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CHEMICAL COMPOSITION OF NAKED BARLEY FOR PRODUCTION OF FUNCTIONAL FOOD

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A b s t r a c t. The objective of the study was to estimate the nutritive value and the functional traits of new lines of naked barley. The study comprised the grain of 23 lines of naked barley and two registered model cultivars – naked cv. Rastik and husked cv. Stratus. In samples of grain from a field experiment, from three consecutive harvest years, assays of the content of total proteins, crude fat and minerals were performed. Special attention was focused on the basic functional traits of the grain – the content of total dietary fibre and its fractional composition, analysing the content of the soluble and insoluble fractions in a water solution of enzymes and in an acid environment. It was demonstrated that the husked cultivar had a higher content of minerals (2.22% d.m.), total dietary fibre (TDF) (22.18% d.m.), AIDF fraction (4.75% d.m.) and SDF fraction (18.09% d.m.). The naked lines were characterised by a higher content of proteins (from 10.15 to 12.05% d.m.), fat (from 1.55 to 1.94% d.m.), and by a more favourable fraction composition of dietary fibre. Compared to the grain of husked barley, a significantly higher content of WSDF (from 5.51 to 7.86% d.m.) and (1-3)(1-4)-β-D-glucans (from 5.51 to 7.86% d.m.) was demonstrated. Lines STH 4561, STH 4671 and STH 4676 proved to be especially applicable for the production of functional food; they are characterised by a high content of the desirable chemical components and a high stability of the traits studied over the whole period of the experiment. Therefore they are an excellent source of genes for further breeding work.

K e y w o r d s: naked barley, ash, protein, fat, dietary fibre

INTRODUCTION

The development of new technologies of food production in the 20th century and the change of life style have led to unfavourable changes in human nutrition and to negative dietary habits. Dietary fibre has been eliminated from many products, especially cereal products, thus increasing the energy density of the food. Fibre deficit in the diet and the consumption of food with high GI appears to be one of the primary causes of such civilisation diseases as obesity, type 2 diabetes, diseases of the circulatory system, cancer of the large intestine, and other disorders (Bingham *et al.* 2003, Kristensen and Jansen 2011). The introduction of a barley component in food may significantly reduce its glycaemic index (GI) with no deterioration to its sensory features (Östman *et al*. 2006). Cavallero *et al*. (2002) studied the effect of an addition of barley material to bread on the value of GI, and observed a linear decrease in the value of the index with increase in the level of (1-3)(1-4)-β-D-glucans.

It is indicated that the main source of dietary fibre in the diet should be wholemeal low-processed cereal products, primarily oats and barley. Research shows that barley products, especially those produced from naked barley, can be successfully applied both in the prophylaxis of hypercholesterolaemia and as an agent supporting its treatment (Talati *et al.* 2009). Researchers recommend dietary fibre dose of 20-40 g per day; this is the amount necessary for correct functioning of the organism and for keeping the proper body weight (James *et al.* 2003). Based on studies conducted by the Institute of Medicine (IOM) of the National Academies (FDA, 2006), the American Food and Drug Administration (FDA) recommends the consumption of 14 g of total dietary fibre/day per every 1000 kcal of energy consumed. McIntosh *et al*. (1991) demonstrated that at moderate hypercholesterolaemia the consumption of 170 g of barley products per day, after four weeks reduces the level of LDL cholesterol while preserving the concentration of the HDL cholesterol fraction. Similar recommendations are given also in the guidelines of the American Heart Association’s National Cholesterol Education Program (NCEP).

Numerous studies confirm also the extensive possibility of application of high-fibre cereal products in the prophylaxis and alleviation of effects of carbohydrate metabolism disorders. Barley and oats products characterised by a high content of (1-3)(1-4)-β-D-glucans are especially recommended (Brennan 2005, Cavallero *et al*. 2002).

