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THE APPLICATION OF RESIDUAL OATS FLOUR IN BREAD PRODUCTION IN ORDER TO IMPROVE ITS QUALITY AND BIOLOGICAL VALUE OF PROTEIN

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Background. High nutritional value of residual oat flour, which is a by-product in the production β-D-glucan concentration BETAVEN, was the reason to make a trial to apply it in the production of wheat and wheat-rye bread. The aim of the study was to establish a formulation for wheat and wheat-rye bread, in which part of wheat flour would be replaced by residual oat flour (at the level 20% of wheat flour), and to check the influence of this additive on sensory and nutritional properties of the products, with special consideration to content and biological value of the proteins.
Material and methods. The material consisted of wheat flour, rye flour and residual oat flour, as well as loaves, baked with these flours. The quality of the obtained loaves was analysed taking into account: organoleptic assessment, loaf mass and volume, moisture content crumb and texture profile of the crumb. In the studied raw materials and bread, the following components were determined according to AOAC methods: protein content, fat, fiber and ash. In addition, composition of amino acids was assessed. Basing on the amino acid composition, Chemical Score (CS) and Exogenic Amino Acid Index (EAAI) were calculated, applying WHO/FAO protein standard (1991).
Results. Bread with the share of residual oats flour received high consumer acceptance (37 points), comparable to control bread (38 points) despite of lower volume. The applied amounts of oats flour did not influence moisture content and texture profile during storage. Wheat and wheat-rye loaves with the share of residual oats flour were characterised by a significantly higher level of dietary fiber, fat and protein, in comparison to control bread. It was found that biological activity of protein in wheat-rye bread was significantly higher (CS = 53.5, EAAI = 91.5) in comparison to wheat bread (CS = 47.9, EAAI = 89.9). The share of oats flour caused an increase in biological value of all bread types – wheat-oats (CS = 52.7, EAAI = 91.2), wheat-rye-oats (CS = 56.4, EAAI = 91.9).
Conclusions. The results indicate that residual oat flour is a good source of proteins with a high biological value. Beneficial amino acid composition, and high contents of dietary

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fiber and fat make the flour an interesting additive for the production of white bread, both wheat and wheat-rye, which could be used in the amounts up to 20% of wheat flour mass.

Key words: bread, residual oat flour, nutritional value, biological value of protein

INTRODUCTION

Oat grain is characterised by especially valuable chemical composition, and the combination of nutritional compounds present in this raw material, makes it a profitable constituent of human diet [Hahn et al. 1990, Bartnikowska et al. 2000, Sadiq Butt et al. 2008, Food... 2008]. Oat grain contains protein with beneficial amino acid composition, advantageous profile of fatty acids, with high amount of PUFA, and large quantity of water soluble β-glucans and antioxidants [Hahn et al. 1990, Bartnikowska 2003, Sadiq Butt et al. 2008].

The major part of oat proteins is built up by globulins (approx. 80% total protein), and the rest (ie. approx. 20%) prolamins and glutenins [Pedo et al. 1999, Bartnikowska et al. 2000, Salehifar and Shahedi 2007, Sontag-Strohm et al. 2008]. High percentage of globulins is typical only for oat proteins, because in other cereals, this fraction constitutes only about 10-15% of all proteins [Bartnikowska et al. 2000, Salehifar and Shahedi 2007, Kohajdová i Karovičová 2008]. In the studies on chickens and pigs it was observed, that oat proteins are easily digestible, the value of TPD – Total Protein Digestibility may reach 89-94% [Pedo et al. 1999, Bartnikowska et al. 2000]. Because of a low level of prolamins, some authors believe that oat products may be safely included in gluten free diet of adults, at the level 50-70 g/day [Janatuinen et al. 1995, Peräaho et al. 2004, Sontag-Strohm et al. 2008]. However, this problem is still being studied.

