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QUALITY OF WHEAT BREAKFAST CEREALS AVAILABLE ON THE POLISH MARKET

Zbigniew Rzedzicki, Emilia Sykut-Domańska, Joanna Popielewicz

Engineering and Cereals Technology Department, University of Life Science in Lublin

Key words: wheat, breakfast cereals, dietary fiber, water solubility index

The objective of the study was to estimate the content of basic nutrients in the most popular assortments of wheat breakfast cereals. Determinations made for samples of the tested products covered the content of dry mass, total ash, total protein, and crude fat. Due to the role of dietary fibre as the main quality determinant of cereal products, the content of that component was tested with three different methods. The Weende method was employed to determine the content of crude fibre, the detergent method – to determine the content of detergent fibre (NDF – neutral detergent fibre, ADF – acid detergent fibre, HCEL – hemicelluloses, CEL – cellulose, ADL – acid detergent lignin), and the enzymatic method – that of dietary fibre (TDF – total dietary fibre, IDF – insoluble dietary fibre, SDF – soluble dietary fibre). Assays were also carried out for the content of soluble components of dry mass (water solubility index – WSI) and the water absorption index (WAI). Assortments of ready-to-eat wheat cereals (1A – 3A) and crispy wheat bread (4B) were characterised by a low protein content (from 6.2% d.m.), low content of total dietary fibre TDF (from 6.49% d.m.) and soluble dietary fiber SDF (average 3.76% d.m.), and high values of the water solubility index that reached even up to 60% d.m. Such assortments of breakfast cereals do not meet the requirements for cereal products of the base of the food pyramid due to the poor chemical composition and high content of soluble components of dry matter.

INTRODUCTION

Over the last decades, changes in life-style, work and leisure not only led to a pandemic of civilisation diseases, but also enforced serious modifications in human diet. An important role in combating metabolic disorders (*e.g.* overweight condition, obesity, diabetes, increased cholesterol) has been attributed to cereal products introduced in the diet [Barton *et al.,* 2005; Villegas *et al.,* 2004; Weickert *et al.,* 2006]. Thus, in the nineteen eighties a group of products was promoted, referred to as breakfast cereals. Due to their content of dietary fibre they were to constitute a functional component of the diet.

Research shows beyond argument that soluble fractions of dietary fibre lower the post-meal glycaemia, *e.g.* through increased viscosity of intestinal contents [Cavallero *et al.,* 2002; Ou Shiyi *et al.,* 2001]. Insoluble dietary fibre increases the volume of faeces by retaining its structure in the colon, which also has a beneficial effect on the peristalsis [Davidson & Mc Donald, 1998; Srikumar, 2000].

Promotion and educational campaigns conducted by the greatest manufacturers of food products are aimed at convincing the consumers about high nutritional value of cereal breakfast products [Górska-Warsewicz, 2001]. Also in Poland, for over a dozen years there has been a growth of interest in the so-called "breakfast cereal confectionery". Breakfast cereal confectionery is immensely popular in highly developed countries due to its taste values and possibility of rapid preparation. Numerous studies indicate that the nutritional value of many currently produced ready-to-eat cereal products are unsatisfactory and should not be classified in the base section of the food pyramid [Rzedzicki, 2005; Rzedzicki & Wirkijowska, 2006; Rzedzicki *et al.,* 2007]. In accordance with the principles of the food pyramid developed by the Harvard School of Public Health [Willet & Skerrett, 2001], highly-processed products of this type, with the seed coat eliminated, should rather be classified for the top section of the pyramid; therefore, such products cannot constitute a component of an everyday diet and their consumption should only be occasional due to an increased hazard of the occurrence of diet-related diseases [Guillon & Champ, 2000; Miller Jones, 2004].

Taking into account the current state of knowledge concerning the role of cereal products in dietary prophylaxis and dietary therapy of metabolic diseases, the authors decided to investigate whether commercially-available assortments of wheat breakfast products may be classified, in terms of their physical properties and chemical composition, among the cereal products of the base segment of the food pyramid and whether they may be recommended as components of an everyday human diet.