Numerous authors emphasise an anti-carcinogenic and health-promoting role of dietary fibre (Jefferson and Cowbrough 2005). Studies conducted by Bingham *et al*. (2003) support the anti-carcinogenic effect of dietary fibre. Those researchers demonstrated that increased consumption of dietary fibre reduces the incidence of colonic carcinoma by 40%. As far back as 1976 in the world of science there appeared the first references to a positive effect of increased consumption of dietary fibre on the work of the intestines (Cummings *et al*. 1976). Increasing the consumption of dietary fibre from 17 to 45 g day^{-1} they observed an increase in the faecal mass from 79.3 g day^{-1} to as much as 228 g day^{-1}. The time of passage of the intestinal contents was reduced from 57.8 to 40.3 hours. It is emphasised that high-fibre products are highly effective in combating obesity and help to regulate the body mass. It has been demonstrated that the consumption of low-processed high-protein wholemeal food is positively correlated with decrease in body mass and negatively with the value of BMI (Howarth *et al*. 2001).

The objective of the study was to estimate the nutritive value and the functional traits of new lines of naked barley.

MATERIAL AND METHOD

Material

The experimental material originated from the plant breeding experimental station of the company Hodowla Roślin Strzelce Sp. z o.o. On the basis of several years of field experimentation and analytical studies, out of 62 lines and cultivars of barley (*Hordeum vulgare* L.) 23 lines were selected for further studies as the most promising in terms of cultivation and technology, and two cultivars for comparative purposes: the naked cv. Rastik and the husked cv. Stratus. The cultivation conditions were the same for all of the chosen lines and cultivars. Prior to the analyses, the grain material was ground using a laboratory stone grinder with working gap of 0.2 mm. Grain of the husked cultivar Stratus was ground together with the husk. All results given are arithmetic means for three consecutive years of the study.

Chemical analyses

In the experimental material the contents of crude ash (AACC, Method 08-01), crude protein (AACC, Method 46-08) and crude fat (AACC, Method 30-10) were determined. Also, the content of (1-3)(1-4)-β-D-glucans (AACC 32-23, AOAC 999.16) and dietary fibre was assayed with the enzymatic method (AOAC 991.43, AACC 32-07, AACC 32-21, AOAC 985.29, AACC 32-05) permitting the determination of the dietary fibre fraction insoluble in water solution of enzymes (WIDF), fraction soluble in water solution of enzymes (WSDF), and total dietary fibre (TDF). The analyses were made using the enzyme set and the procedures of the company Megazyme (Bray, Ireland). The content of total dietary fibre (TDF) was adopted as the sum of fractions WIDF and WSDF.

From the viewpoint of the human physiology, total soluble dietary fibre (SDF) is composed of the WSDF fraction, soluble in water solution of enzymes, and of the ASDF fraction, soluble in the acidic environment of the stomach (Rzedzicki 2009). Both of those fractions generate specific physiological effects characteristic for the soluble fraction. The content of the dietary fibre fraction soluble in an acidic environment (ASDF) was assayed with the detergent method (AIDF) according to the method of Van Soest. The determination comprised the AIDF fractions and their components – cellulose (CEL) and lignin (ADL). The content of dietary fibre soluble in an acid detergent (ASDF) was calculated from the difference between the water insoluble dietary fibre (WIDF) and the acid detergent insoluble dietary fibre (AIDF).

Statistical analysis

The results obtained were subjected to statistical analysis with the use of the statistical software package SAS version 9.1. One-factor analysis of variance was conducted using the Fisher least significant difference test (significance level $\alpha = 0.05$). The Pearson linear correlation coefficients for the parameters studied were also determined.

RESULTS AND DISCUSSION

The primary factor determining the functional properties of a given barley cultivar is the chemical composition of the grain which is related with genetic, agrotechnical as well as weather factors (Andersson *et al*. 2008).

Minerals

The highest content of mineral components was noted for the husked cultivar Stratus for which it amounted to 2.22% d.m. The husked barley differed significantly in this respect from all the naked barley lines studied (Table 1). Ash content in the grain of the naked barley lines varied from 1.80% d.m. for line STH 4883 to 2.03% d.m for STH 4510 (Table 1). The results obtained correspond with those obtained by other authors (Andersson *et al*. 2008, Cramer *et al*. 2005). Therefore, wholemeal products from studied samples will be a valuable source of minerals.

