Pol. J. Food Nutr. Sci., 2012, Vol. 62, No. 4, pp. 207-213
DOI: 10.2478/v10222-012-0056-6
http://journal.pan.olsztyn.pl

Original Paper
Section: Food Technology

Application of Grasspea Wholemeal in the Technology of White Bread Production

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Key words: grasspea wholemeal, white bread, physical properties, dietary fibre, fractional composition of dietary fibre

A study on the possibility of application of grasspea wholemeal for the modification of the chemical composition, physical properties and sensory features of traditional white bread was performed. It was demonstrated that an increase in the share of the pulse material from 1.5% to 12% caused an increase in bread yield (130.7–136.3%). An improvement was also noted in the baking loss, from 15.01% to 9.11%, and in the total baking loss - from 16.56 to 12.23%. Increase in the level of the pulse component caused a decrease in bread volume from 100 g of flour (from 505 to 359 cm^3), and a decrease in bread crumb porosity (from 81 to 61%). Admixture of the pulse component caused only a slight decrease in the point score of the bread as compared to traditional wheat bread. The replacement of wheat flour with grasspea wholemeal had a highly favourable effect on the chemical composition of the bread; the experimental bread produced with 12% of grasspea was characterised by protein content of 14.51% d.m. and total dietary fibre content at the level of 8.75% d.m.

Abbreviations

ADF – acid detergent fibre, ASDF – acid-soluble dietary fibre, AIDF – acid insoluble dietary fibre, IDF – insoluble dietary fibre, SDF – soluble dietary fibre, TDF – total dietary fibre.

INTRODUCTION

The pandemic of civilisation diseases (cardiovascular system diseases, cancer, type II diabetes, obesity, depression and mental diseases) poses highly severe threats. Many research communities argue that a radical change of lifestyle and diet should be the fundamental element of the prophylaxis and control of those diseases [Bennett & Sothern, 2009; Czeczelewski & Raczyński, 2006; Mozaffarian *et al*., 2011; Schaafsma, 2004; Tsugane & Inoue, 2010; Zhang & Hamaker, 2010]. Consumers are recommended to focus particular attention on products with low degree of processing, high nutritional value, high content of dietary fibre with well balanced fractional composition. Dietary fibre (TDF) is composed of a fraction insoluble in a water solution of enzymes (IDF) and a fraction soluble in a water solution of enzymes (SDF). The soluble and the insoluble fractions display varied effects on the human organism. Fibre components soluble in water generate the viscosity of the intestinal contents, slow down the processes of diffusion, slow down and inhibit the absorption of nutrients in the small intestine. In the environment of the large intestine they undergo fermentation processes. The products of bacterial decomposition are methane, CO_2 and short-chain fatty acids, primarily acetic acid, propionic acid and butyric acid. It has been demonstrated that the acid environment of the colon, generated primarily by slowly absorbed butyric acid, is conducive to the growth of probiotic bacteria, inhibits the growth of putrefactive bacteria, thus preventing carcinogenic processes (metabolites of putrefactive bacteria are considered to be the main factor causing cancer of the colon). The viscosity of intestinal contents generated by SDF, slowing down diffusion, reduces the level of total cholesterol, especially of the LDL and VLDL fractions, thus increasing the share of the desirable fraction, HDL [Anderson *et al*., 2009; Liu *et al*., 2002; McIntosh *et al*., 2003; O'Conell *et al*., 2005]. A different action is observed in the case of the insoluble fraction of dietary fibre (IDF). Insoluble fibre stimulates the receptors of intestine epithelium, accelerating the peristalsis and the passage of the intestinal digesta through the intestines, increases the mass of intestinal digesta, prevents diverticulosis, and counteracts faecal impaction [Anderson *et al*., 2009; Meschino, 2008; Weickert *et al*., 2006]. Many cereal and pulse materials have a significant content of a dietary fibre fraction that is insoluble in a water solution of enzymes, but soluble in the acid environment of the stomach (ASDF). In seeds of grasspea the content of that fraction may by up to 17% d.m. That fraction undergoes dispersion in the stomach environment and also affects the properties of intestinal digesta. The dispersed ASDF fraction cannot, therefore, play the role of insoluble fibre (IDF); its effects have to be closer to those of the SDF fraction. It should be concluded that a high share of ASDF

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fibre fraction in pulse crops determines their hypocholesterolaemic properties [Pittaway *et al*., 2008]. Due to the level of consumption, particularly important role in the prophylaxis and control of civilisation diseases is attributed to cereal products, including bread [Moriartey *et al*., 2010; Sanz Penella *et al*., 2008; Slavin, 2010; Wood, 2010].

