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THE INFLUENCE OF ADDITIONAL FLOURS ON THE RETENTION ABILITY OF DOUGH AND THE TECHNOLOGICAL QUALITY OF BAKERY PRODUCTS

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ABSTRACT

The work monitored rheofermentation properties of dough prepared from composite flours formed by 70% of wheat flour T650 and the addition of 30%. Three kinds of additions were used, namely spelt flour, amaranth flour and buckwheat flour. To determine rheofermentation properties Rheofermentometer Rhea F4 was used, by means of which the dough development, the production of fermentation gases, retention ability of dough and the activity of used baking yeast were analysed. The best ability to retain formed fermentation gas had wheat flour (control) and composite flour with the addition of spelt flour. The composite flour with addition of amaranth flour showed a retention coefficient compared to the control lower by 13%, and the composite flour with addition of buckwheat flour showed a retention coefficient compared to the control reduced by 20%. Control flour and composite flours were then processed in the baking experiment. Based on its results it was possible to evaluate the effect of the addition and retention capacity of dough on the quality of the final products (experimental loaves). The biggest loaf volume (200 cm^3) and the optimal vaulting (0.65) were found in the control and a loaf made of composite flour with addition of spelt. Loaf volume, produced from composite flours with the addition of amaranth, and buckwheat was compared to control lower by 18.7%, and 16.3% respectively. The value of vaulting of these products (0.40) can be evaluated as unsatisfactory. Based on the evaluation of results observed by measuring on the rheofermentometer and baking experiment results it can be concluded that a better ability to retain the formed fermentation gas, thus ensuring high volume, had loaves made from wheat flour T650 and composite flour with addition of spelt flour. Based on the findings, it is possible to state that the results of rheofermentometric measurements predict the volume and vaulting of bakery products. By means of Rheofermentometer valuable information has been gained concerning the quality of bakery ingredients, especially flour and yeast.

Keywords: Rheofermentometer; dough properties; retention coefficient; baking experiment

INTRODUCTION

Cereals belong to the most important raw materials of plant origin. They are a source of carbohydrate, proteins, vitamins and minerals. Wheat and rye are bread baking basic raw materials, and the quality of bread and bakery products whose consumption varies in Slovakia at around 66 kg per person per year (**the Statistical Office SR, 2014**), is significantly influenced by the quality of raw materials, mainly flour and yeast.

The term pseudocereals commonly refers to seed crops used in the same way as cereals, but they do not belong to the family *Poaceae*. Compared to grains they tend to have higher levels of nutritionally relevant components, such as essential amino acids, minerals and fibre. Their application to products is reflected by a change in sensory properties, and such products have usually more interesting taste and are more attractive for consumers. Currently we can see higher interest of consumers in pseudocereals, especially in relation to the nutritional composition that is able to enrich ordinary bakery products **(Ikeda, 2002; Kohajdová and Karovičová, 2008; Prugar, 2008; Kocková and Valík, 2011; Arendt et al., 2013; Bojňanská et al., 2013)**.

Protein of wheat flour and spelt flour, however, differ from the protein of pseudocereals flour by ability to form gluten. Gluten is a water-insoluble portion of wheat proteins (gliadins and glutenins) **(Hampl, 1981; Dodok and Szemes, 1998; Rosell et al., 2007)**, whose peptide chains are linked together by hydrogen, disulphide and methylene bridges, and which are capable of forming in dough viscoelastic three-dimensional network. The unique properties of wheat flour to form viscoelastic dough which is able to retain gas are due to protein characteristics of wheat gluten when it is mixed with water **(Roccia at al., 2009)**. High quality and well matured flour with high gluten content after processing produces non-sticky dough that has high water absorption ability and the ability to retain gases. Such dough provides for quality bakery products with good volume **(Lazaridou et al., 2007)**.

Yeast bakery product cannot be prepared without bakery yeast to ferment sugar to carbon dioxide, ethanol and secondary metabolites. By that a sufficient amount of leavening gases that contribute to the desired dough structure is ensured. It is also an important contribution to the formation of aroma and taste of fermented bakery products **(Szemes and Mainitz, 1999; Rezaei et al. 2014)**.

Yeast in addition to these characteristics, has the ability to plastify leavened wheat dough **(Hampl et al., 1981; Verheyen et al., 2014)**, reflecting the fact that they affect the rheological properties of the dough, which have a decisive influence on the final technological quality of baked bakery products. By measuring of these characteristics the properties of baked loaves might be predicted **(Campos et al., 1997)**. Rheofermentometer is used to estimate dough properties during fermentation, by measuring the released CO_2 or produced pressure, knowing the fact that produced CO_2 serves to expand dough and achieve the final bread loaf volume. Reofermentometer can be used in baking industry for punctual determination of time when fermentation is finished **(Torbica et al., 2008)**.

The aim of the research was to study the rheofermentation properties of dough prepared from composite flours made up of wheat flour T650 (70%), and the addition of 30%, and evaluate changes caused by addition in the ability of dough to retain fermentation gases.

