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BUCKWHEAT FLOUR – A VALUABLE COMPONENT OF GLUTEN-FREE FORMULATIONS

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Key words: gluten-free dough, buckwheat flour, rheology, nutrients

In this study buckwheat flour was used as a supplement of a commercial gluten-free formulation (MLECZNA and NISKOBIAŁKOWA). The effect of 30 or 50% substitution of formulation basis with buckwheat flour on the technological and rheological properties of dough was observed. The dough was analysed for contents of proteins, elements and resistant starch. Viscoelastic properties of the examined dough were measured using Rheostress 1 (ThermoHaake) in an oscillation mode. Changes in the viscoelastic properties were expressed as elastic modulus (G') and viscous modulus (G"). The substitution of 30 or 50% of the gluten-free formulation basis with buckwheat flour increased the level of total proteins, macro- and microelements, as total mineral components, and resistant starch. Irrespective of the level of buckwheat flour in gluten-free formulations a decreasing water binding capacity was confirmed. Dynamic rheological studies of gluten-free dough of MLECZNA formulation showed the higher elastic (G') and viscous (G") moduli in comparison with NISKOBIAŁKOWA formulation. Both analysed moduli decreased when buckwheat flour replaced a part of the analysed commercial gluten-free formulations. It indicated that the buckwheat flour could diminish the structural function of compounds substituting for gluten in gluten-free formulations. Based on the results obtained it could be concluded that buckwheat flour is a promising valuable supplement of gluten-free formulations.

INTRODUCTION

In recent years, an increase of the diagnosed cases of the celiac and non-typical celiac diseases, or allergic reaction/intolerances to gluten consumed in food products, caused a growing interest in gluten-free products. A diet based on gluten-free products is characterised by a low content of some nutritional components such as proteins and mineral components, as well as non-nutritional but physiologically important components like dietary fibre. Therefore, the prospecting of the components supplementing gluten-free products, which will provoke an increase in the content of nutritional and dietary components, is important. Many commercially available gluten-free compositions serve as a product for home bread baking. Different substances are added, which could mimic the viscoelastic properties of gluten and result in the improvement of the structure, mouthfeel, acceptability and shelf-life of gluten-free products [Gallagher *et al*., 2003; Gujral *et al*., 2003; Ahlborn *et al*., 2005]. Buckwheat grains are a rich source of a special type of starch [Soral-Śmietana *et al*., 1984a; Soral-Śmietana, 1992; Acquistucci & Fornal, 1997] with dietary lipids [Soral-Śmietana *et al*., 1984b] and contain many valuable compounds, such as proteins with a low content of α-gliadin fraction [Kreft *et al.*, 1996], antioxidative substances, trace elements and dietary fibre [Steadman *et al*., 2001]. Proteins content in buckwheat flour has been reported to range from 8.5 to 18.9%, depending on the variety [Krkošková & Mrázová, 2005]. Buckwheat proteins have a high biological value due to the well-balanced amino-acids composition, although their digestibility is relatively low [Kato *et al*., 2001; Tomotake *et al*., 2006].

The objective of the present investigation was to study the effect of incorporation of buckwheat flour, with specific sensory properties and beneficial for human nutritional composition, into the commercial gluten-free formulations. The influence of buckwheat flour as a supplement of the commercial gluten-free formulations on the content of some nutritional or non-nutritional components and rheological properties of gluten-free dough was tested as well.

MATERIAL AND METHODS

Commercial gluten-free formulations named: NISKOBIAŁKOWA (N) and MLECZNA (M), and commercial buckwheat flour constituted the initial research materials in the present study. The commercial gluten-free formulation MLECZNA contained: wheat and corn starches, corn flour, guar gum, dietary fibre, soy flour, emulsifiers, milk powder, sugar, and salt; whereas NISKOBIAŁKOWA contained: wheat and corn starches, guar gum, pectin, glucose, dietary fibre, emulsifiers and sugar. The amount of water added in order to obtain dough was as follows: 80 g per 100 g of MLECZNA formulation and 88 g per 100 g of NISKOBIAŁKOWA formulation. In the experiment, 30 or 50% of the gluten-free formulation basis were substituted with buckwheat flour. The present

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research concerns the commercial gluten-free formulations, that is why their detailed composition is unknown.

In the commercial gluten-free formulations and their experimental mixtures with 30 or 50% w/w of buckwheat flour, there were determined: nitrogen components according to Kjeldahl method and total elements as a ash after mineralisation in a muflon oven at 600°C according to AOAC standard chemical methods [AOAC, 1990], and resistant starch content according to Champ *et al.* [1999] method. Functional properties, *i.e.* water binding capacity at 25°C and oil sorption, were analysed as well [Soral-Śmietana *et al.*, 1998].

