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CONTENTS OF SELECTED BIOACTIVE COMPONENTS IN BUCKWHEAT GROATS

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Background. Nutritive value of food is determined by its content of basic nutrients essential for the proper functioning of the human organism. Buckwheat grain is one of the most valuable raw materials for production of groats as well as functional food. It is characterized by high contents of starch, protein as well as dietary fibre. Apart from the above mentioned nutrients, buckwheat groats contain flavonoid compounds, playing the role of antioxidants. The aim of this study was to determine contents of dietary fibre and its fraction composition, thiamine and phenolic compounds in roasted buckwheat groats, as well as antioxidant properties of ethanol buckwheat groats extracts.
Material and methods. Experimental material comprised roasted buckwheat groats purchased at a grocery shop. Contents of neutral detergent dietary fibre (NDF) and its fractions were determined by the detergent method according to Van Soest. Thermostable α--amylase (Termamyl 120 L) was used in the digestion of starch. Contents of total dietary fibre (TDF), soluble dietary fibre (SDF) and insoluble dietary fibre (IDF) were determined according to Asp et al. The content of thiamine was determined by the thiochrome method. Total polyphenol content was determined by colorimetry according to the Folina--Ciocalteu method. Antioxidant properties of extracts were estimated based on the capacity of extracts to scavenge the $DPPH^{\bullet}$ radical (1,1-diphenyl-2 picrylhydrazyl) and towards linolic acid. The capacity to inhibit self-oxidation of linolic acid was determined according to Lingnert et al.
Results. The NDF and TDF contents in buckwheat groats, amounting to 5.63 and 8.4%, respectively. The fraction found in biggest amounts was the hemicellulose fraction (3.42%). The level of the IDF fraction was much higher (5.94%) than that of SDF (2.46%). Thiamine content was 0.519 mg/100 g product, while the total content of phenolic compounds extracted from buckwheat groats was 30.592 $\mu g \cdot cm^{-3}$. Ethanol extract of buckwheat groats was characterized by a high $DPPH^{\bullet}$ radical scavenging capacity (80.8%) and exhibited high capacity to inhibit self-oxidation of linolic acid $W_0 = 0.86$.

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Conclusions. Investigations showed that buckwheat groats, widely used in Polish diet, due to their content of biologically active substances, may be a raw material for the production of functional food.

Key words: buckwheat, dietary fiber, antioxidants, thiamine

INTRODUCTION

Nutritive value of food is determined by its content of basic nutrients essential for the proper functioning of the human organism, as well as their proportions, digestibility and bioavailability. Contemporary consumers more and more frequently focus on the so-called healthy lifestyle, which indispensable part is consumed food. Food, which apart from its traditional role also exhibits an additional action promoting health, is called functional food. In accordance with the definition of the FUFOSE (Functional Food Science in Europe) research programme, food may be classified as functional if its advantageous effect on at least one function of the organism, apart from its nutritive effect, has been proven. This effect may consist in improved health state, well-being and reduced risk of disease. Moreover, functional food has to remind conventional food in terms of its form and exhibit an advantageous effect in the amounts which are expected to be consumed in a normal diet. This is not capsules or medication, but a component of the diet [Diplock et al. 1999]. Bioactive components contained in functional food include first of all these ingredients which have a positive effect on cardiac performance, functioning of the cardiovascular system, lipid metabolism, the alimentary system, the condition of bones and teeth, and which enhance the natural immunity of the organism. Such components include lactic acid bacteria (probiotics), dietary fibre, plant sterols, antioxidants, minerals, vitamins, oligosaccharides (prebiotics), essential unsaturated fatty acids, as well as phytocompounds [Mehta 2005, Zduńczyk 1999]. Apart from vegetables and fruit, also cereals and groats are sources of biologically active substances.

Buckwheat has been attracting increasing interest on the world market for health food. Buckwheat grain is one of the most valuable raw materials for production of groats as well as functional food [Christa and Soral-Śmietana 2007, Krkošková and Mrázová 2005]. It is characterised by high contents of starch [Wronkowska and Soral-Śmietana 2008], protein with an advantageous amino acid composition, with a low content of the α-prolamin fraction [Christa and Soral-Śmietana 2007, Tomotake et al. 2006] as well as dietary fibre [Stedman et al. 2001]. Apart from the above mentioned nutrients, buckwheat groats contain flavonoid compounds, playing the role of antioxidants [Dietrych-Szóstak and Oleszek 2001, Zielińska et al. 2007].

