

ZLATICA KOHAJDOVÁ, JOLANA KAROVIČOVÁ

EFFECT OF INCORPORATION OF SPELT FLOUR ON THE DOUGH PROPERTIES AND WHEAT BREAD QUALITY

Streszczenie

Effect replacement of wheat flour with spelt flour on the rheological parameters, baking quality and sensory acceptance was studied. Increasing level of spelt flour in the flour blend concluded in enhanced water absorption capacity and longer dough development time. Addition of spelt flour affected baking and sensory parameters of products. The assessors evaluated as the most acceptable baked goods with 15% addition of spelt flour.

Słowa kluczowe: spelt, farinograph, baking quality

Introduction

Spelt (*Triticum aestivum* var. *spelta*) is an ancient and distant relative to modern wheat (*Triticum aestivum*). The nutty flavour of spelt has long been popular in Europe, where it is also known as 'Farro' (Italy) and 'Dinkel' (Germany) [1]. Spelt is an interesting (hexaploid) crop for marginal regions where environmental factors prevent the cultivation of wheat.

Compared with wheat, spelt is taller (150 ± 200 cm), has long, lax ears (15 ± 20 cm), a brittle rachis and tight glumes [2].

For many years, cultivation of spelt declined, but recent interest in use of spelt for ecologically grown foods has led to resurgence in its cultivation. Spelt wheat is a low-input plant, suitable for growing without the use of pesticides, in harsh ecological conditions and in marginal areas of cultivation. [3].

The nutritive value of spelt wheat is high and it contains all the basic components which are necessary for human beings such as sugars, proteins, lipids, vitamins and minerals [4]. The crude protein composition of spelt varies from 15 to 20 g/100 g

Ing. Z. Kohajdová, PhD, Doc. Ing. J. Karovičová, PhD., Department of Food Science and Technology, Institute of Biotechnology and Food Science, Faculty of Chemical and Food Technology, Slovak University of Technology, Radlinského 9, 812 37 Bratislava, Slovak Republic

grains [5] while, e.g. that of Finnish winter wheat is reported to be 11–12 g/100 g [1]. Grain of spelt is claimed to be naturally higher in fibre, B vitamins and carbohydrates than wheat, but the results vary greatly [5, 6]. The differences may be due to the growing place and season, cultivation, fertilizers and methods of analysis [1]. Spelt has also been recommended for treatment of colitis, ulcerosa, neurodermitis and others allergies [7, 8], high blood cholesterol [7, 8, 9], rheumatoid arthritis, depression and cancer [7, 10].

Spelt is used for baking, brewing, production of pasta, self-supplied animal fodder as well as a number of regional specialities (e.g., the Grünkern of southern Germany) [11].

This study reports effect addition of wholemeal spelt flour on some baking characteristics of wheat flour.

Materials and methods

Materials

Fine wheat flour T650, wholemeal spelt flour, salt, sugar, oil and yeast. All raw materials were procured from the local market in Slovakia. Blends of fine wheat flour and wholemeal spelt flour were prepared by replacing wheat flour with spelt flour at 0, 3, 5, 10, 15, 30, 50 and 100%.

Samples preparation

In the test baking dough (wheat flour or wheat-spelt blend flour 300 g, salt 5.63 g, sugar 3.22 g, yeast 12.06 g, sunflower oil 7.50 g and water to farinographic consistency 400 farinographic units – FU) was mixed during 6 minutes in farinographic mixing bowl. After 20 min fermentation, the dough was divided into 100 g loaves, formed on dough former, proofed 45 min and baked in an electric oven during 13 min at 230°C.

Methods

The measurement of pH was performed using a pH meter InoLab pH Level 2 (WTW Weilheim, Germany). AACC International Approved Method (02-31) method was used for determination of titrable acids (mmol/kg). ICC methods were used for determination of moisture (ICC standard No. 110/1), ash (ICC standard No. 104/1) and starch (ICC standard No. 122/1). Protein was determined by the Kjeldahl method (979.09) (AOAC, 1990), using a nitrogen to protein conversion factor of 5.7. Slovak Technical Norms were used for determination of wet, dry gluten and wet gluten characteristics (STN 46 1011).

