Dough properties during the kneading were evaluated by means of Farinograph and the amount of water needed to create dough with optimal properties was evaluated. Effect of addition of soy flour to flour T 650 is shown in Figure 1 and Table 1.

![Figure 1 View of farinograms of composite flour and flour T 650](Image 305x412 to 570x537)
the volume of baked products, but with sensory values comparable with the control samples.

Wheat and composite flours were then evaluated by extensograph, which allows to detect dough properties by determining the dependence of deformation from certain tension until tearing of sample (Dodok and Szemes, 1998). The measurement results are shown in Figure 2, which compares extensograms of both used flours after 15 minutes of dough maturing and Figure 3 after 30 minute of dough maturing. Based on the results of extensographic measurements in general we can predict the changes of dough consistency, impact of enhancing products, a total volume of products, etc., and based on this to select the appropriate type of flour, additives, and other quality-enhancing products for the final desired properties of bakery products (Bojňanská et al., 2013).

Based on the above facts described as suitable for the production of leavened bakery products. The rheological analyses of evaluated flours were supplemented by results from amylograph, which is used for evaluation of flour quality and its enzymatic and mechanical damage. This information can help when deciding on the application of quality-enhancing products (Dodok and Szemes, 1998). Results and comparison of amylograms of wheat flour and composite flour are shown in Figure 4.

Based on the evaluation of both amylograms it can be said that the beginning of gelatinization of wheat flour was 4.2°C lower compared to composite flour and amylographic maximum was by 211 AU higher in wheat flour than in composite flour. Consequently it shows that composite flour was enzymatically more active than wheat flour. Nevertheless, based on the research of several authors (Dodok and Szemes, 1998; Bojňanská et al., 2013) it can be assumed that both flours will provide products with normal crumb with aligned pores since the flours had optimal activity of amyrase required for leavened bakery products.

To verify the assumptions arising from rheological analysis and detection of bakery quality by direct methods baking experiments were implemented. The results are shown in Table 2 and Table 3.

The best technological quality was found in immediately baked wheat loaves since their volume and cambering can be described as good. After dough was stored at -18°C for one, three and six months the decrease in volume (by 8.6%, by 19.1%, by 23.8% respectively) compared to the control was observed. Volume of loaves baked after 6 months of storage we can evaluate based on recommendations by Bojňanská et al. (2013) as unsatisfactory. Best cambering (optimal value = 0.65) was observed in the control loaves. After the first, third and sixth month of freeze storage was the ratio between the height and width of the loaves significantly lower, and based on that the cambering was evaluated as unacceptable. Simmonds et al. (2012) came to similar findings stating that the bakery products prepared from frozen dough are typically of lower quality than bread prepared from fresh dough.

Based on the evaluation of baking experiments using composite flour it can be observed that the highest volume was not found with loaves baked immediately after dough preparation, but after a one-month freeze storage. The decrease of volume was recorded only after three and six months of freezing (by 13.3% in comparison to products frozen one month).

The cambering value of all test loaves was not optimal, but it was still satisfactory. The volumes of all the baked loaves from composite flour, however, were lower than those baked from wheat flour. One possible reason was the lower portion of gluten in composite flour. Still higher addition of soy flour (up to 50%) caused the reduced flexibility of the products, as identified by Sabinas and Tzia (2009).

<table>
<thead>
<tr>
<th>Table 2 Results of baking experiments from flour T 650</th>
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<tr>
<td>Period of deep-freeze storage</td>
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<td>--------------------------------</td>
</tr>
<tr>
<td>Immediately baked/control</td>
</tr>
<tr>
<td>One month</td>
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<tr>
<td>Three months</td>
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<td>Six months</td>
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<th>Table 3 Results of baking experiments from composite flour</th>
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<td>Six months</td>
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Selected indicators of chemical composition of crumbs of experimental loaves are shown in Table 4. The results show that the addition of soy flour used in an amount of 30% had a positive impact on the nutritional value of bread since the content of crude protein increased by 79.5% and ash content by 126.5% compared to wheat loaves. These results confirm the statements of several authors (Friedman and Brandón, 2001; Mashtayekh et al., 2008; Angiolonì and Collar, 2011; Simmonds et al., 2012) concerning nutrient enrichment of wheat products by soy flour or meal.

CONCLUSION

Addition of gross non-defatted soy flour at 30% had a significant impact on technological quality of loaves baked within the baking experiment. In comparison to wheat flour loaves the loaves from composite flour showed lower bread volume, lower specific gravity, and organoleptic characteristics was less satisfactory as well. Based on the farinographic assessment of composite flour (70% of wheat flour + 30% soybean flour) it was found that the mixture formed was slower hydrated than the pure wheat flour, which was related to high content of protein of the added soybean flour. Created dough could be characterized as strong, holdings optimum of its rheological properties long enough. By extensographic evaluation it has been found that the composite flour has lower extensographic energy, less resistance and lower tensibility compared to wheat dough, which in turn led to insufficient volume production. Analyses by Amylograph showed that composite flour was enzymatically more active than wheat flour. Nevertheless, both flours can be characterised as suitable for leavened bakery products. From a nutritional point of view it was significant that there was higher proportion of protein and ash in pastry made of composite flour. The effect of freezing on dough in case of wheat flour showed the gradual reduction of the quality parameters of the loaves baked from such dough after deep-freeze storage lasting for 1, 3 and 6 months. In case of the composite flour, the decrease in quality was only observed after freeze storage lasting 3 and 6 months. One-month freeze storage did not decrease the quality, to the contrary, a slight increase loaf volume was observed.

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