MATERIAL AND METHODS

Material

The initial material for the study comprised 9 selected assortments of wheat breakfast cereals available in the Lublin retail network: 3 assortments of highly-processed wheat grains and flakes (1A, 2A, 3A), 3 assortments of crisp wheat bread (4B, 5B, 6B), 2 assortments of instant wheat grits (8D,

Author's address for correspondence: prof. dr hab. inż. Zbigniew Rzedzicki, Engineering and Cereals Technology Department, University of Life Science in Lublin, ul. Skromna 8, 20-704 Lublin, Poland; tel.: (48 81) 46 23 314; e-mail: zbigniew.rzedzicki@ar.lublin.pl

9D) and 1 assortment of wheat germs (7C). As a comparative product, ordinary oat flakes were used (10E). Three packages of each of the products were purchased from three different shops. The commercial material obtained from each shop was used to prepare averaged samples. The samples were subjected to fragmentation in a laboratory buhr mill, using a 0.2 mm grinding slot.

Chemical analysis

In the tested samples, the water absorption index (WAI) was determined by means of the centrifuge method and the water solubility index (WSI) according to an AACC Method 56-20 as modified by Rzedzicki *et al.* [2004], water content by means of the oven dry method [AACC, Method 44-15A], total nitrogen content by means of the Kjeldahl method [AACC, Method 46-08], free fat content by means of the Soxhlet method [AACC, 30-26], and total ash content by means of AACC Method 08-01. Also the content of structural components was determined, using three different methods: crude fibre content was determined with the Weende method [AACC, Method 32-10], the Van Soest detergent method [Van Soest, 1963; Van Soest & Wine, 1967] was used to determine the content of detergent fibre fractions (neutral-detergent fibre – NDF, acid-detergent fibre – ADF, cellulose – CEL, hemicellulose – HCEL and acid-detergent lignin – ADL), and the enzymatic method was applied to determine the content of total dietary fibre (TDF), soluble dietary fibre (SDF) and insoluble dietary fibre (IDF) [AOAC, Method 991.43; AACC, Method 32-07; AACC, Method 32-21; AOAC, Method 985.29; AACC, Method 32-05]. In the fibre determinations with the enzymatic method, Megazyme enzymes and methodological procedures were employed. The correctness of determinations in the enzymatic method was verified using a Megazyme control test. Moreover, for every series of samples tested own control samples of casein and starch were introduced. All AACC and AOAC methods were applied according to Approved Methods of AACC [2000].

Statistical analysis

Chemical analyses were made in three replications, WSI and WAI determinations in five replicates. The obtained measurement data were used to calculate mean values, standard deviations, and coefficients of variation. If coefficient of variation was greater than the calculated error for particular method, analyses have been repeated. Statistical analyses were performed using Microsoft Excel procedures (Microsoft Office XP software).

RESULTS AND DISCUSSION

The studied assortments of wheat breakfast cereals displayed highly varied physical properties and chemical composition. Water solubility index (WSI) values fell within a very broad range from 5.3% d.m. for the instant grits (9D) to 54.7% d.m. for chocolate flavoured conches (3A) and 58.8% d.m. for wheat kernels in honey glaze (2A) (Figure 1). Such a high solubility of dry mass is characteristic of high-processed products, strongly degraded by drastic conditions of the technological process that resulted in decomposition of polymers present

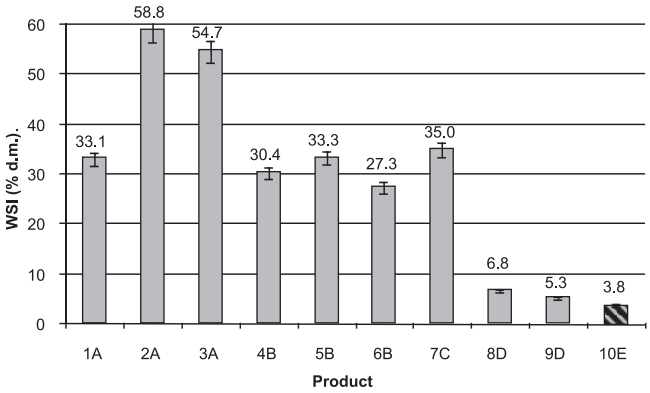

FIGURE 1. Water solubility index (WSI) in wheat breakfast cereals and standard conventional product (ordinary oat flakes) (% d.m.). The results were calculated as mean values of five replications ± SD.