For farinographic determination farinograph Brabender (Germany) was used. Standard method (ISO 5530-1: Wheat flour-Physical characteristics of dough, Part 1: Determination of water absorption and rheological properties using a farinograph was

used for farinographic tests. All farinographic tests were repeated three times and the values presented are means of three replications.

The loaf quality and sensory attributes were evaluated after cooling for 2 h at room temperature. Sensory evaluation was accomplished by the 4-point hedonic scale determination by 7 assessors. The assessors evaluated: shape of product, crust colour and thickness/hardness, crust/crumb odour and taste, crumb: elasticity, porosity colour, resistance to the bite and adhesiveness to palate on longer chewing). Evaluation of loaf quality included: the loaf volume (cm^3), specific loaf volume (cm^3 per 100 g of loaf), cambering (loaf height/width ratio). Millet seeds were used to measure loaf volume as a difference of volume of empty bowl and the bowl with the baked loaf.

Results and discussion

Chemical Characteristics of Fine Wheat and Wholemeal Spelt Flour

In general, spelt may contain higher levels of protein, soluble dietary fiber and minerals depending on the genotype. Thus, spelt consumption could have nutritional consequences relative to common wheat [10]. Abdel-All et al. [5, 10] found in several spelt cultivars 14.9–16%, in hard spelt 17.4% and in the soft spelt 16.5% of proteins, conversely Zielinski et al. [12] found in ten spelt wheat strains originated from Polish breeding only 7.5–10.8% of proteins. Lacko-Bartošová and Rádlová [13] determined in different spelt varieties more than 60% of starch, Abdel-All et al. [5] shows higher content of starch (60.9–65.8%).

Table 1

Chemical characteristics of fine wheat and wholemeal spelt flour.
Chemiczna charakterystyka mąki pszennej i orkiszowej.

| Distinguishing mark Wyróżniki | Wheat flour Mąka pszenna | Spelt flour Mąka orkiszowa |
|--|-----------------------------|-------------------------------|
| pH | 6.10 ± 0.02 | 5.92 ± 0.02 |
| Titrate acids [mmol kg^{-1}] Kwasowość miareczkowa | 30.28 ± 1.2 | 44.20 ± 0.5 |
| Moisture [%] Wilgotność | 11.93 ± 0.2 | 10.65 ± 0.2 |
| Ash [% in dry matter] Popiół [% suchej masy] | 0.68 ± 0.01 | 2.21 ± 0.02 |
| Starch [%] Skrobia | 87.89 ± 0.8 | 66.66 ± 0.6 |
| Protein N-substances x 5.7 [%] Białko (Nx5,7) | 11.20 ± 0.2 | 17.30 ± 0.3 |

Mean value ± standard deviation, n = 3 / Wartość średnia ± odchylenie standardowe

Table 1 summarised the chemical properties and Table 2 gluten characteristics flours used in this study. Wholemeal spelt flour applied in this study was characterised by higher content of proteins (17.3%) and ash (2.2%), lower starch content (66.7%) and had higher gluten content in comparison with wheat flour. The higher protein content in spelt wheat is reported thanks to the higher protein portion of aleuron layer [4]. High ash content in wholemeal spelt flour can be due to the high content of macro- and microelements, confirming previous observation that spelt grain is a richer source of phosphate, zinc, copper and selenium when compared to other cereal grains [12].

Table 2

Gluten characteristics for fine wheat and wholemeal spelt flour.
Charakterystyka glutenu z mąki pszennej i orkiszowej.

| Gluten features Cechy glutenu | Wheat flour Mąka pszenna | Spelt flour Mąka orkiszowa |
|--|---|--|
| Wet gluten [% in dry matter] Gluten [% suchej masy] | 31.55 ± 0.4 | 40.99 ± 0.5 |
| Extensibility of gluten [cm] Rozciągliwość glutenu | 10.70 ± 0.2 medially extensible średnio rozciągliwy | 15.80 ± 0.3 extensible rozciągliwy |
| Sweeling of gluten [cm ³] Pęcznienie glutenu | 18 ± 0.5 | 6 ± 0.5 |
| Dry gluten [% in dry matter] Suchy gluten [% suchej masy] | 10.3 ± 0.4 | 16.0 ± 0.3 |

Explanatory notes as in Tab. 1 / Objasnienia, jak w tab. 1.