Despite of the information campaign in Poland about oat products, and their nutritional benefits [Bartnikowska et al. 2000, Bartnikowska 2003, Gambuś et al. 2006], the interest in the production of oat based food is still low. Oats processing requires highly specialized technological lines [Bartnik and Rothkaehl 1997, Gambuś et al. 2003, Dewettinck et al. 2008], which are costly, and may increase the risk of failure. At present only a limited number of oat products is available on Polish market: flakes, groats, bran, and flour. They account for only 5% of total oat production. Because of the low popularity of these products, the market is open for innovative ways in oat processing. One of the newly introduced products is Betaven, produced by Microstructure Ltd, containing 60% of fiber, including 30% β-D-glucan. Residual oat flour acquired during its production is deprived of a significant part of fiber, isolated by physical means. Other nutritionally important fractions of oat kernel are not affected by this process, so it seems reasonable to use such flour in order to increase nutritional value of wheat and wheat-rye bread, based on white flours (wheat type 650, and rye type 720), which are normally low in such components as proteins, minerals, lipids, vitamins and fiber.

The aim of the study was to establish a formulation for wheat and wheat-rye bread, in which part of wheat flour would be replaced by residual oat flour (at the level 20% of wheat flour), and to check the influence of this additive on sensory and nutritional properties of the products, with special consideration to content and biological value of the proteins.

MATERIAL AND METHODOLOGY

Material consisted of wheat flour (type 650, PZZ Kraków SA), rye flour (type 720, PZZ Kraków SA), and residual oat flour (Microstructure Ltd.), as well as loaves, baked with these flours, baking yeasts (SAF-Instant, Lesaffre), dry acid (Ibis, Lesaffre), and food grade salt. The formulation for bread production contained residual oats flour, at the level 20% of wheat flour used in control sample (Table 1).

Table 1. Formulations for wheat, wheat-oat, wheat-rye, and wheat-rye-oat bread

Raw material	Wheat bread – standard	Wheat-oat bread	Wheat-rye bread – standard	Wheat-rye-oat bread
Wheat flour, g	1 000	800	700	560
Rye flour, g	–	–	300	300
Oat flour, g	–	200	–	140
Yeasts, g	30	30	30	30
Salt, g	15	15	15	15
Dry acid ibis, g	–	–	10	10
Water, cm^3	660	670	670	670

All bread samples were baked by straight method. The dough was mixed in a spiral mixer Diosna type SP 12 for 9 min (3 min at low speed, and 6 min at high speed). Initial fermentation was done for 15 min, and the second one was continued for 30 min, after dividing and shaping dough into loaves (250 g). Both fermentation steps were performed at 40°C. Loaves were baked at 230°C for 30 min in the baking oven MIWE CONDO type CO 2 P608.

After 2-hour cooling, the following analyses were done:

– organoleptic assessment, according to PN-A-74108:1996; appearance, thickness and color of the crust, elasticity, porosity, color and cutting ability, taste and aroma were assessed by trained 15-person panel with checked sensory sensitivity
– loaf mass and volume, according to PN-A-74108:1996; including the calculation of bread yield and baking loss [Jakubczyk and Haber 1981]
– moisture content of the crumb, according to AOAC no 925.10 [AOAC 2006]
– texture profile of the crumb [Surówka 2002] by texture analyzer TA-XTPlus, with software TPA Exponent v. 4.0.13.0. (stable Micro Systems), using probe P-20, at speed 5 mm/s, and deformation 10 mm.

Crumb moisture content, and texture profile were analysed both on the day of baking, and after storage for 72 hours in polyethylene bags HDPE at 20ºC and relative humidity 64%.

Samples used for chemical analyses were initially dried at ambient temperature, and then ground with a laboratory mill Zelmer type 886.8.

The following chemical analyses were done on flours and dried crumbs:

– total protein by Kjeldahl method, according to AOAC no 950.36 [AOAC 2006]
– content of amino acids in a amino acid analyzer AAA 400 (INGOS, Prague, Czech Republic), according to the method of Smith [Protein... 2003]; chemical

score (CS) and Essential amino acid index (EAAI) were calculated according to FAO-WHO [1991]
- crude fat, according to PN-A-74108:1996
- ash, according to AOAC no 930.05 [AOAC 2006]
- dietary fiber, according to AOAC no 991.43 [AOAC 2006].

All analyses were done at least in duplicate for each of two baking batches. Statistical analysis was performed using Statistica 8.0 PL. Duncan test was used for determination of significance of the differences.