Protein

Literature data indicate that in whole kernels of barley proteins account for 10-17% d.m. (Qiunde *et al*. 2004). The lowest protein content was noted in the husked barley cv. Stratus, for which it amounted to 9.68% d.m. and the highest content was noted in grain samples of lines STH 4510 and STH 4561 – above 12% d.m. High and stable protein levels over the whole experimental period were noted in lines STH 4561, STH 4671 and STH 4676 (Table 1), which indicates their high technological value. Protein content in barley grain depends strongly on the environmental conditions, which was evidenced e.g. in studies by Andersson *et al*. (2008). Protein content observed by those authors in barley cv. Rastik grown in Hungary was

18.3% d.m. In the study presented here, under the climate conditions prevailing in Poland, the mean protein content obtained for this cultivar was at the level of only 11.06% d.m. Numerous researchers indicate a relation of protein content with the time and level of nitrogen fertilisation (Zbroszczyk and Nowak 2009) and the amount of water during the vegetation (Gąsiorowski 1997).

Table 1. Chemical composition of husked and naked barley genotypes (% d.m.)

Genotype	Ash	Protein	FAT	(1-3)(1-4)-β-D-glucans
		Naked		
STH 4641	1.84	10.71	1.55	5.27
STH 5004	1.82	10.84	1.65	5.17
STH 4561	1.93	12.04	1.67	5.58
STH 5014	1.86	10.97	1.72	5.11
STH 4671	1.92	11.75	1.85	5.34
STH 4510	2.03	12.05	1.77	5.03
STH 4676	1.88	11.30	1.77	6.29
STH 4609	1.93	11.13	1.89	4.55
STH 4883	1.80	10.73	1.54	4.97
STH 4873	1.86	11.65	1.84	4.83
STH 5005	1.82	11.91	1.70	4.76
STH 4572	1.99	10.62	1.83	4.04
STH 4998	1.84	10.80	1.67	4.61
STH 5189	1.90	10.85	1.94	4.76
STH 4617	1.91	10.23	1.91	4.05
STH 4476	1.93	10.89	1.86	4.90
STH 4636	1.90	10.15	1.80	4.64
STH 4498	1.89	10.49	1.70	4.70
STH 4570	1.91	10.88	1.67	4.36
STH 4599	1.88	10.42	1.77	4.32
STH 5029	1.85	10.92	1.67	4.62
STH 4989	1.94	10.89	1.65	5.23
STH 4995	1.86	10.32	1.60	5.36
RASTIK	2.00	11.06	1.82	4.52
		Husked		
STRATUS	2.22	9.68	1.49	4.13
NIR	0.10	0.95	0.19	0.33

According to Gąsiorowski (1997), both an excess of moisture and its deficit have a considerable effect on the protein yield of spring barley. The high, for barley, protein content in the lines studied creates a possibility of their utilisation for food production, especially as concerns the abovementioned lines STH 4561, STH 4671, STH 4676 which, over three vegetation periods, did not display statistically significant differences in protein content in spite of the differences in weather conditions in the consecutive years of the experiment.

Fats

Barley is a cereal with low fat content, though its levels from 1.9 to even 4.6% d.m. have been recorded (Fastnaught *et al*. 2006, Baik and Ullrich 2008). In the barley lines and cultivars studied no such high fat levels were noted. The three-year mean content of crude fat in the naked barley lines studied varied within the range from 1.54% d.m. for STH 4883 to 1.94% d.m. for STH 5189 (Table 1). The lowest fat content was noted for the husked barley – 1.49% d.m. Comparable values of fat content were obtained also in other studies (Cramer *et al*. 2005, Oscarsson *et al*. 1996).

In barley kernel, lipid substances are located primarily in the germ and in the aleurone layer (Gąsiorowski 1997). Such a distribution of lipids permits a more extensive application of barley grain in technologies where oat grain cannot be used due to its high lipid content in the endosperm cells (Lehtinen *et al*. 2003). Thus barley can be used for the production of food with low calorific value. Bran obtained from naked barley is less susceptible to fat rancidity and can be stored for longer periods of time (Bhatty 1995).