The viscoelastic properties of the examined dough were measured using Rheostress 1 (ThermoHaake) in an oscillation mode. Serrated plate-plate device (diameter of 20 mm) was used for dynamic measurements. Dough was placed between the plates, and the gap was adjusted to 3 mm. Dough edges were trimmed and coated with silicone oil to prevent drying. The dough rested between the plates for 15 min before testing, so that the residual stress would relax. Changes in viscoelastic properties were expressed as elastic modulus (G') and viscous modulus (G").

For baking experiment the amount of added water was 80 g per 100 g of MLECZNA formulation and 88 g per 100 g of NISKOBIAŁKOWA formulation, also sunflower oil, fresh yeast, salt and sugar were added. The baking tests were carried out in an electric oven with an incorporated proofing chamber (Sadkiewicz Instruments, Poland). Initially, fresh yeast dissolved in warm water were added to the dry basic components, than the sunflower oil was added. The mixture was blended with a planetary rotation of mixing within a 5-speed mixer (Kitchen Aid, USA) for 12 min. The dough was proofed at 35-40°C for 40 min and baked at 215°C for 25-35 min. Measurements of loaves were carried out after cooling to a room temperature. The volume of gluten-free breads was determined following the Polish Standard [PN-A-74123:1997].

A sensory acceptance test was carried out by an 8-member panel using the profile sensory method – Quantitative Description Analysis (QDA). The panellists evaluated 16 quality attributes: colour, taste, smell, texture and desirability in a hedonic scale of 10 degrees of liking.

RESULTS AND DISCUSSION

The adherence to a gluten-free diet requires the elimination of food products obtained from cereal grains: wheat, rye, barley, or oat. This diet is generally poor in components important for maintaining the well-being of a human organism, such as proteins or mineral compounds. Therefore, we were interested in the supplementation of commercial gluten-free formulations with buckwheat flour which contains proteins characterised by a very low level of a gliadin fraction and a good amino-acid balance [Krkošková & Mrázová, 2005].

The gluten-free formulations: NISKOBIAŁKOWA and MLECZNA used in this study were characterised by a very low content of proteins (1.5 and 1.6% d.m., respectively), while proteins content in the buckwheat flour reached 12.6% d.m. (Table 1). The substitution of 30 or 50% of the gluten-free formulation basis with buckwheat flour caused a significant increase in the contents of proteins and total elements.

TABLE 1. Contents of proteins, ash and resistant starch in the investigated materials.

Materials	Proteins (% d.m.)	Ash (% d.m.)	Resistant starch (% d.m.)
NISKOBIAŁKOWA formulation	1.53 ± 0.24	0.14 ± 0.03	2.52 ± 0.13
with 30% of buckwheat flour	4.11 ± 0.14	0.69 ± 0.02	5.25 ± 0.42
with 50% of buckwheat flour	6.22 ± 0.14	1.11 ± 0.03	5.71 ± 0.42
MLECZNA formulation	1.60 ± 0.14	0.49 ± 0.01	4.43 ± 0.40
with 30% of buckwheat flour	4.89 ± 0.05	1.12 ± 0.01	5.08 ± 0.38
with 50% of buckwheat flour	6.79 ± 0.05	1.58 ± 0.04	5.91 ± 0.14
Buckwheat flour	12.61 ± 0.18	2.42 ± 0.08	6.56 ± 0.20

Besides, resistant starch content increased after the addition of the buckwheat flour into the investigated formulations (Table 1). These results indicated the improvement of the quality of experimental baking products upon the enrichment in nutritional compounds (proteins and elements). Also the increase in resistant starch content, which revealed the physiological function in human organism [Soral-Śmietana & Wronkowska, 2004] and could complete the pool of dietary fibre, was observed as well.

Water binding capacity measurement was conducted at 25°C, which is connected with water addition during the bread making process. Oil sorption was the next parameter which is necessary for the preparation of a mixture of gluten-free bread. Both parameters describe hydrophilic and hydrophobic properties of the investigated gluten-free formulations. The results of the analysis of functional properties indicated higher oil sorption ability of buckwheat flour in comparison with both gluten-free formulations (Table 2). The presence of 30 or 50% w/w of buckwheat flour in the gluten-free formulations did not change significantly the functional properties of a mixture. However, a decrease of water binding capacity was observed, which suggests some hydrophobic tendency of the new experimental compositions. Zheng *et al.* [1998] studied functional properties of buckwheat, corn and rice starches. They confirmed that the pasting temperature of buckwheat starch was similar to that of corn and rice starches (75°C), and that the swelling power of buckwheat starch increased almost linearly from 65 to 95°C, whereas that of corn and rice starches increased more rapidly from 85 to 95°C. Besides, the solubility of buckwheat starch was similar to those of corn or rice starches at 65-85°C. Wronkowska *et al.* [2005] demonstrated that the industrially-isolated starches of different botanical origin (wheat, potato, pea, tapioca, corn, waxy corn)

TABLE 2. Water binding capacity and oil sorption of the investigated materials.