in the raw material (mainly starch and dietary fibre) to water-soluble forms [Mezreb *et al*., 2003]. WSI values reaching up to 50% d.m. were also demonstrated for other assortments of breakfast cereals, such as cereal co-extrudates, roast wheat kernels, cinnamon or corn flakes [Rzedzicki, 2005; Rzedzicki & Wirkijowska, 2006]. In chocolate multi-cereal breakfast cereals WSI values reached up even 55% d.m. as well [Rzedzicki *et al.,* 2007]. It should be emphasized that such strongly degraded products are rapidly digested and absorbed, dangerously modifying the post-meal glycaemia [Guillon & Champ, 2000]. The seriousness of the situation is aggravated by the fact that products of this type are particularly attractive for children due to their colourful packaging and fanciful advertisements. The reality, however, is less fairy tale-like. The cereal products from the ads are frequently 60% sweets [Rzedzicki *et al.,* 2007], only not so sweet in taste. Not all examined breakfast cereals are characterised by such features; on the contrary – WSI of ordinary oat flakes (10E) was only 3.7%. In other investigations, properly produced oat products were characterised by dry mass solubility that was even ten-fold lower and did not exceed 4% d.m. [Rzedzicki, 2006].

Changes in dry matter solubility are always accompanied by a change in water absorption (WAI). Products with higher water absorption are usually characterised by lower dry matter solubility, and *vice versa* (Figure 2). The water binding capacity

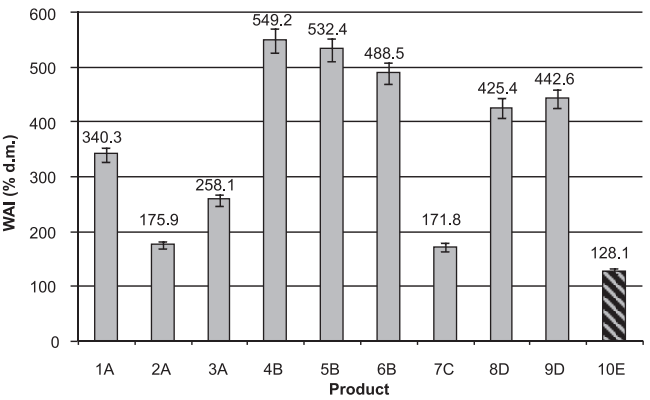

FIGURE 2. Water absorption index (WAI) in wheat breakfast cereals and standard conventional product (ordinary oat flakes) (% d.m.). The results were calculated as mean values of five replications ± SD.

in the studied assortments was recorded within the range from 171.7% d.m. for wheat germs (7C) to 549.2% d.m. for Graham crispy wheat bread (4B). High water absorption of a product is a very important ballast-forming factor and is especially favourable as it is formed by non-digestible fibre structures.

Moisture content of the products was determined immediately after opening the packaging. Diversified water content was observed – from 3.1% d.m. in wheat kernels in honey glaze (2A) to 10.3% d.m. in the instant grits (9D) (Table 1). A low moisture content in assortments 1A – 3A (average of 3.7% d.m.) indicates correctly performed packing operation and air-tightness of the packaging. A high moisture level was characteristic of both the assortment of instant grits and of wheat germs and indicated that these products were not toasted. Increased moisture of cereal products, conductive of lipids peroxidation, involves deterioration of quality and of the shelf life of products. Special attention should be paid to the moisture content of highly-processed and toasted products; in such products the water content should not exceed 2.5–3.0% [Rzedzicki & Kondzielska, 2006].

In the assortments under study notable differences were also observed in the content of ash – from 1.0% d.m. in the instant grits (8D) to 4.9% d.m. in the wheat germs (7C), (Table 1).