Unfortunately, the traditional white wheat bread preferred by consumers does not meet those requirements [Bakke & Vickers, 2007]. To improve the chemical composition and the functional properties of bread numerous studies are conducted on modification of baking technology and raw material composition. Various admixtures are introduced in material blends, including non-bread cereals and seeds of pulse plants [Karolini-Skaradzińska *et al*., 2006; Kasprzak & Rzedzicki, 2010; Korus *et al*., 2002; Lisiewska *et al*., 2003; Wojciechowicz & Gil, 2009]. Introduction of dietary fibre with proper fractional composition into bread allows the consumers to balance their daily diet correctly. An increased level of dietary fibre can deteriorate quality attributes of ready products. The deterioration may affect the sensory and the physical properties (bread volume, crumb porosity) [Conforti & Davis, 2006; Gómez *et al*., 2003, Kasprzak & Rzedzicki, 2010; Michałowska *et al*., 2011; Wojciechowicz & Gil, 2009; Siemianowska *et al*. 2009; Škrbić *et al.,* 2009].

Seeds of grasspea (*Lathyrus sativus*) are a specific material that should become an accepted baking component. Grasspea has been grown in Poland for a long time, especially in the region of Podlasie. Seeds of grasspea are characterised by a light colouring of cotyledons that does not darken in processes of thermal treatment, a high nutritional value and attractive taste values. Special note should be taken of the chemical composition of grasspea seeds: protein content may even reach 30% d.m., total dietary fibre (TDF) content exceeds 33% d.m., at insoluble dietary fibre (IDF) level of more than 28% d.m. and soluble dietary fibre fraction (SDF) content of 4.26% d.m. [Kasprzak & Rzedzicki, 2008; Stodolak *et al*., 2009; Truchliński *et al*., 2002]. A specific feature of grasspea is its high content of acid-soluble dietary fibre (ASDF) that can be as high as 21% d.m. [Kasprzak & Rzedzicki, 2008]. Proteins of grasspea seeds are characterised by very good amino acid composition and good digestibility [Hanbury *et al*., 2000; Monsoor & Yusuf, 2002]. Seeds of grass pea are also characterised by a low content of fat (about 1% d.m.) [Kasprzak & Rzedzicki, 2008] therefore they do not notably raise the energy value of the food. Dominant in the fatty acid composition of grasspea are linoleic acid, oleic acid, palmitic acid, linolenic acid and stearic acid [Hanbury *et al*., 2000]. Grasspea seeds are also a rich source of a number of bioactive non-nutritional components of food: inhibitors of proteolytic enzymes, phytinians, tannins, oligosaccharides, pectins and phytoestrogens. Grasspea seeds can also contain ODAP (β-oxalyl–L-α,β–diaminopropionic acid) and BOAA (β–N–oxalylamino–L–alanine). In the case of extended (many months) application of grasspea mono-diet those compounds can induce a disease known as lathyrism. The disease can appear in humans and domestic animals. It should be emphasised that a necessary condition for the disease to appear in humans is the application of a diet containing 30–50% of grasspea seeds for a period of minimum 6 months. Based on studies conducted on Polish grasspea cultivars it was concluded that the content of those compounds in the material tested oscillated at a very low level [Grela *et al*., 2010]. It is emphasised that the neurolathyrogens (neurotoxins responsible for lathyrism) contained in grasspea are water-soluble and undergo degradation during thermal treatment [Korus *et al*., 2002]. Whereas, Kuo *et al*. [2000] observed that fermentation of seeds of *Lathyrus sativus* leads to the elimination of nearly 95% of β-ODAP compared to the raw material, which is of particular importance when grasspea is applied as a bakery component. It should be noted that all the reports on lathyrism concern countries suffering from starvation. In this situation it is hard to formulate justified conclusions on whether lathyrism is caused by consuming grasspea, by extreme exhaustion of the organism due to malnutrition, or by the deficit of certain microelements, *e.g.* zinc. In Poland, although grasspea has been consumed for hundreds of years, not a single case of the disease has been recorded to date. Numerous research reports present the definite conclusion that biologically-active compounds are an important element of the prophylaxis and control of civilisation diseases and should not be eliminated from food [Hanbury *et al*., 2000; Srivastava & Khokhar, 1996; Wang *et al*., 1998].