Total dietary fibre (TDF)

Dietary fibre and its fractional composition constitute the most important indicator of the quality of cereals destined for food (Rzedzicki *et al*. 2008). Numerous studies indicate that barley is a rich source of dietary fibre with a high share of the soluble fraction (Bhatty 1995, Yalçın *et al*. 2007). This study confirmed high levels of dietary fibre and its fractions in the barley lines tested. However, statistical analysis revealed significant differences in total dietary fibre content between husked and naked forms of barley. The three-year mean content of TDF in the grain of naked barley varied within the range from 16.27% d.m. for line STH 4599 to 19.10% d.m. for STH 4676. One of the higher values of TDF content was noted for the line STH 4671 mentioned earlier. In grain of the husked cultivar Stratus the content of TDF was assayed at 22.84% d.m. (Table 2). It should be kept in mind, however, that the high level of TDF in husked barley is determined by the amount of glume which accounts for 10-13% of kernel mass (Shewry *et al*. 2008). As the husk is not an edible element and has to be removed in the hulling operation, the content of dietary fibre assayed in husked cultivars does not mean the amount of fibre available for consumption. In a study on pearled barley of husked barley, Rzedzicki *et al*. (2008) noted TDF content at the level of 12.53 to 13.57%. Andersson *et al*. (2008) obtained total dietary fibre content in husked barley at the level of 20-24% d.m., and in naked cultivars – 15% d.m. Apart from the cultivar factor, the content of total dietary fibre content in cereals is strongly affected by the weather and cultivation conditions (Yalçın *et al*. 2007).

Insoluble dietary fibre

Numerous researchers indicate a high share of cellulose and lignin in the insoluble fraction of dietary fibre (Oscarsson *et al*. 1996). Confirmation or contradiction of such reports requires the definition of what insoluble dietary fibre is, and if it is insoluble then what medium is it insoluble in (Fig. 1). The problem of definition of the particular fractions of soluble and insoluble dietary fibre and of the determination of the contents of the particular fractions has been presented by Rzedzicki (2009). Insoluble dietary fibre assayed with the enzymatic method is fibre insoluble in a water solution of enzymes (WIDF). However, a part of the fraction determined in this way does dissolve in an acidic detergent and is referred to as ASDF; the remainder is the AIDF fraction defined as dietary fibre insoluble in enzyme solution and in acidic detergent.

The content of lignin and cellulose in WIDF calculated in conformance with those assumptions is presented in Fig. 2. Results obtained with this method confirm high contents of cellulose and lignin in the insoluble dietary fibre, but at the same time indicate a very high share of the ASDF fraction.

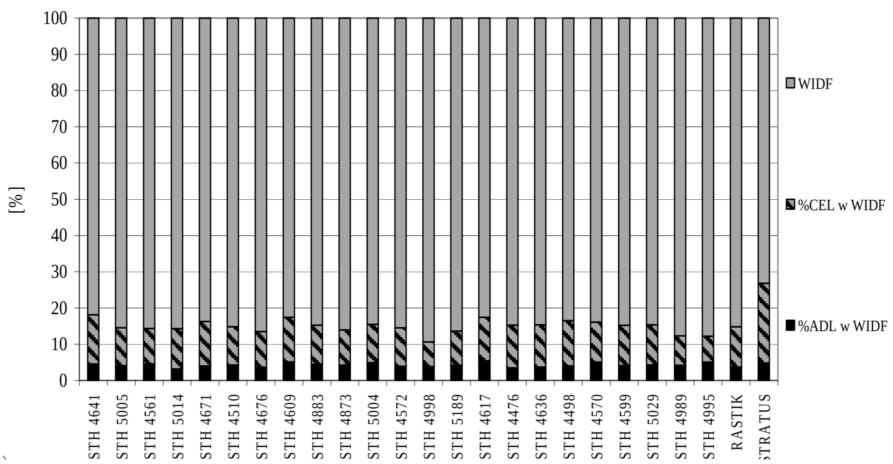

Fig 1. Cellulose and lignin contents in dietary fibre fraction insoluble in water solution of enzymes