The amount of wet gluten as an indicator is closely connected with the baking quality of bread grains. For food wheat the demand is minimum 25% of gluten [4]. Lacko-Bartošová and Rádlová [13] presented that the content of wet gluten of different spelt wheat varieties ranged from 31.01 to 39.50% and Bojňanská and Frančáková [4] found that wet gluten content in 5 spelt cultivars varied between 30.60 and 51.80%. Zielinski et al. [12] found in spelt wheat strains originated from Polish breeding from 30.1 to 37.2% of wet gluten. We found that the content of gluten in the Slovak wholemeal spelt flour was about 1.3 times higher as in the fine wheat flour. Gluten quality is characterised by the degree of extensibility and elasticity [14]. Spelt wheat flour gluten was more dispersed with less flexibility and was more extensible as fine wheat flour.

Farinograph characteristics of blend flours

Several authors presented that dough made from spelt flours is characterised by lower stability, less elasticity, and higher extensibility than common wheat dough.

Spelt dough is very soft and sticky after kneading; thus, handling spelt dough is more difficult, and the loaf volume is generally lower than modern wheat cultivars [2, 5, 15, 16, 17]. The effect of different levels of spelt flour on farinograph characteristics is shown in Table 3.

Table 3

The effect of different additives of spelt flour on farinograph characteristics of wheat flour.
Charakterystyka farinograficzna mąki pszennej z różnymi dodatkami mąki orkiszowej.

| Addition of spelt flour [%] Dodatek mąki orkiszowej | Water absorption [%] Absorpcja wody | Dough development time [min] Czas rośnięcia ciasta | Degree of softening [FU] Stopień mięknięcia | Mixing tolerance index [FU] Wskaźnik tolerancji mieszania | Dough stability [min] Stabilność ciasta |
|--|--|---|--|--|--|
| 0 | 60.1 ± 1.5 | 3.5 ± 0.1 | 77.8 ± 1 | 90 ± 3 | 5.5 ± 0.3 |
| 3 | 60.3 ± 2.0 | 3.55 ± 0.1 | 81.0 ± 1 | 81 ± 3 | 5.36 ± 0.2 |
| 5 | 61.0 ± 2.0 | 3.65 ± 0.2 | 83.5 ± 2 | 80.3 ± 2 | 5.3 ± 0.2 |
| 10 | 61.2 ± 1.5 | 3.95 ± 0.2 | 87.5 ± 1 | 77.0 ± 2 | 5.15 ± 0.2 |
| 15 | 61.6 ± 1.5 | 4.0 ± 0.25 | 89 ± 2 | 74.0 ± 2.5 | 4.8 ± 0.1 |
| 30 | 63.2 ± 2.5 | 4.05 ± 0.3 | 100 ± 3 | 70.0 ± 2.5 | 4.6 ± 0.2 |
| 50 | 65.0 ± 2.0 | 4.15 ± 0.3 | 125 ± 2 | 65 ± 2 | 3.8 ± 0.1 |
| 100 | 69.3 ± 2.0 | 4.25 ± 0.3 | 175 ± 4 | 56.0 ± 1 | 3.5 ± 0.1 |

Explanatory notes as in Tab. 1 / objaśnienia, jak w tab. 1.

Water absorption gives an indication of the potential of the protein molecules to absorb moisture. Higher protein content flour generally results in higher water absorption [18]. It was clear that the water absorption for the wheat flour was 60.1% and it ranged between 60.3 and 69.3% with increase in the spelt flour from 3 to 100% in the blends. Ceglinska [16] found lower water absorption for spelt (62%), Bonafaccia et al. [3] noted water absorption of 58% and Pruska-Kędzior et al. [17] observed only 57.7% water absorption capacity for spelt flour.