In view of the above, the authors undertook a study on the possibility of the application of grasspea wholemeal in baking traditional wheat bread and determined the effect of grasspea wholemeal addition on the physical properties, sensory features and chemical composition of bread.

MATERIAL AND METHODS

Raw materials

The experimental material was wholemeal of grasspea of the Polish cultivar “Derek” from an individual farm and commercially available wheat flour type 550. The grass pea was grinded using a universal impact grinder type H-111/3 until obtaining the required level of mean diameter. The sieve analysis of the raw materials was conducted on the laboratory sifter type SZ-1. The sifting of samples with the weight of 500 g was conducted for a period of 10 min on suitably selected sets of sieves. The equivalent diameter was calculated from a formula:

$$ø = (\sum_{i=1}^{n} ø_i \times m_i) / M$$

where: ø – equivalent diameter [mm], $ø_i$ – mean diameter of i-th range [mm], m_i – weight of sample from i-th range [g], and M – weight of sample used for determinations [g].

The determinations were made in five replications, from which mean values were calculated.

The fractional composition of the raw materials and the values of equivalent diameter are given in Table 1. The basic components were used to prepare wheat-grasspea blends with content of the pulse components within the range of 1.5 to 12% (with a step of 1.5%). The model sample (sample no. 1) was type 550 wheat flour.

TABLE 1. Sieve analysis of the wheat flour type 550 and grasspea wholemeal.

Fraction (mm)	Quantity (%)
Wheat flour type 550	
>0.25	1.34
0.25–0.2	2.83
0.2–0.125	20.12
0.125–0.1	30.62
0.1–0.063	38.22
0.063–0.045	6.93
<0.045	0.00
Mean diameter (mm)	0.112
Grasspea wholemeal	
>1.6	0.11
1.6–1.2	3.02
1.2–1.0	7.56
1.0–0.8	33.05
0.8–0.5	23.87
0.5–0.265	18.34
<0.265	14.05
Mean diameter (mm)	0.694

Flour analysis

The quality of the wheat flour was verified on the basis of wet gluten content [PN-EN ISO 21415–1:2007], its flowability and moisture content [PN-EN ISO 21415–3:2007] and of the value of the falling number [PN-ISO 3093:2007].

Bread making

The wheat flour and the wheat-pulse blends were used to prepare dough with yield of approximately 160%. The dough was raised under laboratory conditions, in accordance with the single-phase method. In the experiment constant levels of yeast (3%) and salt (1.5%) were applied. In the experimental samples a part of the wheat flour was replaced with the grasspea component in amounts from 1.5% to 12% (Table 3). The dough kneading time applied in the study was constant at 10 min. After mixing the dough was placed in a fermentation chamber at a temperature of 32°C for 80 min. Afterwards, the dough was punctured to release the accumulated gases, following which a second fermentation was conducted, lasting 40 min. Rounds of dough, with the weight of 250 g, were placed in baking pans and subjected to final fermentation that lasted until full maturity of the dough was achieved. Then the surface of the dough was moistened with water and the pans were placed in a laboratory oven (PL-10). The baking of the bread was conducted at a temperature of 240°C for 30 min. For each kind of bread four loaves were baked.