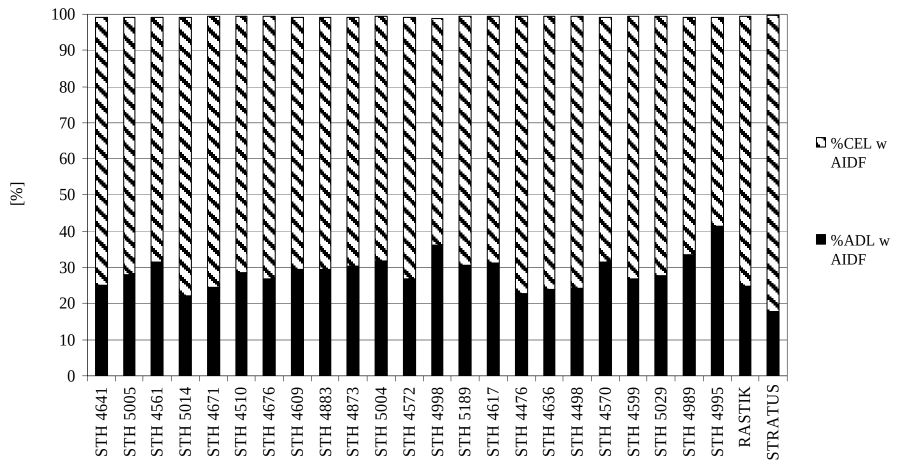

Fig. 2. Cellulose and lignin contents in dietary fibre fraction insoluble in acidic detergent

The analysed samples of naked barley grain did not differ statistically significantly in terms of their content of dietary fibre insoluble in water solution of enzymes (WIDF) and displayed WIDF levels from 10.30% d.m. for line STH 4883 to 12.31% for STH 4572 (Table 2). A significantly higher value – 17.64% d.m. – was recorded for the husked barley cv. Stratus. The content of dietary fibre insoluble in acidic detergent (AIDF) varied within the range from 1.20% d.m. to 2.14% d.m. in the naked lines STH 4998 and STH 4641, respectively. For the husked barley cultivar a significantly higher value of that fraction was noted compared to the naked barley, amounting to as much as 4.75% (Table 2).

The higher content of WIDF in husked cultivars is related with the presence of the glume which is built primarily of insoluble fractions of dietary fibre (Oscarsson *et al*. 1996, Shewry *et al*. 2008). WIDF values presented in the literature for husked barley vary within a broad range, from 14 to 20% d.m., while for naked barley that range is from 12.17 to 19.30% d.m. (Virkki *et al*. 2004). It is emphasised that the content of WIDF is determined by such factors as the cultivar, the weather conditions, and the cultivation conditions (soil, tillage, fertilisation etc.) (Yalçın *et al*. 2007).

Soluble dietary fibre

The naked lines of barley were characterised by very high contents of dietary fibre soluble in water solution of enzymes (WSDF), within the range from 5.51% d.m. for line STH 4599 to 7.86% d.m. for STH 4671. High levels of that fraction of dietary fibre were also noted in lines STH 4561 and STH 4676. A decisive majority of samples of naked barley differed statistically significantly from the husked cultivar Stratus with respect to the content of WSDF (Table 2). The lines of naked barley were characterised by a high percentage share of WSDF in the total dietary fibre, varying from 33.28% to as much as 42.51%, while in the husked cultivar Stratus it was only 22.77% (Fig. 3). A higher content of soluble dietary fibre in naked barley compared to husked barley was also obtained by Bhatty (1995).

Table 2. Chemical characteristics of total dietary fibre fractions (% d.m.)