The dough development time of spelt-wheat blend dough increased from 3.5 to 4.25 min indicating slower hydration at higher levels of spelt flour.

A longer dough stability period indicates a stronger tolerance to mixing and greater flexibility in blending operations [19]. Bojňanská et al. [4] and Bonifacia et al. [3] determined shorter dough stability for spelt flour in comparison with hard red winter wheat. The dough stability was shortened from 5.5 min to 3.5 min with increase in the spelt flour from (0 to 100% in the blends). Schober et al. [20] found that spelt dough had less mixing tolerance index in comparison with wheat dough. Mixing tolerance index samples of wheat-spelt dough decreased with increasing addition of spelt flour from 81 to 56 FU. Stiegert and Blanc [19] stated that higher weakening degree

numbers indicate lower dough stability. Our results were in agreement in these authors. Further it was found that dough prepared only from wholemeal spelt flour were very soft and sticky during kneading. This fact can be explained thereby that rheological properties of spelt gluten are predominated by gliadins as a very sticky monomeric plasticizer, while those of common wheat gluten by glutenins as a networking polymeric factor [17].

The sensory analysis and loaf quality

The baking experiments were performed on blend flour samples containing from 0 to 50% of spelt flour because dough prepared only from wholemeal spelt flour was very sticky. Results of baking experiments are presented in Table 4.

Table 4

Results of baking experiments of bread using different spelt flour.

Wyniki próbnego wypieku chleba z udziałem różnych dodatków mąki orkiszowej.

| Distinguishing mark Wyróżniki | Addition of spelt flour [%] / Dodatek mąki orkiszowej | | | | | | |
|--|---|--------------------|--------------------|--------------------|--------------------|--------------------|---------------------|
| | 0 | 3 | 5 | 10 | 15 | 30 | 50 |
| Amount of added water [cm ³] Dodatek wody | 180 ± 1 | 183 ± 0.5 | 185 ± 1.5 | 186,8 ± 1 | 187,3 ± 1 | 194.3 ± 1.5 | 199 ± 1.5 |
| Before baking weight [g] Masa przed wypiekiem | 100.3 ± 0.1 | 100.3 ± 0.1 | 100.1 ± 0.2 | 100.1 ± 0.15 | 100.1 ± 0.15 | 100.03 ± 0.2 | 100.03 ± 0.2 |
| After baking weight [g] Masa po wypieku | 87.7 ± 0.2 | 87.5 ± 0.3 | 87.4 ± 0.2 | 87.6 ± 0.25 | 86.5 ± 0.1 | 88.4 ± 0.1 | 87.7 ± 0.2 |
| Loaf volume [cm ³] Objętość bochenka | 328.3 ± 4.5 | 322.1 ± 5 | 319 ± 4.8 | 318 ± 3.6 | 313.1 ± 4 | 311.7 ± 4.3 | 278.3 ± 4.7 |
| Specific volume [ml/100g] Objętość właściwa | 369.8 ± 6 | 368.1 ± 5.4 | 365 ± 5.1 | 363 ± 6.5 | 362 ± 5.9 | 352.5 ± 6.8 | 317.3 ± 6.2 |
| Cambering Sklepienie | 0,620 ± 0.05 | 0.575 ± 0.04 | 0.539 ± 0.04 | 0.504 ± 0.03 | 0.482 ± 0.04 | 0.396 ± 0.03 | 0.344 ± 0.025 |
| Baking loss [%] Strata piecowa | 12.5 ± 0.5 | 12.7 ± 0.4 | 12.7 ± 0.4 | 12.4 ± 0.3 | 13.5 ± 0.4 | 11.6 ± 0.2 | 12.4 ± 0.3 |

Explanatory notes as in Tab. 1 / objaśnienia, jak w tab. 1.

The loaf volume and its specific volume are very important indicators for bread making quality [4]. The effect different levels of spelt flour on loaf volume and specific volume is showed in the Fig. 1.