Evaluation of physical properties of breads

The breads produced were weighed immediately after removal from the oven (to determine the baking loss) and after 24 h to calculate the bread yield and the total oven loss. Determinations of the physical properties of the breads included bread volume from 100 g of flour [PN-A-74108:1996] and crumb porosity. The determination of the porosity of the bread crumb consisted in comparing the differences between the volume of a cube of porous bread crumb with that after the removal of the air through compression. Determinations of the physical properties were made in 6 replications.

After 24 h from baking, the produced model wheat bread and the experimental wheat-pulse breads were subjected to sensory evaluation based on the 9-point hedonic scale. The sensory evaluation covering the external appearance, crumb, crust, taste and flavour of the breads, using a 9-point scale. Control bread was used as the point of reference, and it was scored the maximum number of points. The evaluation was made by a team of 10 panelists with proven sensitivity to the sensory features under estimation.

Chemical compounds of raw materials and breads

Analysis of the chemical composition of the raw materials and the breads produced comprised determinations of mineral components in the form of ash [AACC, Method 08–01], and protein [AOAC, Method, 981.10]. Dietary fibre was determined with the enzymatic method TDF (AACC Method 32–05, AACC Method 32–07, AOAC Method 985.29, AOAC Method 991.43), whereas IDF and SDF (AACC Method 32–21, AOAC Method 991.43) were determined based on the methods of Lee *et al*. [1992] and Prosky *et al*. [1988, 1992] using Megazyme enzymes and procedures [Megazyme, 2007]. The content of acid-soluble dietary fibre (ASDF) was calculated as the difference between IDF and ADF determined after detergent method [Van Soest, 1963a, b]. In the enzymatic method Megazyme enzymes and procedures were applied. The activity of the enzymes was checked based on Megazyme tests. The correctness of dietary fibre determinations in each series was verified by means of control samples of starch and casein (Megazyme International Ireland).

Statistical analysis

The results were processed statistically using the SAS ver. 9.1 statistical software package, calculating mean values, standard deviations and coefficients of variation. If the values of the coefficient of variation exceeded the limits of error estimated for a given method, the results were rejected and the analyses were repeated. Results were developed statistically with the one-way analysis of variance using the Duncan test, at $\lambda=0.05$.

RESULTS AND DISCUSSION

The basic material used in the study – wheat flour type 550, was characterised by a good quality. The content of gluten oscillated at levels above 30%, at its moisture content of 64.5% and flowability of 8.7 mm (Table 2). In numerous studies conducted with the use of Polish materials [Ceglińska *et al*., 2001; Karolini-Skaradzińska *et al*., 2007; Krawczyk *et al*., 2008; Sobczyk, 2008], the content of gluten varied within the range of 25.1–35.8%. Therefore, the basic raw material applied in this study – type 550 wheat flour, should assure comparability of results. An additional index determining

TABLE 2. The quality of the wheat flour type 550.

Property	Mean value
Gluten content (%)	30.1±0.1
Gluten moisture content (%)	64.5±0.5
Flowability (mm)	8.7±0.8
Falling number (s)	243.0±5.0

The results were calculated as mean values of three replications ± standard deviation.

the baking value of flour is the falling number; for the type 550 wheat flour the value of that parameter was 243 s (Table 2). Gawrysiak-Witulska & Ryniecki [2005] recommend that flour to be used for bread baking should be characterised by falling number values above 220 seconds.

Both the model wheat bread and the experimental wheat-grasspea bread were characterised by good yield and correct values of baking loss and total oven loss (Table 3). The yield of the wheat bread exceeded 128.1% and was significantly lower in relation to the whole assortment of the experimental breads.

For the wheat-pulse breads the values of yield varied within the range from 130.7 to 136.3% (Table 3). In other studies [Ceglińska *et al*., 2001; Krawczyk *et al*., 2008] similar yield values were obtained for breads produced from common wheat flour. Therefore, the addition of the pulse component unquestionably caused an increase in the yield of the breads produced.