The aim of this study was to determine contents of dietary fibre, phenolic compounds and thiamine in roasted buckwheat groats.

MATERIAL AND METHODS

Experimental material comprised roasted buckwheat groats purchased at a grocery shop. Groats were comminuted in a Cyclotec grinding mill by Tecator.

Contents of dietary fibre. Contents of neutral detergent dietary fibre (NDF), acid detergent fibre (ADF) and cellulose were determined by the detergent method according to Van Soest [1963, 1967]. Thermostable α-amylase (Termamyl 120 L) was used in the digestion of starch [McQueen and Nicholson 1979]. Contents of hemicelluloses were calculated as a difference between NDF and ADF. Determinations were performed using a FIBERTEC apparatus by Tecator. Contents of total dietary fibre (TDF), soluble dietary fibre (SDF) and insoluble dietary fibre (IDF) were determined according to Asp et al. [1983]. Results were expressed in g/100 g groats.

Determination of thiamine content. The content of thiamine was determined by the thiochrome method using a Jenway fluorimeter (model 6200) [Rettenmaier et al. 1979]. This method consists in oxidation of thiamine in a basic medium to thiochrome, which is characterized by an intensive, blue fluorescence. This fluorescence is proportional to the concentration of thiochrome, and indirectly to the content of thiamine.

Extraction of phenolic compounds. Extraction of phenolic compounds was run using 96% ethanol at room temperature for 24 h. Total polyphenol content was determined by colorimetry at a wavelength of 750 nm according to the Folina-Ciocalteu method [Horowitz 1970]. Results of analyses were presented as an equivalent of gallic acid in μg/ml extract.

Determination of antioxidant properties. Antioxidant properties of extracts were estimated based on the capacity of extracts to scavenge the DPPH$^{\bullet}$ radical (1,1--diphenyl-2 picrylhydrazyl) and towards linolic acid. Results were compared with the reference standard of phenolic compounds and BHT.

Determination of DPPH$^{\bullet}$ radical scavenging capacity. The DPPH$^{\bullet}$ radical scavenging capacity was determined based on changes in the concentration of the stable DPPH$^{\bullet}$ radical in relation to the blank test, assessed by colorimetry (λ = 517 nm) [Mensor et al. 2001, Sanchez-Moreno et al. 1998]. Results were presented as antioxidant activity (AA) expressed by the following equation:

$$AA\ [\%] = 100 - \{[(Abs_{tested\ sample} - Abs_{blank\ test\ sample}) \times 100] / Abs_{control}\}$$

Determination of capacity to inhibit linolic acid self-oxidation. The capacity to inhibit self-oxidation of linolic acid was determined according to Lingnert et al. [1979]. This method consists in the determination by spectrophotometry (λ = 234 nm) of an increment in contents of conjugated dienes in 10 mM linolic acid emulsion, pH 7.2, after 19 h incubation in the dark at 37°C. Antioxidant efficiency (W_0) expressed by the ratio of the difference in the increment of absorption in the control and the tested sample to the increment of absorption in the control sample:

$$W_0 = \triangle Abs_{234K} - \triangle Abs_{234} / \triangle Abs_{234K}$$

Statistical analysis. Assay results reported in the study constitute a mean of three replications. In order to make the inference process more objective, the collected results were analyzed statistically. The one-way analysis of variance with the use of the Scheffe test was used to determine the significance of differences between means. Dependencies at the significance level $p < 0.05$ were considered statistically significant.