RESULTS AND DISCUSSION

Dietary fiber in flours: oat and rye (Table 2) was comparable and two times higher as compared to wheat flour. The highest content of soluble fraction was determined for rye flour, because soluble β-D-glucans were in major part removed from residual oat flour, as the major component of BETAVEN. Oat flour contained two times more ash, and three times more fat, than both analysed bread flours (Table 2). It should be stressed, that oat fat is rich in polyunsaturated fatty acids, and its digestibility is higher than in other cereals [Bartnikowska 2003, Czerwiński et al. 2004, Sadiq Butt et al. 2008].

Table 2. Chemical composition of flours used for baking

Chemical composition, % d.m.		Type of flour		
		wheat type 650	rye type 720	oat
Dietary fibre	insoluble fraction	1.87 ±0.05 a	4.27 ±0.06 b	5.07 ±0.06 c
	soluble fraction	1.66 ±0.03 a	3.67 ±0.11 c	2.91 ±0.07 b
	total	3.53 ±0.09 a	7.94 ±0.08 b	7.98 ±0.10 b
Crude fats		1.47 ±0.20 a	1.29 ±0.09 a	6.95 ±0.011 b
Total ash		0.80 ±0.07 a	0.90 ±0.06 a	1.62 ±0.01 b
Total protein (N×5.7)		11.82 ±0.05 b	6.45 ±0.09 a	12.35 ±0.07 b

Values in rows marked with different letters are significantly different at $\alpha = 0.05$.

Total content of protein in oat flour, was only slightly higher than in wheat flour, but two times higher as compared to rye (Table 3). Table 3 includes the data about content of amino acids in proteins isolated from wheat, rye and oat flours. The data demonstrate, that oat protein contains more exogenic amino acids than rye, and significantly more than wheat – EAAI for oat protein was 94.39%, rye – 92.89%, and wheat – only 83.85%. Protein of oat flour was higher in lysine, aspargine and arginine (two times), as well as valine, alanine, glycine and tyrosine, as compared to proteins of bread flours (Table 3). Chemical score which was in all cases calculated for lysine, was comparable for oats and rye flour, and about two times higher in comparison to wheat flour, which demonstrates high biological value of both proteins [Bartnikowska et al. 2000, Bartnikowska 2003, Sontag-Strohm et al. 2008]. The lower content of proteins in rye flour is however, limiting the availability of lysine in rye products.

Table 3. Content of protein and amino-acid profile in flour used for baking (purposes)

Biological value of proteins	Type of flour		
	wheat type 650	rye type 720	oat
Total protein (N×5.7), % d.m.	11.82 ±0.05 b	6.45 ±0.09 a	12.35 ±0.07 b
Amino acid profile, % d.m.			
Asp	0.42 ±0.05 a	0.39 ±0.04 a	0.84 ±0.08 b
Thr	0.28 ±0.02 b	0.18 ±0.02 a	0.34 ±0.03 c
Ser	0.49 ±0.03 b	0.23 ±0.02 a	0.48 ±0.02 b
Glu	3.53 ±0.13 b	1.22 ±0.12 a	1.98 ±0.33 a
Pro	1.28 ±0.07 b	0.54 ±0.03 a	0.53 ±0.03 a
Gly	0.37 ±0.02 b	0.22 ±0.02 a	0.50 ±0.03 c
Ala	0.31 ±0.02 b	0.23 ±0.03 a	0.48 ±0.03 c
Cys	0.35 ±0.03 b	0.20 ±0.01 a	0.46 ±0.02 c
Val	0.43 ±0.03 b	0.27 ±0.02 a	0.54 ±0.03 c
Met	0.22 ±0.01 b	0.13 ±0.01 a	0.24 ±0.01 b
Ile	0.38 ±0.03 b	0.19 ±0.01 a	0.40 ±0.02 b
Leu	0.73 ±0.03 b	0.35 ±0.03 a	0.76 ±0.05 b
Tyr	0.34 ±0.01 b	0.17 ±0.02 a	0.40 ±0.04 b
Phe	0.53 ±0.02 b	0.27 ±0.03 a	0.55 ±0.05 b
His	0.24 ±0.01 b	0.13 ±0.01 a	0.25 ±0.03 b
Lys	0.22 ±0.02 a	0.22 ±0.01 a	0.42 ±0.01 b
Arg	0.46 ±0.07 b	0.32 ±0.01 a	0.86 ±0.05 c
Chemical score CS (lys)	33.20 ±2.74 a	62.02 ±2.96 b	65.91 ±1.83 b
Essential Amino Acids Index (EAAI)	83.85 ±1.51a	92.89 ±2.64 b	94.39 ±0.98 b