Some assortments of wheat breakfast cereals were characterised by a low content of proteins determined with the Kjeldahl method (Figure 3). The lowest values were recorded for the wheat kernels in honey glaze – 6.2% d.m. (2A). Such a low level of protein content cannot result from raw material composition; there are no wheat cultivars with protein content that low. Such values result from a high share of sugar in the recipe, which is indicated by high WSI values. The highest protein content, 36.5% d.m., was recorded for the wheat germs (7C), which was in accordance with expectations. The germs, a rich source of proteins and biologically-active substances,

TABLE 1. Moisture content, total ash and crude fiber content in wheat breakfast cereals and standard conventional product (ordinary oat flakes) (% d.m.).

Wheat breakfast cereals	Moisture content (%)	Total ash (% d.m.)	Crude fiber (% d.m.)
1A – whole grain wheat flakes	4.4±0.1	1.95±0.02	4.4±0.06
2A – wheat kernels in honey glaze	3.13±0.09	1.26±0.01	3.14±0.09
3A – chocolate flavored conches	3.57±0.01	2.1±0.01	3.57±0.09
4B – Graham crispy wheat bread	5.84±0.12	1.95±0.01	5.85±0.08
5B – crispy wheat bread	4.13±0.01	2.63±0.04	4.13±0.05
6B – whole grain crispy wheat bread	3.23±0.02	1.91±0.02	3.24±0.1
7C – wheat germ	9.32±0.01	4.94±0.03	9.32±0.18
8D – instant grits	9.2±0.03	1.01±0.01	0.31±0.04
9D – instant grits	10.3±0.03	1.1±0.02	0.4±0.05
10E – ordinary oat flakes	8.59±0.63	1.68±0.08	1.27±0.02

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

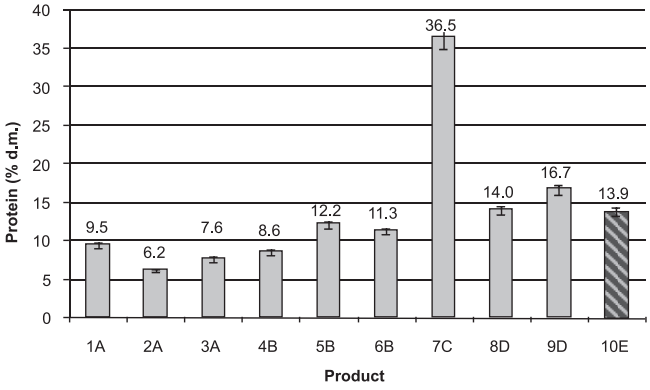

FIGURE 3. Protein content in wheat breakfast cereals and standard conventional product (ordinary oat flakes) (% d.m.). The results were calculated as mean values of three replications±SD.

should be used in particular for enriching food products. The assortments of wheat grits were characterised by a moderate protein content (average of 15.35% d.m.). Lower values were recorded for the assortments of crunchy wheat crispy products (average of 10.7% d.m.). Such low values of protein content in the crunchy bread are the result of incorrect selection of raw materials; two of these assortments were produced from whole grain meal. Values of protein in some wheat products are in contrast to that of oat flakes (10E), where protein content was 13.9%. It should be kept in mind that nitrogen determined with the Kjeldahl method does not determine the available protein as certain amounts of amino acids are included in the composition of Maillard reaction products. It is to be assumed, therefore, that the content of proteins in the tested products was lower than the determined value.

The wheat breakfast cereals were characterised by a low content of fat as determined with the Soxhlet method (Figure 4). The recorded values varied from 0.7% d.m. for the instant grits (8D) to 12.0% d.m. for the wheat germs (7C). Within the assortment of highly-processed wheat products (1A – 6B) the average content of fats was 2.1% d.m., which means that oil was not added into the tested assortments. Following thermoplastic treatment, highly-processed products absorb oil easily; hence they are frequently subjected to the oil-coating operation. Fat content recorded for chocolate-milk co-