RESULTS

The content of neutral detergent fibre (NDF) in buckwheat groats (per 100 g groats) was 5.63%, while that of total dietary fibre (TDF) was 8.40% (Table 1). The fraction found in the biggest amounts was the hemicellulose fraction (3.42%), while the contents of the lignin (L) and cellulose fractions were similar, accounting for 1.17 and 1.04%, respectively (Table 2). The level of the insoluble dietary fibre (IDF) fraction was much higher than that of the soluble dietary fibre (SDF) fraction, amounting to 5.94 and 2.46%, respectively. Percentages of individual fractions in dietary fibre of groats are presented in Figure 1. Neutral detergent dietary fibre in buckwheat groats was characterized by similar percentages of the lignin and cellulose fractions, 21% and 18%, respectively, while the percentage of the hemicellulose fraction was the highest, amounting to 61%. The proportion of the insoluble fraction in total dietary fibre was 71%, while that of the soluble fraction was 29%. The ratio of the insoluble to the soluble fractions in buckwheat groats was 2.4. Dietary fibre as a structurally heterogeneous substance is composed of many compounds with differing properties. As a result of the use of different definitions and assay methods applied to dietary fibre, considerable problems are encountered when attempting to determine their actual contents in food. For this reason it is crucial to define not only the total content of dietary fibre in the diet, but also its fraction composition, since individual fractions are characterised by diverse action in the human organism.

Table 1. The content of biological substances in buckwheat groats

Substances	Content
Neutral detergent fiber – NDF, g/100 g of product	5.63 ±0.12
Acid detergent fiber – ADF, g/100 g of product	2.21 ±0.18
Total dietary fiber – TDF, g/100 g of product	8.40 ±0.20
Thiamine, mg/100 g of product	0.519 ±0.05
Total phenolics content in buckwheat groats exstract, $\mu g \cdot cm^{-3}$	30.592 ±0.33

Table 2. The content of dietary fiber fractions in the buckwheat groats

Fractions	Content, g/100 g of product
Hemicelluloses (H)	3.42 ±0.12
Lignin (L)	1.17 ±0.05
Cellulose (C)	1.04 ±0.08
Insoluble fraction (IDF)	5.94 ±0.12
Soluble fraction (SDF)	2.46 ±0.10

Cereals are the most concentrated sources of dietary fibre and its chemical characteristic has been the subject of numerous papers. The main components of cereal fibre are hemicelluloses, constituting 65% total amount of fibre expressed as NDF, whreas

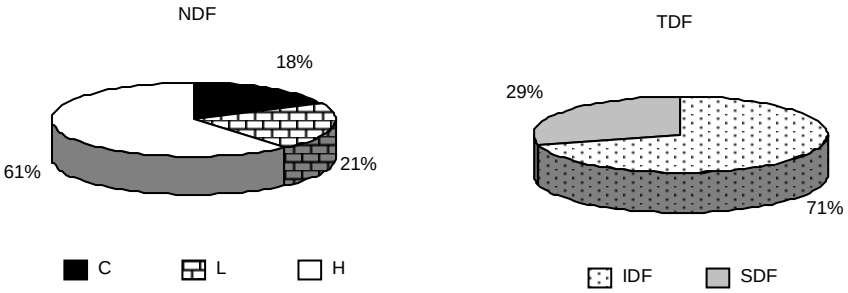

Fig. 1. Percentage content of fractions dietary fiber of buckwheat groats: NDF – neutral detergent fiber, TDF – total dietary fiber, C – cellulose, L – lignin, H – hemicelluloses, IDF – insoluble dietary fiber, SDF – soluble dietary fiber

the proportion of cellulose accounts for less than 25%, while lignin has the lowest level in fibre of analyzed cereals [Newman and Newman 1991]. In cereal products the content of fibre is highly diverse and depends on their proportions of individual parts of the kernel. During grain processing to produce groats the seed coat is removed together with the germ and, depending on milling rate, also a portion of the aleurone layer [Stedman et al. 2001]. The main components of TDF are non-starch polysaccharides (e.g. cellulose) and non-cellulose polysaccharides, concentrated primarily in the aleurone layer, the glume and the seed coat. From the point of view of nutrition, TDF is classified as IDF (insoluble dietary fibre) and SDF (soluble dietary fibre). Generally IDF comprises cellulose, lignin and certain non-cellulose polysaccharides, while SDF includes pectins, β-glucans and certain hemicelluloses. According to Grigelmo et al. [1999], dietary fibre exhibits the most effective physiological action at the ratio of the soluble to the insoluble fraction of 1.0-2.3. The high content of dietary fibre recorded in this study, as well as appropriate proportions of the IDF and SDF fractions indicate a potential application for buckwheat groats in the production of functional food.