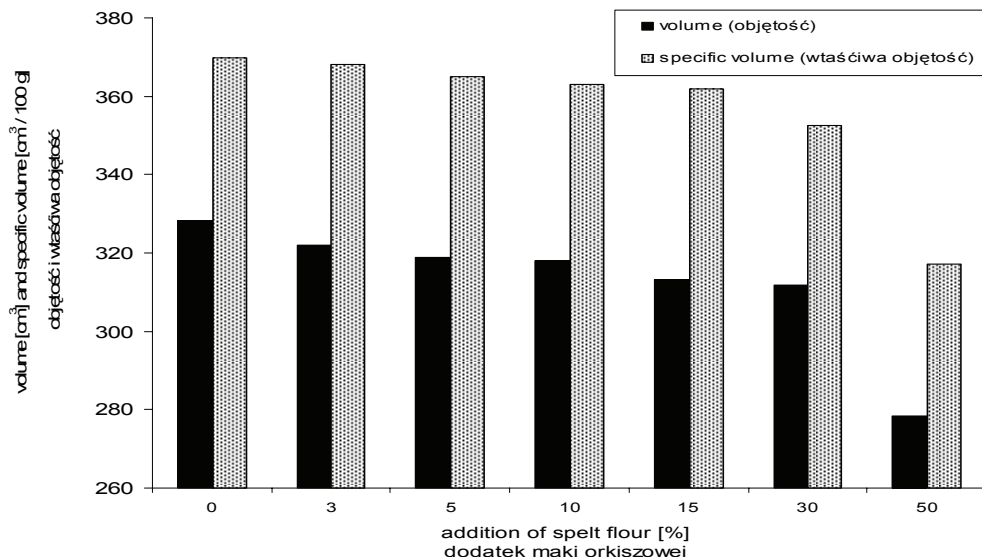


Fig. 1. Effect of spelt flour addition on volume and specific volume of loaves.

Rys. 1. Wpływ dodatku mąki orkiszowej na objętość i objętość właściwą.

These parameters decreased with the increasing content of spelt flour in the flour blend. The highest decreasing was observed at 50% addition of spelt flour in the flour blend (about 1.8 times). Cambering is an important parameter because spelt bread tends to become flat [12]. The cambering values between 0.601 and 0.700 are regarded to good and cambering values under 0.5 are not considered to sufficient. [21]. The cambering of our baked goods decreased from 0.620 (fine wheat loaves) to 0.344 with increasing content of spelt flour in the blend flour. Values under 0.5 were observed in blends contained 15, 30 and 50% addition of spelt flour. Conversely Bojňanská and Frančáková [4] found higher cambering values for baked goods (0.6–0.7) prepared only from spelt flour.

Abdel-Aal et al. [15] found out that bread made from spelt flour only had worse volume, texture and crumb colour in comparison to bread made from hard red spring wheat. The sensory aspect of such bread was evaluated as average. Conversely, Bojňanská and Frančáková [4] showed that acceptability of spelt breads in the sensory test was good and the loaves made from Holsterkorn, Schwabenkorn and Baulärded Spelz cultivars were evaluated as the best one according to the taste evaluation. Diagram of loaf sensory evaluation is presented to Fig. 2.