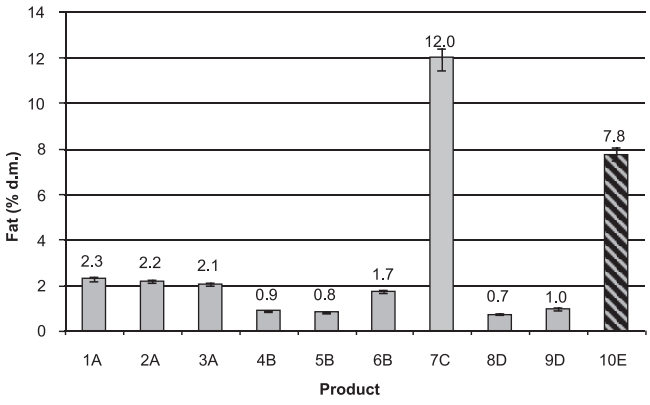

FIGURE 4. Fat content in wheat breakfast cereals and standard conventional product (ordinary oat flakes) (% d.m.). The results were calculated as mean values of three replications±SD.

extrudates and for cinnamon flakes exceeded even 18% d.m. [Rzedzicki, 2005]. Such products are real calorific bombs, especially for obese people and for growing children, hence their consumption should absolutely be reduced and they should be definitely removed from the base of the food pyramid. Among the assortments studied no such products were found.

The component that largely determines the quality of cereal products is dietary fibre. In the study reported herein comparative determinations were made of the content of structural components using three different analytical methods: the Weende method (crude fibre), the detergent method and the enzymatic method. The tested products were characterised by diverse content of dietary fibre. The lowest values were recorded with respect to crude fibre: from 0.3% d.m. in the instant grits (8D) to 9.3% d.m. in the wheat germs (7C) (Table 1). Notably higher values were recorded for the NDF detergent fibre (Table 2): from 2.9% d.m. for the instant grits (8D) to 14.7% d.m. for the wheat germs (7C). The assortments of instant grits were characterised by the lowest shares of detergent fibre particular fractions: mean content of hemicelluloses HCEL – 2.9% d.m., of cellulose CEL – 0.4% d.m., and of lignin ADL – 0.2% d.m. The assortments of crunchy breads had a high content of hemicelluloses – average of 7.7% d.m. The highest contents of hemicelluloses (10.1% d.m.), celullose (2.4% d.m.) and lignin (2.2% d.m.) were recorded in the wheat germs (7C).

The Weende method and the detergent method, being chemical methods, applied for the determination of ballast components in cereal products do not reflect the physiological conditions of dietary fibre digestion. For this reason, determinations were performed using the enzymatic method, recommended by successive World Congresses on Dietary Fibre [Asp, 2001, 2004]. Results obtained with this method indicated very extensive differences in the quantitative share of structural components as determined with the three methods. The content of total dietary fibre (TDF) was recorded within the range from 6.49% d.m. for wheat kernels in honey glaze (2A) to 34.5% d.m. for wheat germs (7C) (Figure 5). In all of the determined samples the content of soluble dietary fibre (SDF) appeared to be low: from 2.5% d.m. for instant grits (8D) to 6.31% d.m. for wheat germs (7C). Good breakfast cereals should primarily supply dietary fibre as well as a sufficient amount of prebiotics [Rzedzicki, 2005] that include, among others, (1-3)(1-4)-β-D-glucans with proven hypocholesterolaemic and hypoglycaemic effects [Cavallero *et al*., 2002; Martinez-Flores & Chang, 2004]. Therefore, the studied assortments are not a good source of prebiotic fractions. Moreover, worthy of notice is that most of those products were produced under drastic conditions of thermoplastic treatment. In products of this type, a notable part of soluble dietary fibre is not a native fraction but is constituted by water-soluble products of decomposition of insoluble dietary fibre devoid of prebiotic properties [Camire *et al.,* 1993; Martin-Cabrejas *et al.,* 1999]. The tested products contained also small amounts of insoluble dietary fibre that could improve intestinal peristalsis. The exception here was the Graham crispy wheat bread (4B) in which the content of the insoluble fibre fraction was 14.1%. In the examined oat flakes (10E) total dietary fibre was up to 19% and soluble dietary fibre up to 7% d.m. It should be kept in mind that most of oats SDF fraction are native (1-3)(1-4)-β-D-glucans – the best prebiotic in food.