Genotype	TDF	AIDF	ASDF [a]	WSDF	WIDF
	% d.m.				
Naked					
STH 4641	18,51	2,14	9,55	6.83	11,69
STH 5005	17,97	1,69	9,80	6.49	11,49
STH 4561	17,73	1,53	8,99	7.22	10,52
STH 5014	18,09	1,66	9,86	6.57	11,52
STH 4671	18,49	1,74	8,89	7.86	10,63
STH 4510	17,83	1,64	9,37	6.82	11,01
STH 4676	19,10	1,58	10,03	7.49	11,60
STH 4609	17,70	1,93	9,04	6.73	10,97
STH 4883	16,80	1,59	8,71	6.51	10,30
STH 4873	18,12	1,67	10,20	6.25	11,87
STH 5004	17,44	1,68	9,07	6.69	10,74
STH 4572	18,45	1,80	10,51	6.14	12,31
STH 4998	17,40	1,20	9,90	6.30	11,09
STH 5189	17,76	1,47	9,23	7.06	10,70
STH 4617	16,56	1,92	9,00	5.64	10,92
STH 4476	16,41	1,64	9,04	5.72	10,69
STH 4636	17,73	1,70	9,28	6.75	10,98
STH 4498	16,92	1,81	9,11	6,00	10,92
STH 4570	17,23	1,79	9,23	6.21	11,02
STH 4599	16,27	1,65	9,11	5.51	10,76
STH 5029	17,48	1,72	9,39	6.37	11,11
STH 4989	18,10	1,43	10,07	6.60	11,50
STH 4995	17,62	1,33	9,46	6.83	10,79
RASTIK	18,29	1,72	9,83	6.74	11,55
Husked					
STRATUS	22,84	4,75	12,89	5.20	17,64
NIR/LSD	2,18	0,32	–	0,84	2,25

[a] calculated value based on the averages of WIDF and AIDF

Analysing the contents of dietary fibre and its fractions in various research reports one encounters the problem of ambiguity of results, resulting probably from the application of various analytical methods (Champ *et al*. 2003). It is therefore necessary that researchers adapt not only to the latest definitions of dietary fibre, but also to the analytical methods recommended by the latest DF Congresses – Vienna in 2009 and Rome in 2012.

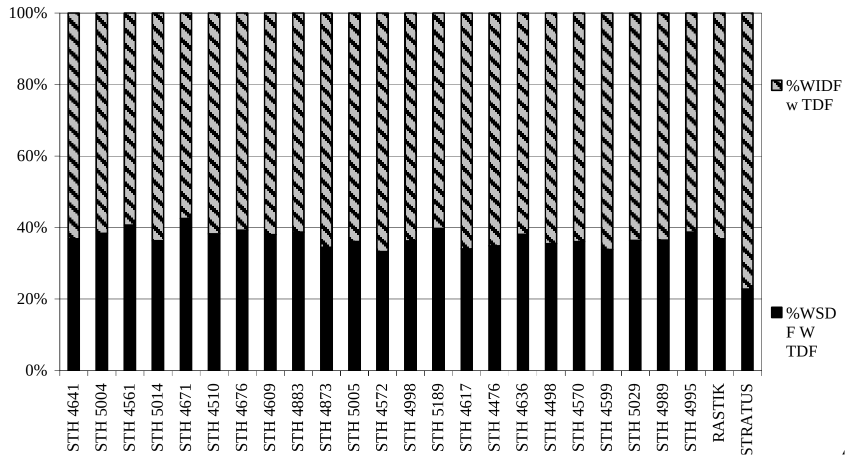

Fig. 3. Percentage shares of fractions soluble and insoluble in water solution of enzymes in the total dietary fibre

(1-3)(1-4)-β-D-glucans

From the viewpoint of human nutrition and health, (1-3)(1-4)-β-D-glucans are a very important component of the soluble fraction of dietary fibre (Östman *et al.* 2006). Compared to other cereals, barley is characterised by extraordinarily favourable parameters in terms of their content. The content of β-glucans in barley is comparable to that of oats (Bhatty 1995, Yalçın *et al*. 2007). In this study, the three-year mean content of (1-3)(1-4)-β-D-glucans varied within the range from 4.04% d.m. for line STH 4572 to 6.29% d.m. in barley line STH 4676. The other two lines that on many occasions proved to be outstanding against the remaining ones, i.e. STH 4561 and STH 4671, also displayed ones of the highest contents of the compounds in question, at 5.58 and 5.34% d.m., respectively. In the husked barley cultivar, the mean content of β-glucans for the whole period of the study was 4.13% d.m. and it was significantly lower compared to most of the naked barley lines (Table 1). Numerous researchers emphasise significantly higher contents of (1-3)(1-4)-β-D-glucans in naked forms of barley compared to the husked forms (Bhatty 1999). Cramer *et al*. (2005) recorded (1-3)(1-4)-β-D-glucans content in naked barley cultivars in the range of 4.5-7.4% d.m. and 4.1-5.7% d.m. in husked cultivars, while Andersson *et al*. (2008) obtained values from 4.6 to 6.5% d.m. and from 3.7 to 5.4% d.m., respectively, for naked and husked barley.