Values in rows marked with different letters are significantly different at $\alpha = 0.05$.

According to recent studies [Gąsiorowski 2003, Kawka 2009], production of nutritionally enriched bread, should allow to incorporate as much technological additive, such as oat flour, as it is possible (at least 10%). This is why in the study the level was established to 20% of wheat flour. It should be kept in mind, that for the consumers, the nutritional value is not the only measure of bread quality. From earlier reports it is evident that all such bread additives usually result in worsening of volume and texture [Flander et al. 2007, Dewettinck et al. 2008], so the nutritional benefits of partial replacement of wheat flour with residual oat flour may be only important, when bread is still tasty and acceptable for consumers.

Quality attributes of the loaves baked with 20% addition of residual oat flour are included in Table 4. In all wheat-oat samples, the significant decrease in bread volume was observed (Photo 1), while only a slight change was found for wheat-rye-oat loaves (Photo 2). Organoleptic scores were however not influenced by this change, because all

Table 4. Quality evaluation of wheat, wheat-oat, wheat-rye and wheat-rye-oat breads

Type of bread	Weight of cold bread g	Volume of loaf (bread) cm^3	Bread volume from 100 g of flour cm^3	Yield of bread %	Total baking loss %	Sensory evaluation	
						sum of scores	quality grade
Wheat standard	214 ±2 b	779 ±2 b	517 ±3 b	142.0 ±0.3 b	14.5 ±0.2 a	38	1
Wheat-oat (20%)	210 ±3 a	678 ±4 a	453 ±3 a	140.4 ±0.4 a	15.9 ±0.2 b	37	1
Wheat-rye standard	215 ±3 a	652 ±3 b	435 ±3 b	143.3 ±0.3 a	14.2 ±0.2 a	38	1
Wheat-rye-oat (20%)	214 ± 2 a	614 ±2 a	409 ±4 a	142.8 ±0.4 a	14.5 ±0.3 a	37	1

Values in columns marked with different letters are significantly different at $\alpha = 0.05$.

the loaves were qualified by the consumers as first quality class. The observed trend was already reported by other authors [Oomah 1983, Oomah and Lefkowitch 1988, Gambuś et al. 2003, 2006, Kawka 2009], who attribute the loss in wheat-oat bread

Photo 1. Exterior appearance of loaves and the internal crumb structure of standard wheat and wheat breads supplemented with oat flour (from left: wheat standard, wheat-oat 20%)

Photo 2. Exterior appearance of loaves and the internal crumb structure of mixed wheat-rye standard breads and breads supplemented with oat flour (from left: wheat-rye, wheat--rye-oat 20%)

volume to the increase of soluble protein and non-protein nitrogen fractions, and the decrease in contents of gliadin, and glutenin, which are the components of gluten.

The share of oat flour in wheat-oat bread caused a decrease in its yield, and consequently higher baking loss, while no such change was found for wheat-rye-oat bread. The decrease in bread yield may result from the change in water absorption of wheat-oat flour mixture [Gambuś et al. 2003, 2006, Salehifar and Shahedi 2007]. Earlier studies did not show significant changes in water absorption, or slight decrease of its value with increasing share of oat flour in the mixture, which could be affected by a range of factors, such as chemical composition, or granularity of the flour [Gąsiorowski 1995, Gambuś et al. 2006].

Moisture content of wheat-oat, and wheat-rye-oat bread was comparable to standard, both on the day of baking and during 72 hours of storage (Table 5), which manifests the lack of influence of oat flour on the change of moisture of bread crumb.