Materials	Water binding capacity (g water/g d.m.)	Oil sorption (g oil/g d.m.)
NISKOBIAŁKOWA formulation	1.02 ± 0.01	1.20 ± 0.01
with 30% of buckwheat flour	0.97 ± 0.02	1.32 ± 0.02
with 50% of buckwheat flour	0.94 ± 0.01	1.22 ± 0.01
MLECZNA formulation	0.93 ± 0.02	1.14 ± 0.01
with 30% of buckwheat flour	0.84 ± 0.01	1.16 ± 0.04
with 50% of buckwheat flour	0.85 ± 0.01	1.18 ± 0.01
Buckwheat flour	1.25 ± 0.02	1.32 ± 0.01

were characterised by hydrophobic properties, as their oil sorption ranged from 1.16 to 1.48 g oil per 1 g of dry matter of starch, whereas the water binding capacity ranged from 0.64 to 0.97 g water per 1 g of dry matter of starch. Both investigated gluten-free formulations constituted a mixture containing wheat and corn starches, and some hydrocolloids (pectin or guar gum). The replacement of such a significant amount (30 or 50% w/w) of the sum of components of this mixture with the buckwheat flour provoked changes of their functional properties during kneading and forming of dough.

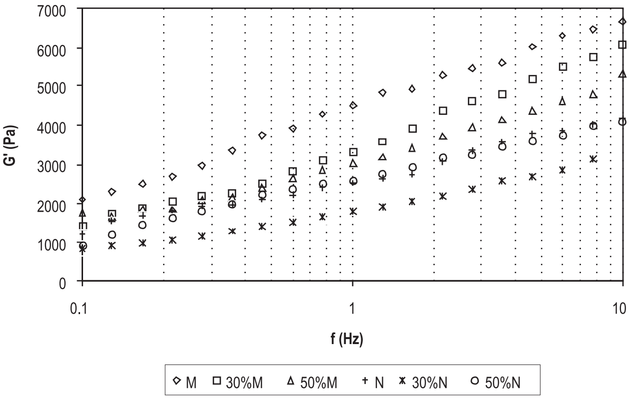

FIGURE 1. Elastic modulus (G') for gluten-free dough with buckwheat flour.

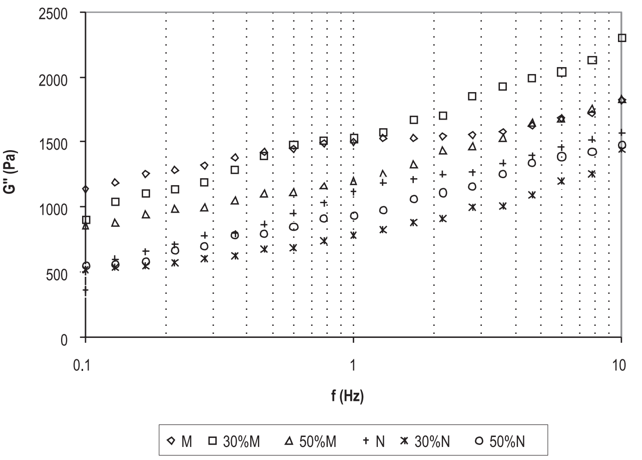

FIGURE 2. Viscous modulus (G") for gluten-free dough with buckwheat flour.

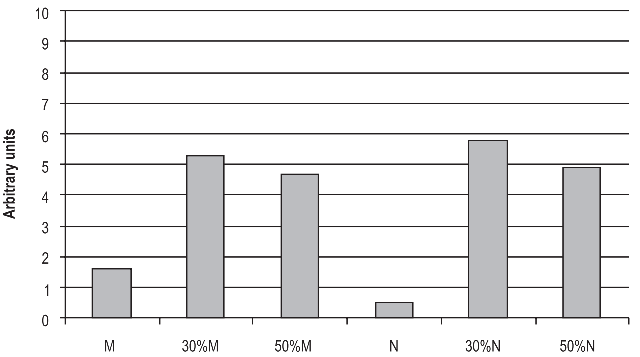

FIGURE 3. Effect of buckwheat flour on sensory panel overall acceptability score of gluten-free breads.