The contents of (1-3)(1-4)-β-D-glucans and of the WSDF fraction of dietary fibre correspond with the results of studies on the distribution of those compounds in kernels of the particular cultivars. Wirkijowska *et al*. (2012) determined the distribution of (1-3)(1-4)-β-D-glucans in kernels of the barley lines studied. It was demonstrated that high-glucan lines STH 4561, STH 4671 and STH 4676 were characterised by more centralised distribution of those valuable prebiotics. Such barley lines become, therefore, "resistant" to technological losses of (1-3)(1-4)-β-D-glucans and can be subjected to processes of surface cleaning and potential surface processing of kernels. Highly sensitive to those processes are the low-glucan line STH 4572 and cultivar Rastik in which (1-3)(1-4)-β-D-glucans were located in the aleurone and subaleurone layers. The husked cultivar Stratus is characterised by uniform distribution of β-glucans within the endosperm of the kernel (Wirkijowska *et al*. 2012), but at the same time also by a low content of those compounds. Quinde *et al*. (2004) and Quinde-Axtell *et al*. (2006) recorded that pearling reduces the content of insoluble fibre, ash, protein and free lipids, but increases the contents of β-glucan and starch.

The high content of (1-3)(1-4)-β-D-glucans and their highly favourable distribution in lines STH 4676, STH 4561 and STH 4671 indicate extensive possibilities of their utilisation in food production, including functional food (grits, hot meals, flakes).

Pearson's correlation analysis

Analysing the matrices of Pearson correlation coefficients between the mean values for the whole period of the study a positive correlation was noted between ash content and the level of dietary fibre insoluble in water solution of enzymes (WIDF) ($r = 0.75$) and also the insoluble fraction (AIDF) ($r = 0.70$) and soluble fraction (ASDF) ($r = 0.67$) in acidic detergent (Table 3).

Table. 3. Pearson's correlations between chemical components of naked barley grain

	TDF	WSDF	WIDF	ASDF	AIDF	β-glucan	Protein	Ash
TDF	1.000		0.90	0.71	0.80			0.69
WSDF		1.000	0.44	0.64		0.74	0.59	
WIDF	0,90	0,44	1.000	0.84	0.89		0.39	0.75
ASDF	0,71	0,64	0,84	1.000	0.76	0.41	0.47	0.67
AIDF	0,80		0,89	0,76	1.000		0.39	0.70
β-glucans		0,74		0,41		1.000	0.48	

$p < 0.005$

A positive correlation was also demonstrated with the total dietary fibre (TDF), for which the coefficient of correlation was $r = 0.69$ (Table 3). These correlations are related with a high percentage share of the insoluble fibre fraction in the total dietary fibre, and with the highest concentration of WIDF in the seed cover of the kernel, where the highest amount of ash is located (Gąsiorowski 1997).

Protein content was positively correlated with fibre fraction soluble in water solution of enzymes (WSDF) (r = 0.59) and with the content of (1-3)(1-4)-β-D-glucans (r = 0.48), and negatively correlated with dietary fibre insoluble in water solution of enzymes (WIDF) (r = 0.39) as well as with dietary fibre insoluble (AIDF) (r = 0.39) and soluble in acidic detergent (ASDF) (0.47) (Table 3). No significant correlation was noted between protein content and TDF, which was demonstrated by Yalçın *et al*. (2007).

The analysis of correlation revealed in the barley lines tested a very strong positive correlation between TDF and the successive fractions of dietary fibre: WIDF (r = 0.90), ASDF (r = 0.71) and AIDF (r = 0.80) (Table 3). Numerous relations were also observed between the particular fractions of dietary fibre (Table 3).