Table 5. Moisture of crumb wheat, wheat-oat breads, wheat-rye, and wheat-rye-oat breads

Days of storage	Type of bread	Moisture of crumb %	Type of bread	Moisture of crumb %
0	wheat standard	44.34 ±0.26 a	wheat-rye standard	43.86 ±0.28 a
	wheat-oat 20%	44.27 ±0.31 a	wheat-rye-oat 20%	44.10 ±0.28 a
1	wheat standard	43.79 ±0.23 a	wheat-rye standard	43.54 ±0.31 a
	wheat-oat 20%	44.52 ±0.29 a	wheat-rye-oat 20%	43.21 ±0.24 a
2	wheat standard	43.09 ±0.27 a	wheat-rye standard	42.41 ±0.28 a
	wheat-oat 20%	43.49 ±0.25 a	wheat-rye-oat 20%	42.33 ±0.29 a
3	wheat standard	42.57 ±0.29 a	wheat-rye standard	41.64 ±0.30 a
	wheat-oat 20%	41.67 ±0.31 a	wheat-rye-oat 20%	42.16 ±0.26 a

Values in columns marked with different letters are significantly different at $\alpha = 0.05$.

Staling process was monitored by hardness, chewiness, and resilience of the crumb during 72 hours of storage. Hardness of the wheat-oat loaves was not significantly different to control, both on the day of baking, as well as after storage. In the case of wheat-rye-oat bread, the initial hardness was the same as for wheat-rye standard, but after storage the loaves were significantly harder (Fig. 1). This adverse change could be attributed to the higher content of dietary fiber in wheat-rye-oat breads, as compared to wheat bread (Table 6) [Gambuś et al. 2006, Dewettinck et al. 2008]. On the day of baking this factor could be balanced by high fat content of oat flour (Table 6). Even low addition of fat (below 0.5%) to bread, may significantly modify physical properties of the dough, improve its stability during processing and fermentation, and positively impact crumb texture [Ambroziak 2003].

On the day of baking wheat-oat bread revealed significantly lower chewiness as compared to standard, but after storage both loaves were comparable in this aspect (Fig. 2). In the case of wheat-rye-oat no changes in crumb chewiness, as compared to control, were observed neither on the day of baking, nor after storage (Fig. 2). Resilience of the crumb was not affected by the addition of oat flour, irrespective of the presence or absence of rye flour (Fig. 3).

Table 6. Chemical composition contents in protein of wheat, wheat-oat breads, wheat-rye, and wheat-rye-oat breads

Chemical composition, % d.m.		Type of bread			
		wheat standard	wheat-oat 20%	wheat-rye standard	wheat-rye-oat 20%
Dietary fiber	insoluble fraction	3.69 ±0.05 a*	4.23 ±0.04 b	4.22 ±0.03 b	5.12 ±0.02 c
	soluble fraction	1.43 ±0.03 a	2.42 ±0.11 c	1.90 ±0.09 b	2.75 ±0.04 d
	total content	5.12 ±0.07 a	6.65 ±0.13 b	6.12 ±0.09 b	7.87 ±0.08 c
Crude fat		1.65 ±0.09 a	2.79 ±0.13 b	1.37 ±0.14 a	2.04 ±0.21 b
Total protein (N×5.7)		12.82 ±0.05 c	13.38 ±0.09 d	10.56 ±0.06 a	11.47 ±0.07 b

Values in rows marked with different letters are significantly different at α = 0.05.

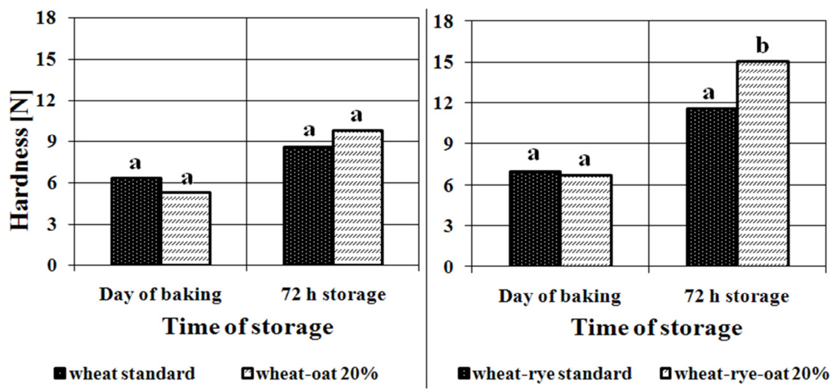

Fig. 1. Hardness of wheat, wheat-oat breads crumb, wheat-rye and wheat-rye-oat breads crumb on the day of baking and during storage for 3 days