Conducted investigations showed that buckwheat groats are a good source of thiamine. The content of this vitamin in buckwheat groats was 0.519 mg/100 g product (Table 1). Cereal grains, their outer parts as well as processed cereal products are the primary sources of thiamine. Thiamine is also found in bread, especially dark bread (rye flour contains 0.3-0.45 mg thamine/100 g product), as well as porcine and cattle liver, and the muscle tissue. Thiamine content in raw pork is 0.75 mg/100 g product [Szymandera-Buszka 2003]. In view of the recorded high content of thiamine in buckwheat groats (0.519 mg/100 g), as well as the daily thiamine requirement of humans, amounting to 1-2 mg, buckwheat groats may be considered a good source of this vitamin.

The total content of phenolic compounds extracted from buckwheat groats was 30.592 $\mu g \cdot cm^{-3}$ (Table 1). Ethanol extract of buckwheat groats exhibited a higher $DPPH^{\bullet}$ radical scavenging capacity (80.8%) than that of 0.02% BHT, which activity was 25.4% (Fig. 2). However, in comparison to 0.02% gallic acid it was a significantly lower level of activity. Figure 3 presents the effect of 0.2 ml extract on the stability of linolic acid in the emulsion. Calculated protection factors (W_0) showed that buckwheat groats extract was characterised by a high capacity to inhibit self-oxidation of linolic

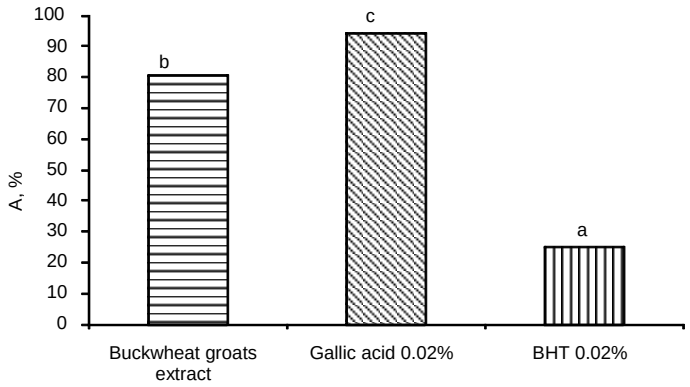

Fig. 2. The DPPH scavening effect of buckwheat groats extracts: a, b, c – sgnificantly different ($p < 0.05$)

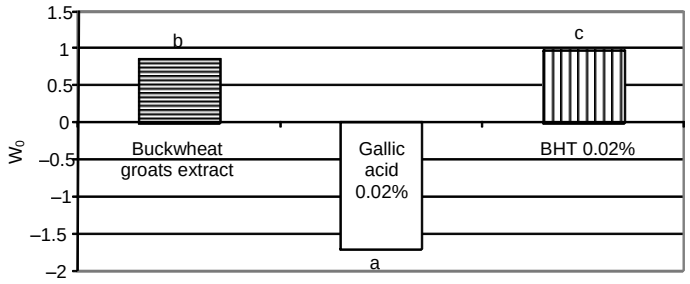

Fig. 3. The antioxidants activity of buckwheat groats extracts in emulsion system: a, b, c – significantly different ($p < 0.05$)

acid (0.86). Gallic acid did not exhibit a protection activity; on the contrary, it even promoted oxidation, while BHT almost completely inhibited oxidative changes in the emulsion.

Presented results indicate high antioxidant activity of analyzed extracts in applied model systems. They were characterized by high efficiency in neutralizing free radicals, higher than the activity of green tea, oolong and black tea extracts [Yen and Chen 1995]. In the opinion of many authors, antioxidant activity of buckwheat groats extracts depends on the content of flavonoids, including mainly rutin, catechins and quercetin [Dietrych-Szóstak and Oleszek 2001, Kreft et al. 2006, Zielińska et al. 2007]. Phenolic compounds, extracted with the use of different solvents from buckwheat seeds by Sun and Ho [2005], at 0.1 mg/ml yielded the scavenging effect ranging from 40% to 80%, while in case of ethanol extract this effect was approx. 70%. Antioxidant activity of produced extracts in relation to linolic acid was not dependent on the level of phenolic compounds they contained, which was reflected in a study by Kähkönen et al. [1999].