CONCLUSIONS

The study showed statistically significant differences in the contents of the main chemical components, such as proteins, lipids, dietary fibre, minerals, between the husked barley cultivar and the naked lines. Significant differences were also demonstrated with regard to the fractional composition of dietary fibre (Table 2). The naked forms had lower contents of total dietary fibre (TDF) and water-insoluble dietary fibre (WIDF), and displayed a higher level of the particularly valuable water-soluble fraction (WSDF) and (1,3)(1-,4)-β-D-glucans. The content of lipids, high contents of proteins, minerals, and especially of the soluble fibre fractions WSDF and ASDF, and the high content of (1,3)(1-4)-β-D-glucans in the naked barley lines STH 4676, STH 4671 and STH 4671, indicate that they can be an excellent material for the production of food with functional properties. The lines enumerated, due to the high stability of the properties studied, should be used in further genetic studies as gene carriers.

The division of dietary fibre into fractions SDF and IDF, closely related with the AACC and AOAC analytical methods (AOAC 991.43, AACC 32-07, AACC 32-21, AOAC 985.29, AACC 32-05), does not fully take into account the functional properties of those fractions and their physiological effects. This concerns not only the fibre components soluble (WSDF) and insoluble (WIDF) in water solution of enzymes. Following that course of action, in the naked barley lines and cultivars under study the content of WSDF was assayed at the level of 6.50% d.m., and that of WIDF at 11.37% d.m. However, it should be kept in mind that intensive physiological effects are generated also by the dispersed fractions of dietary fibre soluble in the acidic environment of the stomach. Adopting that point of reference (Rzedzicki

2009), it turns out that the mean content of the soluble fraction SDF in naked barley is not 6.50% d.m. as it has been reported so far, but as much as 16.80% d.m. According to this classification, the content of the completely insoluble fibre fraction (AIDF) is not 11.37% but less than 2% d.m. (Table 2). If the fractional composition of dietary fibre is considered in this way, naked barley turns out to be an ideal material for the production of functional food. The absence of the glume and the favourable distribution of (1-3)(1-4)-β-D-glucans in the kernels of the recommended lines of naked barley (Wirkijowska *et al*. 2012) make that kind of barley material especially predisposed for the production of functional food.

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SKŁAD CHEMICZNY JĘCZMIENIA NAGIEGO DO PRODUKCJI ŻYWNOŚCI FUNKCJONALNEJ

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Streszczenie. Celem pracy była ocena wartości żywieniowej i cech funkcjonalnych nowych rodów jęczmienia nagiego. Badaniom poddano ziarno 23 rodów jęczmienia nagiego i dwóch zarejestrowanych odmian wzorcowych – nagiego Rastik i oplewionego Stratus. W próbach ziarna pochodzących z badań polowych z trzech kolejnych lat zbiorów badano zawartości białka ogólnego, tłuszczu surowego i składników mineralnych. Szczególnej uwadze poddano podstawowe funkcjonalne cechy ziarna – zawartość błonnika pokarmowego całkowitego i jego skład frakcyjny. Analizowano zawartość frakcji rozpuszczalnych i nierozpuszczalnych w wodnym roztworze enzymów oraz w środowisku kwaśnym. Wykazano, że odmiana oplewiona wykazywała wyższą zawartość składników mineralnych (2,22% s.m.), błonnika pokarmowego całkowitego (TDF) (22,18% s.m.), frakcji AIDF (4,75% s.m.) oraz frakcji SDF (18,09% s.m.). Rody nieoplewione cechowały się wyższą zawartości białka (od 10,15 do 12,05% s.m.), tłuszczu (od 1,55 do 1,94% s.m.) oraz korzystniejszym składem frakcyjnym błonnika. Wykazano istotnie wyższą zawartość WSDF (od 5,51 do 7,86% s.m.) i (1-3)(1-4)-β-D-glukanów (od 5,51 do 7,86% s.m.) w porównaniu do ziarna jęczmienia oplewionego. Rody STH 4561, STH 4671 i STH 4676 wykazywały szczególną przydatność do produkcji żywności funkcjonalnej; charakteryzują się wysoką zawartością pożądanych składników chemicznych, wysoką stabilnością badanych cech w całym okresie badawczym. Są więc doskonałym nośnikiem genów do dalszych prac hodowlanych.

Słowa kluczowe: jęczmień nagi, popiół, tłuszcz, białko, błonnik pokarmowy