MATERIAL AND METHODOLOGY

The work studied the impact of composite flours on the retention properties of flour dough comparing the results with objective baking properties of the baked bakery products. For the production of dough the wheat flour T650 (Mill Pohronsky Ruskov, Inc.) was used, which was a control sample. Composite flours were created by mixing wheat flour T650 (70%) with addition of flour (from spelt – A, amaranth – B and buckwheat – C) in an amount of 30%. Spelt semi-coarse wholemeal flour and buckwheat flour were from the producer J. Vince Ltd., amaranth wholemeal flour from J. Kroner Ltd.

In flours *content of minerals*,% **(ICC Standard No. 104/1 (1990)** and *crude protein content* (*Nx5.7)*,% **(ICC Standard No. 105/2 (1995**) was determined). An important ingredient – fresh pressed bakery yeast came from the production of Old Herold Hefe, s.r.o., Trenčín, Slovakia. All of flours and yeast were purchased commercially.

Additionally, rheofermentometer studies were used to analyse dough development according to fermentation time and gas production and release of gas from the dough. The recipe of dough tested in rheofermentometer comprised of the portion of flour, or composite flour in an amount of 250 g and of fresh yeast in an amount of 2.8%. The dough was kneaded in the farinograph. After the first minute of dough making the salt was added in an amount of 2%, and mixing continued for six more minutes. The volume of water added depended on the water absorption of flour (to create dough with optimal consistency). Subsequently was the test dough (315 g) inserted in Rheofermentometer Rhea F4 (Trippetta & Renaud Chopin, Villeneuve-la-Garenne, France) **(AACC Method 89-01.01)**, in which following properties were established during the three-hour test: *the total volume of gas formed* (cm^3) *the volume of gas leaked to environment* (cm^3), *the volume of gas retained in dough* (cm^3) and the *retention coefficient R* (%) which is the ratio of the volume actually detained in dough to the total volume of formed CO_2.

Baking experiment was conducted by the standard method used in the workplace: to flour or composite flour, weighing 500 g yeast (4%), sucrose (1%), salt (1.8%) were added and water according to water absorption of flours determined by farinograph. The dough was processed in a laboratory mixer Diosna SP 12. Then the dough was shaped into loaves, which were rising in the rising room for 20 minutes at 30 °C and then baked at 240 °C for 20 minutes in a furnace Miwe Condo. The baked loaves were evaluated by objective methods, establishing *volume of products* (cm^3), a *specific product volume* ($cm^3/100g^{-1}$), *baking loss* (%) and *cambering* (the ratio between height and width).

RESULTS AND DISCUSSION

Bread and pastries are the source of the energy from polysaccharides and proteins, and their consumption is an important part of the Central European eating habits. Therefore, the demands for the technological quality of these products are high. The practical significance of gluten for bakery technology lies in the fact that during the dough development it retains fermentation gas, allows dough rising, its thorough baking and the pore structure of a bakery product **(Bojňanská, 2004; Gajdošová and Šturdík, 2004)**. Flours other than of wheat raw materials cannot be used alone for the production of bread, pastries, and other fermented products. As these flours do not contain gluten forming protein, they can be used only in certain amounts as additional flours **(Palenčarová and Gálová, 2010)** to the wheat flour. The reason for their addition is mainly nutritional enrichment of bakery products. This was confirmed and selected results are shown in Table 1.

All additional flours (A, B, C) had higher ash content as compared to the wheat flour; the maximum level was in

Table 1 Content of crude protein and ash content in used flours

Flour sample	T650 control	A	B	C
Crude protein, %	13.4	12.3	15.9	7.6
Ash content, %	0.48	1.3	2.3	0.7

Legend:

A – spelt flour
B – amaranth flour
C – buckwheat flour

amaranth flour and spelt flour. As whole grain flours were used, they contained the coating grain layers rich in minerals. For amaranthus high ash content is characteristic and phosphorus, potassium, magnesium and calcium dominant minerals in the raw seeds **(Gamei et al., 2006)**. In spelt wheat the content of zinc, iron and selenium is important **(Gomez-Becerra et al., 2010; Zhao et al., 2009)**.

Amaranth is a raw material with high content of crude protein. The advantage of amaranth grains compared to conventional cereals is a relatively high content of proteins and more balanced composition of essential amino acids. Amaranth grain is rich in lysine, methionine, arginine and tryptophan **(Michalová, 1999; Pisaříková et al., 2005; Mota et al., 2014)**. The flour of spelt wheat, and buckwheat contain in comparison to wheat flour lower amount of crude protein. From a nutritional point of view proteins in pseudocereals can be classified as very valuable, because the portion of albumins and globulins in their seeds is about twice that of wheat **(Mota et al., 2014)**. **Písaříková et al**. **(2005)** indicate that the index of essential amino acids EAAI has in amaranth value of 90.4% while in wheat values EAAI are around 50 – 55%. Mixing of wheat flour, in which the limiting amino acid is lysine with flour from pseudocereals in which the proportion of lysine is approximately twice as much, might improve amino acid profile of bakery products **(Fornal, 1999; Ikeda, 2002; Arendt et al., 2013)**. Bread made with the addition of pseudocereal flours has a fuller flavour and is nutritionally more varied **(Mashayekh et al., 2008; Dhinda et al., 2012; Ma, 2013; Sanz-Penella et al., 2013; Biney et al. 2014)**.