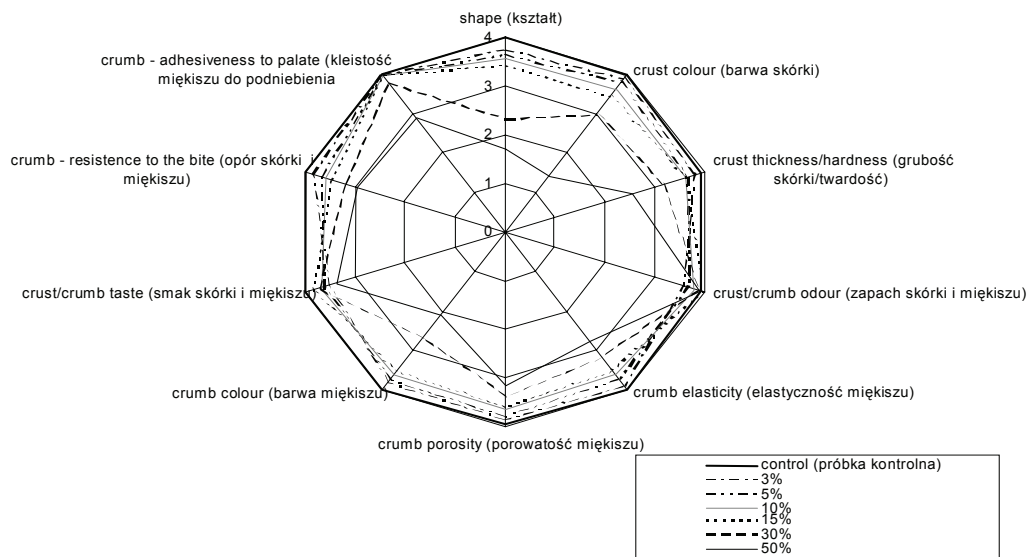


Fig. 2. Effect of spelt flour addition on sensory parameters of baked goods.

Rys. 2. Wpływ dodatku mąki orkiszowej na charakterystykę sensoryczną pieczywa.

The shape products contained 30 and 50% of spelt flour had

The crust and crumb colour was darker with increasing addition of spelt flour. The assessors evaluated as the most acceptable baked goods prepared with blend contained 15% of spelt flour. These products had also the most pleasant crust/crumb taste and odour. The crumb samples contained 30 and 50% of spelt flour was fewer elastic and samples were soften in compare with wheat baked goods. Samples with addition of 15 and more percent of spelt flour have a slightly perceptible nutty taste.

Conclusion

Spelt showed behaviour different from modern wheat in baking. Addition of wholemeal spelt flour affected the dough properties, baking quality and sensory parameters.

Baked goods prepared from spelt flour had a lower volume, specific volume and a rather open grain and coarse texture. For assessors the products containing 15% of spelt flour was the most acceptable. In conclusion for preparation these type of products we recommended application of improvement agent for example ascorbic acid to reduction of the dough extensibility [4] and improvement both texture and loaf volume [22].

Acknowledgement

This paper was supported by the Slovak Grant Agency for Science VEGA (Grant No. 1/3546/06), APVT (Grant No. 20-002904), AV (Grant No. 4/0013/07) and APVV (Grant No. 031006).