The addition of grasspea wholemeal caused a decrease both in the baking loss and in the total oven loss. For the bread with 12% addition of grasspea wholemeal the lowest values of baking loss (9.11%) and total oven loss (12.23%) were obtained. Those values differed statistically significantly from both the model bread (sample no 1) and from other bread with additions grasspea wholemeal (sample no 2–8). Similar relations were observed also in the case of breads with an addition of a high-fibre component [Kasprzak & Rzedzicki, 2010; Korus *et al*., 2002].

The sensory examinations revealed high quality of the breads with an addition of grasspea wholemeal. Its addition did not cause any taste-flavour changes to the breads. The taste and flavour were described as mild, aromatic and typical of wheat bread. All the kinds of bread were characterised by correct external appearance, uniform porosity and good resilience of crumb, and by crumb and crust colouring typical of wheat bread. The surface of the breads was smooth, free of cracks and deformations, which confirms the correctness of the process of fermentation and baking. The obtainment of typical colouring of bread crumb, with no darker fragments, was due to the light colour of the seed coat and cotyledons of grasspea that do not darken under the effect of the processing applied. In the 9-point scale of overall evaluation, the model wheat bread received the maximum score of points; it was characterised by the best crumb porosity and high values of bread volume from 100 g of flour. The addition of grasspea wholemeal caused a lowering of the point scores. Slightly lower scores (8.9–8.1 pts) were awarded to the breads with 1.5–7.5% addition of grasspea wholemeal (Table 3). The lowest score (7.6 pts) was awarded to the bread produced with 12% addition of the pulse component. The point scores obtained were probably a result of personal preferences of the members of the examining board. The breads with grasspea addition were not disqualified by the testers; they were definitely different from the traditional white wheat breads to which the testers were accustomed. The differences related in particular to the structure and pore size, and to the degree of rise of the loaves.

A reduction in the point scores with increasing levels of a high-fibre component was also noted in studies by Conforti & Davis [2006] and by Gómez *et al*. [2003].

The percentage share of the pulse component in the dough mass caused a differentiation in the quality indices of the breads, such as bread volume and crumb porosity. Breads with an addition of a high-fibre component are characterised by a lower volume compared to wheat bread [Conforti & Davis, 2006; Gómez *et al*., 2003; Kasprzak & Rzedzicki, 2010; Wang *et al*., 2002; Wojciechowicz & Gil, 2009]. The authors attribute this fact to deteriorated capacity for gas retention. A similar orientation of changes was observed in this study. The experimental breads with an addition of grasspea wholemeal were characterised by volume values

TABLE 3. Results of baking test, physical properties and point-scale ratings of wheat and wheat-grasspea breads.

Sample No.	Addition of grasspea wholemeal (%)	Bread yield (%)	Baking loss (%)	Total oven loss (%)	Sensory evaluation (pts)	Bread volume from 100 g of flour (cm^3)	Crumb porosity (%)
1	0.0	128.1^{f}±0.8	15.06^{a}±0.28	17.29^{a}±0.53	9.0	515^{a}±5	84^{a}±2
2	1.5	130.7^{e}±0.9	15.01^{a}±0.91	16.56^{b}±0.55	8.9	505^{a}±6	81^{a}±3
3	3.0	132.3^{d}±0.2	$14.40^{a,b}$±0.37	15.99^{c}±0.16	8.7	473^{b}±7	77^{b}±1
4	4.5	132.9^{d}±0.4	13.52^{b}±0.62	15.38^{d}±0.23	8.6	446^{c}±2	75^{b}±2
5	6.0	133.1^{d}±0.4	13.41^{b}±0.66	$14.93^{d,e}$±0.26	8.3	432^{d}±7	70^{c}±3
6	7.5	134.5^{c}±0.0	13.09^{b}±1.42	14.77^{e}±0.02	8.1	425^{d}±8	$68^{c,d}$±2
7	9.0	$134.9^{b,c}$±0.6	11.60^{c}±0.59	$14.81^{d,e}$±0.41	7.9	413^{e}±9	$66^{d,e}$±1
8	10.5	$135.7^{a,b}$±0.0	10.46^{c}±0.49	13.29^{f}±0.02	7.8	385^{f}±4	$63^{e,f}$±2
9	12.0	136.3^{a}±0.4	9.11^{d}±0.96	12.23^{g}±0.27	7.6	359^{g}±3	61^{f}±2

The results of bread volume from 100 g of flour and crumb porosity were calculated as mean values of six replications ± standard deviation.
$^{a, b, c}$ – mean values in the columns, denoted by different letters, differ statistically significantly (Duncan's test, $p \leq 0.05$).