By the means of rheofermentometer the retention capacity of formed composite mixtures (70% flour T650 + 30% additional flour) was compared with the control flour T650 (Table 2).

The data in Table 2 show that the control sample produced during the test the smallest volume of the fermentation gas, but was able to retain it in a very large quantity (84.4%). The volume of gas formed in dough of the composite flour with the addition of spelt wheat (A) was higher by 12.5%, with the addition of amaranth (B) by 21%, and with the addition of buckwheat (C) as much as by 27.3% compared to the control.

The volume of gas leaks was lowest in control and then in the composite flour with the addition of spelt, which resulted in the highest retention coefficients. The amount of gas leaks in a composite flour with the addition of amaranth was higher by 105% compared to the control, and in the flour containing buckwheat flour the volume of gas leaks was higher by 165% compared to the control. Doughs with addition of pseudocereals had significantly lower retention coefficient, mainly due to a lower proportion of gluten in the flour composition. The retention coefficient of the finest flours obtained from the endosperm, which are low-milled, has a value close to 100%, in high-milled flours with a higher content of outer grain layers reaches this value about 50% **(Chopin**

Table 2 Rheofermentometric properties of composite flours

	control	A	B	C
Total volume, cm^3	1408.0	1584.0	1705.0	1792.0
Volume of CO_2 lost, cm^3	219.0	318.0	451.0	580.0
Retention volume, cm^3	1189.0	1267.0	1254.0	1212.0
Retention coefficient, %	84.4	80.0	73.5	67.6

Legend:
control – 100 % wheat flour T650
A – 70 % T650 + 30 % spelt wheat flour
B – 70 % T650 + 30 % amaranth flour
C – 70 % T650 + 30 % buckwheat flour

Table 3 Selected results of baking experiment

	control	A	B	C
Product volume, cm^3	200.0	200.0	162.5	166.3
Specific product volume, cm^3.100g	231.4	226.7	192.0	196.5
Baking loss, %	14.6	14.6	15.8	17.9
Cambering	0.65	0.65	0.4	0.4

Legend:
control – 100 % wheat flour T650
A – 70 % T650 + 30 % spelt wheat flour
B – 70 % T650 + 30 % amaranth flour
C – 70 % T650 + 30 % buckwheat flour

Technologies: Methods and Equipments, 2013). Lower amount of gluten forming proteins in composite flours has a negative impact directly on a quality of final products, but also on the rheological properties of doughs and their ability to retain fermentation gases **(Wiesner, 2007)**.

The best ability to retain formed fermentation gas was found in a control and in a sample A (with the addition of spelt wheat), despite the fact that in those doughs the smallest volume of gas was formed during the test. Gas forming ability of flours is significantly affected by the amount of originally present (pre-existing) sugars in them **(Muchová, 2005; Bojňanská et al., 2013)**, and precisely composite flours with the addition of amaranth and buckwheat have a lower gluten content and higher originally present sugar content **(Michalová, 1999; Steadman et al., 2001, Bojňanská, 2004, Muchová 2005; Steertegem et al., 2014)**.

Poor retention is an indication of an insufficient ability of dough to retain gas produced during fermentation, and it manifests itself by less volume of baked products. Table 3 shows the results of baking test, in which the same composite flours were used as in the rheofermentometric evaluation.

Results of baking experiment, which are shown in Table 3 indicate that the best breadmaking quality of the baked products was observed in the control and the sample A (spelt wheat), mainly thanks to the largest volume and specific volume of products. The volume of the loaves prepared from composite flours (B and C) was by 18.7%, and by 16.8% respectively lower than in control loaves. Best cambering was found in the control and in the sample with spelt wheat, unlike the loaves with amaranth and buckwheat, in which cambering can be identified according **Muchova (2005)** and **Hampl et al. (1981)** as unsatisfactory. Losses during baking are a natural part of making bread and pastries, but values above 15% are not desirable. The control and the sample with the spelt wheat the losses were adequate, and both samples had optimal retention coefficient. In samples with the addition of amaranth and buckwheat their lower retention capacity manifested itself by higher losses during baking. Overall, the best breadmaking quality was observed in control and in a sample of composite flour with an addition of spelt wheat.

CONCLUSION

Based on the evaluation of results obtained by measuring on rheofermentometer and baking experiment results it can be concluded that a better ability to retain the formed fermentation gas, thus ensuring high volume, had loaves made from wheat flour T650 and composite flour with the addition of spelt wheat at 30%.

Based on the findings, it can be stated that the results of rheofermentometric measurements predict the volume and vaulting of bakery products. By means of rheofermentometer valuable information about the quality of baking raw materials were obtained.

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