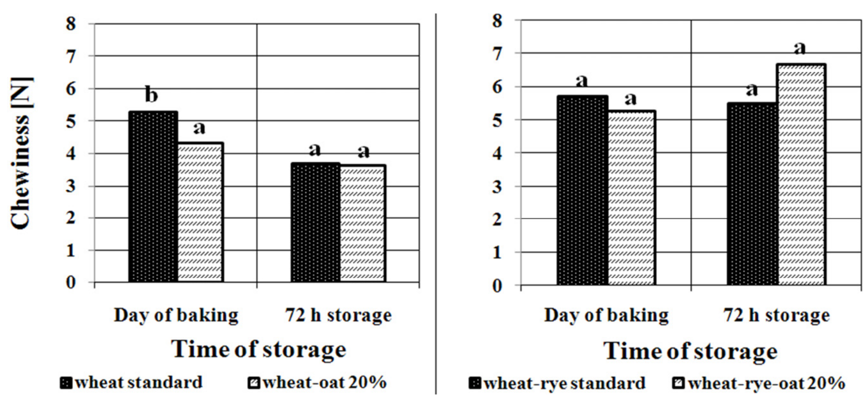

Fig. 2. Chewiness of wheat, wheat-oat breads, wheat-rye and wheat-rye-oat breads crumb on the day of baking and during storage for 3 days

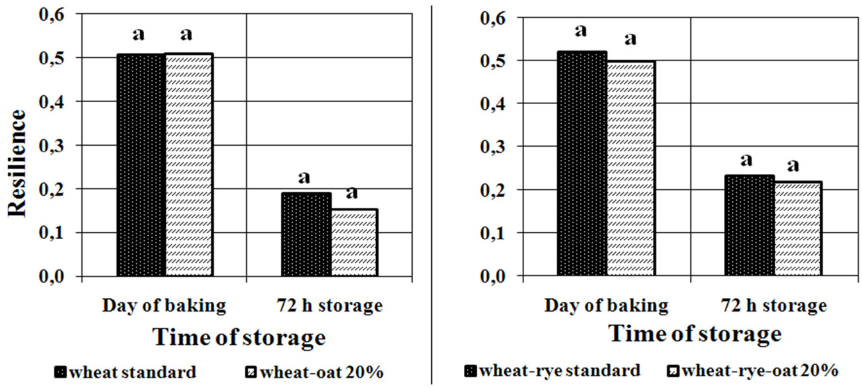

Fig. 3. Resilience of wheat, wheat-oat breads, wheat-rye and wheat-rye-oat breads crumb on the day of baking and during storage for 3 days

To analyse the nutritional value of bread, total protein content, selected amino acids, crude fat, and dietary fiber (soluble and insoluble fractions) were determined. The results were collected in Tables 6 and 7.

Wheat bread revealed significantly lower level of dietary fiber, as compared to wheat-rye bread (Table 6). The content of fiber in both wheat and wheat-rye bread, was affected by the addition of residual oat flour, and the increase was statistically significant (Table 6). In the case of wheat-oat bread, the increase in soluble fraction was more evident, while in wheat-rye-oat bread the changes in both fractions of fiber were the same (Table 6).

In both types of bread, the incorporation of oat flour caused a significant increase of crude fat (Table 6), originating solely from oat flour.