TABLE 4. Content of ash, crude proteins and particular fractions of dietary fibre in wheat flour type 550 and in grasspea wholemeal.

Material	Ash	Crude protein	TDF	IDF	SDF	ASDF	AIDF
	(% d.m.)						
Wheat flour type 550	$0.53^{b}\pm0.01$	$10.49^{b}\pm0.03$	4.07	$1.86^{b}\pm0.01$	$2.21^{b}\pm0.01$	1.59	$0.27^{b}\pm0.02$
Grasspea wholemeal	$3.63^{a}\pm0.03$	$28.47^{a}\pm0.05$	30.00	$25.71^{a}\pm0.40$	$4.29^{a}\pm0.03$	17.72	$7.99^{a}\pm0.03$
1	$2.06^{g}\pm0.05$	$12.13^{h}\pm0.10$	4.56	$2.00^{h}\pm0.01$	$2.56^{g}\pm0.03$	1.24	$0.75^{f}\pm0.02$
2	$2.12^{f}\pm0.02$	$12.33^{g}\pm0.02$	5.36	$2.65^{g}\pm0.03$	$2.71^{f}\pm0.05$	1.81	$0.83^{f}\pm0.01$
3	$2.20^{e}\pm0.06$	$12.92^{f}\pm0.23$	5.94	$3.01^{f}\pm0.12$	$2.93^{e}\pm0.08$	2.06	$0.95^{e}\pm0.13$
4	$2.24^{d,e}\pm0.00$	$13.44^{e}\pm0.06$	6.59	$3.43^{e}\pm0.06$	$3.16^{d}\pm0.11$	2.26	$1.17^{d}\pm0.09$
5	$2.27^{d}\pm0.01$	$13.61^{d}\pm0.06$	7.00	$3.70^{d,e}\pm0.15$	$3.30^{d}\pm0.06$	2.45	$1.26^{d}\pm0.06$
6	$2.33^{c}\pm0.02$	$13.91^{c}\pm0.01$	7.39	$3.93^{c,d}\pm0.07$	$3.46^{c}\pm0.02$	2.52	$1.41^{c}\pm0.01$
7	$2.37^{b,c}\pm0.02$	$14.24^{b}\pm0.02$	7.68	$4.12^{c}\pm0.15$	$3.56^{b,c}\pm0.02$	2.60	$1.51^{c}\pm0.02$
8	$2.42^{a,b}\pm0.01$	$14.37^{a,b}\pm0.06$	8.06	$4.41^{b}\pm0.39$	$3.65^{b}\pm0.18$	2.63	$1.78^{b}\pm0.09$
9	$2.46^{a}\pm0.02$	$14.51^{a}\pm0.01$	8.75	$4.85^{a}\pm0.11$	$3.90^{a}\pm0.07$	2.89	$1.96^{a}\pm0.07$

The results were calculated as mean values of three replications ± standard deviation. $^{a, b, c}$ – mean values in the columns, denoted by different letters, differ statistically significantly (Duncan's test, $p \leq 0.05$).

from 359 to 505 cm^3, while in the case of the model wheat bread the value obtained was 515 cm^3 (Table 3).

With an increasing level of grasspea there was a decrease in crumb porosity - from 84% in the model bread to 61% for the bread with 12% addition of grasspea wholemeal (Table 3). Kasprzak & Rzedzicki [2010] obtained crumb porosity of wheat-pea bread within the range from 51.58 to 66.67%, while wheat bread was characterised by porosity values above 71%. Ceglińska *et al*. [2001] and Gómez *et al*. [2003] emphasise the dependence of crumb porosity on the process of fermentation, baking properties of the flour used, and on the raw material composition of the dough.