Conducted investigations showed that buckwheat groats, widely used in Polish diet, due to their content of biologically active substances, may be a raw material for the production of functional food.

CONCLUSIONS

1. Buckwheat groats were characterized by high contents of dietary fibre. The fraction found in the highest amounts was the hemicellulose fraction, while the cellulose fraction was found in the smallest amounts. Buckwheat groats contained more insoluble than soluble fibre. Also the content of thiamine in buckwheat groats was high.

2. Ethanol extracts of buckwheat groats were characterized by high antioxidant activity.

3. Gallic acid exhibited the highest anti-radical activity, while BHT exhibited better antioxidant properties in relation to linolic acid.

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ZAWARTOŚĆ WYBRANYCH SKŁADNIKÓW BIOLOGICZNIE AKTYWNYCH W KASZY GRYCZANEJ

Wprowadzenie. O wartości odżywczej żywności decyduje zawartość w niej podstawowych składników pokarmowych niezbędnych do prawidłowego funkcjonowania organizmu człowieka. Ziarno gryki jest jednym z najcenniejszych surowców kaszarskich, a także materiałem do produkcji żywności funkcjonalnej. Charakteryzuje się ono dużą zawartością skrobi, białka oraz błonnika pokarmowego. Oprócz wymienionych składników pokarmowych, w kaszy gryczanej znajdują się związki flawonoidowe, pełniące rolę przeciwutleniaczy. Celem pracy było określenie zawartości błonnika pokarmowego i jego składu frakcyjnego, tiaminy oraz związków fenolowych w kaszy gryczanej prażonej, jak również właściwości przeciwutleniających etanolowych ekstraktów kaszy gryczanej.
Materiał i metody. Materiałem do badań była kasza gryczana prażona zakupiona w sklepie spożywczym. Zawartość neutralnego detergentowego błonnika pokarmowego (NDF) i jego frakcji oznaczono metodą detergentową Van Soesta. Do trawienia skrobi wykorzystano termostabilną α-amylazę (Termamyl 120 L). Zawartość błonnika pokarmowego całkowitego (TDF), rozpuszczalnego (SDF) i nierozpuszczalnego (IDF) określono metodą Aspa i in. Zawartość tiaminy oznaczono metodą tiochromową. Zawartość polifenoli ogółem oznaczono kolorymetrycznie metodą Folina-Ciocalteu. Właściwości przeciwutleniające ekstraktów oszacowano na podstawie zdolności ekstraktów do zmiatania rodnika $DPPH^{\bullet}$ (1,1-difenylo-2 picrylhydrazyl) oraz wobec kwasu linolowego. Zdolność do hamowania autooksydacji kwasu linolowego określono metodą Lingnerta i in.
Wyniki. Kasza gryczana cechowała się dużą zawartością NDF i TDF, odpowiednio 5,63 i 8,4%. Frakcją występującą w największej ilości była frakcja hemicelulozowa (3,42%). Poziom frakcji IDF był znacznie wyższy (5.94%) niż frakcji SDF (2,46%). Zawartość tiaminy w kaszy gryczanej kształtowała się na poziomie 0,519 mg/100 g produktu, a całkowita zawartość związków fenolowych wyekstrahowanych z kaszy gryczanej wynosiła

30,592 μg·cm^{-3}. Ekstrakt etanolowy kaszy gryczanej cechował się dużą zdolnością wygaszania rodników DPPH$^{\bullet}$ (80,8%) oraz wykazywał dużą zdolność do hamowania samoutleniania kwasu linolowego W_0 = 0,86.
Wnioski. Przeprowadzone badania wykazały, że kasza gryczana, powszechnie stosowana w polskiej diecie, może spełniać rolę surowca do produkcji żywności funkcjonalnej ze względu na zawartość substancji biologicznie aktywnych.

Słowa kluczowe: kasza gryczana, błonnik pokarmowy, przeciwutleniacze, tiamina

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