The use of a rheometer to analyse rheological behaviour of the gluten-free dough has been rather sparse [Gujral *et al*., 2003; Sivaramakrishnan *et al*., 2004; Lazaridou *et al*., 2007]. Dynamic rheological studies of the dough obtained from gluten-free formulations named: NISKOBIAŁKOWA and MLECZNA showed that their elastic modulus (G') was higher than the viscous modulus (G"), which suggests a solid elastic-like behaviour of both investigated gluten-free doughs (Figures 1 and 2). However, in comparison with dough obtained from NISKOBIAŁKOWA, the dough prepared from MLECZNA formulation showed higher values of both elastic and viscous moduli. Incorporation of buckwheat flour into the dough of both formulations affected the lowering of elastic modulus (Figure 1), however it was not related with the amount of added buckwheat flour. This result suggests that the buckwheat flour may replace some part of hydrocolloids, guar gum and pectin, presented in the analysed gluten-free formulations, and its structural properties are not strong enough to form the proper dough structure formation. Lazaridou *et al*. [2007] reported that the elastic modulus was greater than the viscous modulus for gluten-free dough formulations with the addition of five different hydrocolloids. Sivaramakrishnan *et al*. [2004] demonstrated that rice flour dough had higher elastic and viscous moduli than wheat dough, and for the rice dough the value of G' was higher than G". Furthermore, they found that in the case of rice dough with a low concentration of hydroxypropylmethyl cellulose (HPMC, used as a gluten substitute) the values of both mentioned moduli were similar to that obtained for wheat dough. However, at a higher concentration of HPMC the rheological characteristics of the dough displayed properties of the additive rather than these of dough. Wronkowska & Walkowski [2004] ascertained that the rheological properties of wheat flour dough supplemented with an industrial potato fibre preparation were dependent on the amount of potato fibre preparation used, which was probably connected with very high hydrophilic abilities of the analysed preparation. The higher content of potato fibre preparation caused an increase of elastic modulus of the investigated wheat dough, which is likely to result from the competition for water between gluten of wheat flour and fibre potato preparation.

In order to evaluate the acceptability of gluten-free bread with 30 and 50% of buckwheat flour the laboratory baked breads were tested by an 8-person sensory panel (Figure 3). The baking products obtained from MLECZNA and NISKOBIAŁKOWA formulations with 30% of buckwheat flour reached significantly better notes in comparison with the control samples. In the case of bread containing 50% of buckwheat flour obtained from both formulations the total score was lower, however still much higher than for the control sample.

CONCLUSIONS

Buckwheat flour could be applied as a supplement and/or additive component of a gluten-free formulations, which may fulfil the function of a substrate constituting a source of nutritional and non-nutritional substances. The preliminary sensory evaluation of gluten-free breads with 30% of buckwheat flour showed significant improvement of the sensory quality in comparison with control breads which obtained very low notes in total score. Therefore, based on the results obtained, the utilisation of buckwheat flour could be suggested as a substrate combining both biological and sensory functions in gluten-free products.

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MĄKA GRYCZANA – CENNY SKŁADNIK PRODUKTÓW BEZGLUTENOWYCH

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W badaniach określono suplementujący wpływ mąki gryczanej, zastępującej 30 oraz 50% handlowych mieszanek bezglutenowych MLECZNA i NISKOBIAŁKOWA, na składniki odżywcze oraz nie odżywcze. Wykonano badania określające oddziaływania tego komponentu na właściwości technologiczne i reologiczne ciasta. Analizowano wybrane składniki chemiczne mieszanek bezglutenowych oraz mąki gryczanej, a także nowych laboratoryjnych kompozycji z wymianą masy na 30 lub 50% w/w mąki gryczanej. Charakteryzowano właściwości reologiczne ciasta za pomocą reometru oscylacyjnego RheoStress1 (Haake) w układzie pomiarowym płytka-płytka ryflowana PP20T, mierząc moduły sprężystości (G') oraz lepkości (G") ciasta z kompozycji doświadczalnych w porównaniu z mieszankami handlowymi. Zastosowanie mąki gryczanej w kompozycjach bezglutenowych spowodowało zwiększenie zawartości białka ogółem, składników mineralnych ogółem oraz skrobi amylazoopornej. W wyniku udziału mąki gryczanej stwierdzono tendencję zmniejszania właściwości hydrofilnych nowych kompozycji bezglutenowych. Moduły sprężystości i lepkości ciasta z mieszanki bezglutenowej MLECZNA były wyższe niż ciasta z mieszanki bezglutenowej NISKOBIAŁKOWA. Dowodzi to, że struktura ciasta bezglutenowego MLECZNA jest bardziej zwarta niż ciasta z mieszanki bezglutenowej NISKOBIAŁKOWA. Zastąpienie w 30 lub 50% badanej mieszanki mąką gryczaną obniżyło parametry reologiczne w obu kompozycjach bezglutenowych, co świadczy o rozluźnieniu konsystencji ciasta i zmniejszeniu jego lepkości.

Uzyskane wyniki dowiodły, że mąka gryczana może stanowić bardzo korzystny odżywczy i funkcjonalny suplement w kompozycjach bezglutenowych, z jednoczesnym wyraźnym jej oddziaływaniem na konsystencję ciasta oraz poprawę jakości sensorycznej produktu.