The lowest protein content was found for standard wheat-rye bread (Table 6), which is due to the low level of protein in rye flour (Table 2). The share of 20% residual oat flour (as calculated to wheat flour), caused a significant increase in this constituent. The level of protein in such bread, even after the enrichment of oat flour, was still significantly lower than in standard wheat bread (Table 6), and especially wheat-oat bread. The protein present in wheat-rye bread, was of significantly higher biological value (Table 7), which is demonstrated by chemical score. Its value in standard wheat-rye bread was 53.54%, in wheat-rye-oat bread 56.41%, while in wheat bread only 47.89%, and in wheat-oat bread 52.68%. The difference caused by the presence of rye flour was approximately 5%. Exogenic amino acid index in wheat bread was comparable to wheat-rye bread only after the supplementation with residual oat flour (Table 7).

Taking into account chemical composition of the analysed bread, and especially biological value of protein present in those breads, the enrichment with residual oat flour is fully recommendable. Especially wheat-rye-oat bread should be considered for an industrial production, because it exhibits almost the same volume as standard wheat-rye bread. On the other hand, it should be remembered that crumb hardening after 72 hours is in this case more pronounced than in wheat-oat bread.

In the conclusion it should be stated, that residual oat flour, acquired during the production of β-D-glucan concentrate, could be used for the production of wheat, and wheat-rye bread, as an additive enriching them in dietary fiber, easily digestible fats, and protein of high biological quality.

Table 7. Amino acid contents in protein of wheat, wheat-oat breads, wheat-rye, and wheat-rye-oat breads

Biological value of proteins	Type of bread			
	wheat standard	wheat-oat 20%	wheat-rye standard	wheat-rye-oat 20%
Amino acids content, % d.m.				
Asp	0.54 ±0.02 ab	0.64 ±0.09 b	0.50 ±0.01 a	0.59 ±0.04 b
Thr	0.35 ±0.01 a	0.37 ±0.06 b	0.30 ±0.01 a	0.33 ±0.01 a
Ser	0.58 ±0.02 c	0.58 ±0.01 c	0.45 ±0.02 a	0.48 ±0.01 b
Glu	3.89 ±0.36 b	3.62 ±0.33 b	2.97 ±0.34 a	2.91 ±0.10 a
Pro	1.42 ±0.02 b	1.27 ±0.20 ab	1.10 ±0.04 a	1.07 ±0.06 a
Gly	0.46 ±0.01 c	0.50 ±0.08 c	0.39 ±0.01 a	0.43 ±0.02 b
Ala	0.40 ±0.01 b	0.45 ±0.08 b	0.35 ±0.01 a	0.40 ±0.02 b
Cys	0.39 ±0.01 b	0.40 ±0.03 b	0.33 ±0.01 a	0.34 ±0.02 b
Val	0.53 ±0.01 b	0.56 ±0.09 b	0.44 ±0.01 a	0.49 ±0.02 ab
Met	0.23 ±0.01 b	0.23 ±0.02 b	0.20 ±0.01 a	0.19 ±0.01 a
Ile	0.47 ±0.01 b	0.48 ±0.08 b	0.38 ±0.01 a	0.41 ±0.02 ab
Leu	0.87 ±0.01 b	0.80 ±0.14 b	0.70 ±0.03 a	0.75 ±0.03 ab
Tyr	0.42 ±0.01 b	0.45 ±0.06 b	0.34 ±0.01 a	0.36 ±0.01 a
Phe	0.63 ±0.01 b	0.64 ±0.09 b	0.51 ±0.02 a	0.55 ±0.01 a
His	0.28 ±0.02 a	0.28 ±0.03 a	0.23 ±0.03 a	0.24 ±0.01 a
Lys	0.32 ±0.02 ab	0.37 ±0.07 b	0.30 ±0.01 a	0.35 ±0.03 b
Arg	0.56 ±0.06 b	0.66 ±0.06 c	0.48 ±0.04 a	0.56 ±0.07 b
Chemical Score CS (lys)	47.89 ±2.27 a	52.68 ±0.53 b	53.54 ±0.42 b	56.41 ±0.48 c
Essential Amino Acids Index (EAAI)	89.92 ±0.62 a	91.16 ±0.49 b	91.53 ±0.13 b	91.96 ±0.13 c

Values in rows marked with different letters are significantly different at $\alpha = 0.05$.