Literatura

- [1] Puumalainen P., Nykopp H., Tuorilaw H.: Old Product in a New Context: Importance of the Type of Dish for the Acceptance of Gru'nkern, a Spelt-Based Traditional Cereal. *Lebensm.Wiss. Technol.*, 2002, **35**, 549-553.
- [2] Zanetti S., Winzeler M., Feullet C., Keller B., Messner M.: Genetic analysis of bread-making quality in wheat and spelt. *Plant Breeding*, 2001, **120**, 13-19.
- [3] Bonifácia G.V., Galli V., Francisci R., Mair V., Skrabanja V., Kreft I.: Characteristics of spelt wheat products and nutritional value od spelt wheat- based bread. *Food Chem.*, 2000, **68**, 437-441.
- [4] Bojňanská T., Frančáková H.: The use of spelt wheat (*Triticum spelta L*) for baking applications. *Rostl. Výr.*, 2002, **48 (4)**, 141-147.
- [5] Abdel-Aal E.S., Hulc P., Sosulski F. W.: Compositional and nutritional characteristics of spring einkorn and spelt wheats. *Cereal Chem.*, 1995, **72**, 621-624.
- [6] Grela E.R.: Nutrient composition and content of antinutritional factors of spelt (*Triticum spelta L*) cultivars. *J. Sci. Food Agric.*, 1996, **71**, 399-404.
- [7] Lacko-Bartošová M., Otepka P.: Evaluation of choosen yield components of spelt wheat cultivars. *J. Central Eur. Agric.*, 2001, **2 (3-4)**, 279-284.
- [8] Ranhorta G.S., Gelroth J.A., Glaser B.K., Lorenz K.J.: Baking and nutritional qualities of spelt wheat sample. *Lebensm. Wiss Technol.*, 1995, **28**, 118-122.
- [9] Rozeng R.: Phytosterol analysis and characterisation in spelt (*Triticum aestivum ssp. spelta L.*) and wheat (*T. aestivum L.*) lipids by LC/APCI-MS. *J. Cereal Sci.*, 2003, **38**, 189-197.
- [10] Abdel-aal E. S., Hucl P.: Amino acid composition and in vitro digestibility of selected ancient wheat and their preproducts. *J. Food Comp. Anal.*, 2002, **15**, 737-747.
- [11] Büren M., Lüthy J., Hübner P.: A spelt-specific γ -gliadin gene: discovery and detection. *Theor. Appl. Gen.*, 2000, **100**, 271-279.
- [12] Zielinski H., Ceglinska A., Michalska A.: Bioactive compounds in spelt bread. *Eur. Food Res. Technol.*, 2007 (in press).
- [13] Lacko-Bartošová M., Rédlová M.: The significance of spelt wheat cultivated in ecological farming in the Slovak Republic. In: *Proceeding of conference Organic farming, Praha: ČZV, 2007*, pp. 79-81.
- [14] Šimić G., Horvat D., Jurković Z., Drezner G., Novoselović K., Dvojković K.: The genotype effect on the ratio of wet gluten content to total wheat grain protein. *J. Central Eur. Agric.*, 2006, **7 (1)**, 13-18.
- [15] Abdel-Aal E.S.M., Hucl P., Sosulski F.W., Bhirud P.R.: Kernel, milling and baking properties of spring einkorn and spelt wheats. *J. Cereal Sci.*, 1997, **26 (3)**, 363-370.
- [16] Ceglińska A.: Technological value of a spelt and common wheat hybrid. *Electric J. Polish Agric. Universities.*, 2003, **6 (1)**, 1-9.
- [17] Pruska-Kedzior A., Kedzior Z., Klockiewicz-Kaminska E.: Comparison of viscoelastic properties of gluten from spelt and common wheat. *Eur Food Res Technol.*, 2007 (in press).
- [18] Meintjés G. D.: The use of HPLC for quality prediction of South African wheat cultivars. *Wyd. University of the Free State, Bloemfontein* 2004.

- [19] Stiegert K., Blanc J. P.: Japanese demand for wheat protein quantity and quality. *J. Agric. Res. Econ.* 2000, **22** (1), 104-119.
- [20] Schober T. J., Clarke I., Kuhn M.: Characterisation of functional properties of gluten proteins in spelt cultivars using rheological and quality factor measurements. *Cereal Chem.*, 2002, **79** (3), 408-417.
- [21] Smelík A.: Laboratorium odboru – Chémia a technológia sacharidov. Wyd. Edičné stredisko SVŠT, Bratislava 1987.
- [22] Demirap H., Celik S., Koxsel H.: Effects of oxidizing agents and defatting on the electrophoretic patterns of flour proteins during dough mixing. *Eur. Food Res. Technol.*, 2000, **211**, 322-325.

WPLYW DODATKU MĄKI PSZENICY 'ORKISZ' NA WŁAŚCIWOŚCI CIASTA I JAKOŚĆ CHLEBA PSZENNEGO

S u m m a r y

Badano wpływ zastąpienia mąki pszennej mąką z orkiszem na właściwości reologiczne ciasta, wartość wypiekową i sensoryczną akceptowalność pieczywa. Stwierdzono że zwiększanie dodatku mąki orkiszowej powoduje wzrost absorpcji wody i wpływa na przedłużenie czasu wyrobienia ciasta. Dodatek mąki orkiszowej wpływa również na wypiek i parametry sensoryczne produktów. Badania sensoryczne wykazały, że uzyskane wypieki miały najlepszą jakość, gdy dodatek mąki orkiszowej wynosił 15%.

Key words: orkisz, farinograf, wartość wypiekowa ☒