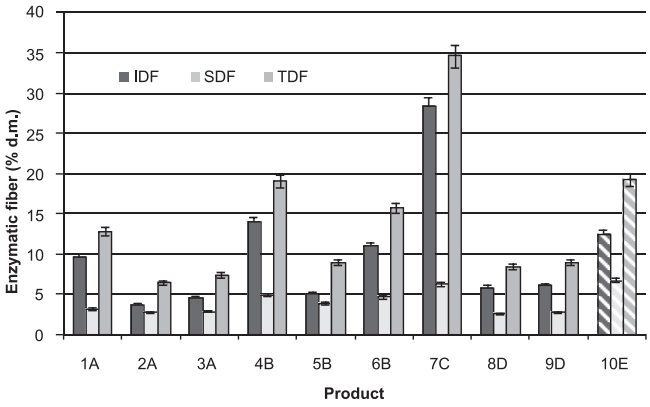

FIGURE 5. Content of total dietary fiber (TDF), insoluble dietary fiber (IDF) and soluble dietary fiber (SDF) in wheat breakfast cereals and standard conventional product (ordinary oat flakes) (% d.m.). The results were calculated as mean values of three replications±SD.

TABLE 2. Content of detergent fiber (NDF, ADF, HCEL, CEL, ADL) in wheat breakfast cereals and standard conventional product (ordinary oat flakes) (% d.m.).

Wheat breakfast cereals	NDF	ADF	HCEL	CEL	ADL
	(% d.m.)				
1A	8.45±0.73	2.24±0.05	6.21±0.69	1.53±0.01	0.72±0.05
2A	5.15±0.44	1.13±0.05	4.02±0.48	0.64±0.06	0.49±0.01
3A	5.92±0.14	2.29±0.03	3.63±0.11	1.79±0.01	0.5±0.03
4B	10.69±0.07	2.59±0.01	8.11±0.08	1.57±0.04	1.02±0.05
5B	7.59±0.18	0.77±0.1	6.82±0.08	0.49±0.03	0.27±0.07
6B	11.41±0.22	3.36±0.04	8.06±0.26	2.27±0.01	1.09±0.04
7C	14.74±0.06	4.65±0.33	10.09±0.28	2.42±0.06	2.23±0.27
8D	2.9±0.25	0.48±0.03	2.43±0.28	0.35±0.08	0.13±0.06
9D	4.11±0.16	0.74±0.15	3.37±0.01	0.49±0.02	0.25±0.13
10E	8.57±0.43	1.83±0.1	6.74±0.34	0.83±0.04	0.99±0.06

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

The methods applied in the study for the determination of dietary fibre structures, the detergent, enzymatic and Weende methods, indicate the necessity of unification of methodologies for the determination and balancing of that group of compounds. In the estimation of dietary fibre content, especially in the case of highly-processed products, the Weende method proves to be totally inapplicable. In turn, the detergent method is reliable in the estimation of insoluble fractions of TDF, especially cellulose and lignin. Considerable caution should be exercised with respect to all dietary fibre data originating from decades ago, when the Weende method was the sole method applied (since the nineteen sixties, also the detergent method was in use). At present, only the AACC and AOAC enzymatic methods are recommended for the estimation of total, insoluble and soluble dietary fibre content in highly-processed products.

CONCLUSIONS

1. In view of their very high water solubility index values, the tested products 1A – 6B should be classified in the top section of the food pyramid.
2. Highly-processed wheat assortments 1A – 6B were characterised by a low protein content.
3. Highly-processed wheat flakes and grains, crispy wheat bread and wheat grits displayed also a low content of dietary fibre (the exception were Graham crispy bread and wheat germs).
4. Low content of soluble dietary fibre (SDF) was observed in all determined samples.
5. Due to the low content of native soluble dietary fibre fraction (SDF), wheat breakfast cereals are not a suitable source of prebiotic fractions of dietary fibre.
6. Application of three methods for dietary fibre determination indicated an enormous scatter of results. For testing cereal products, especially those subjected to thermoplastic treatment, it is recommended to use the enzymatic method for the determination of dietary fibre; the other methods proved to be highly unreliable.

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