CONCLUSIONS

1. Residual oat flour, acquired during the production of β-D-glucan concentrate "Betaven", contained comparable amounts of dietary fiber as rye flour, and higher ash, crude fat and protein, as compared to both bread flours: wheat and rye.
2. Biological value of protein present in residual oat flour (CS and EAAI) was similar to the biological value of rye flour protein, and significantly higher than protein present in wheat flour.
3. Wheat and wheat-rye breads enriched with oat flour (at the level 20% of wheat flour), received identical consumer acceptance, as standard breads, despite of significant decrease in volume of wheat-oat breads.

4. The incorporation of oat flour in both types of bread, did not influence the changes in moisture content, and analysed texture parameters: hardness, chewiness, and resilience, on the day of baking and after 72 hours of storage.

5. Content of dietary fiber, fat and protein was significantly higher in the breads enriched with oat flour, as compared to standards, and the highest biological value was exhibited by protein present in wheat-rye-oat bread.

6. Residual oat flour could be successfully used for enrichment of white bread, wheat and wheat-rye, at the level of 20% of wheat flour.

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ZASTOSOWANIE CZĄSTKOWEJ MĄKI OWSIANEJ DO PRODUKCJI CHLEBA W CELU POPRAWY JAKOŚCI I WARTOŚCI BIOLOGICZNEJ BIAŁKA

Wstęp. Duża wartość odżywcza cząstkowej mąki owsianej, która jest produktem ubocznym w produkcji preparatu β-D-glukan BETAVEN przesądziła o jej zastosowaniu w produkcji chleba pszennego i pszenno-żytniego. Celem badań było opracowanie receptury na chleb pszenny i pszenno-żytni. Część mąki pszennej zastąpiono cząstkową mąką owsianą (20% przewidzianej masy) i sprawdzono wpływ tego udziału na cechy organoleptyczne i wartość odżywczą produktów finalnych, ze szczególnym uwzględnieniem wartości biologicznej białka.

Materiał i metody. Materiałem badawczym były mąki: pszenna, żytnia i cząstkowa owsiana, a także wypieczone z nich chleby. Jakość otrzymanych chlebów analizowano, biorąc pod uwagę: ocenę organoleptyczną, masę i objętość, wilgotność i profil tekstury miękiszu. W badanych surowcach i uzyskanych chlebach metodami AOAC oznaczono zawartość: białka, tłuszczu, włókna pokarmowego i popiołu. Ponadto oznaczono skład aminokwasowy, na podstawie którego obliczono wskaźnik aminokwasu ograniczającego

(CS) i zintegrowany wskaźnik aminokwasów egzogennych, posługując się białkiem wzorcowym rekomendowanym przez WHO/FAO (1991).
Wyniki. Pieczywo z mąką cząstkową uzyskało dużą akceptację konsumencką (37 punktów), porównywalną z chlebem kontrolnym (38 punktów), pomimo mniejszej objętości. Zastosowana ilość mąki owsianej nie wpłynęła na zmiany wilgotności i profilu tekstury miękiszu w czasie przechowywania. Chleby pszenne i pszenno-żytnie z dodatkiem cząstkowej mąki owsianej charakteryzowały się istotnie większą zawartością włókna pokarmowego, tłuszczu i białka, w porównaniu z pieczywem kontrolnym. Stwierdzono istotnie większą wartość biologiczną białka w chlebie pszenno-żytnim (CS = 53,5, EAAI = 91,5) w stosunku do białka chleba pszennego (CS = 47,9, EAAI = 89,9). Mąka owsiana wpłynęła na wzrost wartości biologicznej białka wszystkich chlebów: pszenno-owsiany (CS = 52,7, EAAI = 91,2), pszenno-żytnio-owsiany (CS = 56,4, EAAI = 91,9).
Wnioski. Cząstkowa mąka owsiana okazała się dobrym źródłem białka o wysokiej wartości biologicznej. Korzystny skład aminokwasowy i duża zawartość błonnika oraz tłuszczu sprawiają, że jest ona wartościowym surowcem (w ilości 20% masy mąki pszennej) do produkcji białego pieczywa zarówno pszennego, jak i pszenno-żytniego.

Słowa kluczowe: chleb, mąka owsiana resztkowa, wartość żywieniowa, wartość biologiczna białka

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