The grasspea wholemeal was characterised by a significant higher, compared to the wheat flour, content of mineral components (in the form of ash), dietary fibre (IDF, SDF, TDF) and the ASDF fraction of dietary fibre. The content of TDF, IDF and SDF in the grasspea wholemeal was 30.00% d.m., 25.71% d.m. and 4.29% d.m., respectively, while in the wheat flour the corresponding values were only 4.07% d.m., 1.86% d.m. and 2.21% d.m. (Table 4). Special note should be taken of the level of the acid-soluble dietary fibre fraction (ASDF) in the grasspea wholemeal; it was 17.72% d.m. The grasspea wholemeal was also characterised by a very high protein content (28.47% d.m.). Many researchers indicate that grasspea protein is characterised by relatively good digestibility and biological value [Grela *et al*., 2010; Monsoor & Yusuf, 2002; Lisiewska *et al*., 2003; Rybiński *et al*., 2006, 2008].

The substitution of a part of the wheat flour with the pulse component contributed to an increase of the ash content, protein and dietary fibre in the breads and the differences were statistically significant (Table 4).

It should be kept in mind that every attempt at increasing the content of dietary fibre in bread improves its functional properties and becomes an element of prophylaxis of civilisation diseases [Barton *et al*., 2005; Sanz Penella *et al*., 2008; Schaafsma, 2004; Wang *et al*., 2002]. The contents of TDF, SDF, IDF and ASDF were significantly higher in every sample of the experimental breads with a content of grasspea wholemeal compared to the model bread. At 12% content of grasspea the content of total dietary fibre (TDF) was 8.75% d.m., soluble dietary fibre (SDF) 3.90% d.m., and insoluble dietary fibre (IDF) 4.85% d.m.; in the model wheat bread the corresponding values were 4.56% d.m., 2.56% d.m. and 2.00% d.m., respectively (Table 4). Therefore, the addition of just 12% of grasspea wholemeal in the bread recipe enabled doubling the content of dietary fibre.

Similar trends for wheat bread with an addition of fibre components were obtained by other authors [Dhingra & Jood, 2001; Kasprzak & Rzedzicki, 2010; Škrbić *et al.,* 2009; Wang *et al*., 2002]. Wang *et al*. [2002] showed that TDF and IDF of the fibre-enriched breads was higher than in the control bread (no added fibre). The TDF increase ranged from 71% with added carbon fibre to 82% with pea fibre, compared to the control. The total dietary fibre content at the level of 3.09–5.44% d.m. was obtained in white wheat bread by Borawska *et al*. [1995] and by Siemianowska *et al*. [2009].

In the experimental breads the insoluble fraction of dietary fibre appeared in the greatest amounts. The share of IDF in the total dietary fibre exceeded 50% for most of the breads examined. Grasspea, however, is a specific material. The insoluble dietary fibre of grasspea does not dissolve in a water medium, it does, however, dissolve in acid environments. Thus it constitutes a valuable prebiotic that additionally enhances the functional properties of the experimental breads.

CONCLUSIONS

In conclusion we confirm that the grasspea wholemeal applied in the study proved to be a good material for baking traditional white bread. The breads produced were characterised by typical taste, flavour, and light colouring of crumb and crust, characteristic of traditional wheat bread. Application of the grasspea wholemeal caused a decrease in the physical properties and sensory attributes of bread. The substitution of a part of the wheat flour with grasspea wholemeal distinctly improved the values of baking loss and total oven loss and caused an increase in the content of ash, protein, particular fractions of dietary fibre. The experimental breads with a content of grasspea wholemeal were characterised by a high content of the prebiotic fibre fractions SDF and ASDF. Bread with 12% addition of grasspea wholemeal was characterised by protein content of 14.51% d.m., total dietary fibre content of 8.75% d.m., soluble dietary fibre in water solution of 3.90% d.m., and soluble dietary fibre in acid solution of 2.89% d.m.

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Received August 2011. Revisions received December 2011 and January 2012. Accepted February 2012. Published on-line on the 25th of April 2012.