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A STUDY ON SELECTED ASSORTMENTS OF MULTI-CEREAL BREAKFAST CEREALS

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Key words: breakfast cereals, dietary fiber, protein, fat, water solubility index

The study concerned nine assortments of multi-cereal breakfast flakes. Tests were performed to determine the content of dry mass, crude ash, crude proteins, crude fat, and crude fibre. The fractional composition of dietary fibre was determined with the detergent method (NDF, ADF, HCEL, CEL, ADL) and with the enzymatic method (TDF, IDF, SDF). Also, determinations were made of the content of soluble components of dry mass (WSI) and of the water absorption index (WAI). The multi-cereal assortments of breakfast flakes under study were characterised by a low protein content (5.33–9.78% d.m.), low content of dietary fibre TDF (5.03–10.21% d.m.), increased moisture and high content of soluble components of dry mass reaching up to 60%.

Due to their poor chemical composition and high content of soluble components of dry mass, the tested assortments of breakfast cereals do not meet the requirements for cereal products of the base of the nutrition pyramid. Such products should definitely be classified among those of the top section of the pyramid.

INTRODUCTION

In developed countries, civilisation diseases (cardiovascular system diseases, neoplastic diseases, diabetes, obesity, overweight) reached pandemic scale. Many renown epidemiologists include among the primary causes of those civilisation diseases such factors as cigarette smoking, ill-balanced diet, and deficiency of physical exercise [Miller Jones, 2001]. Research shows that the introduction of dietary fibre in the human diet improves the metabolism of lipids and sugars, preventing the development of hypercholesterolaemia and diabetes [Berg *et al.*, 2003; Karmally *et al.*, 2005; Villegas *et al.*, 2004; Weickert *et al.*, 2006]. Low energy value of whole-grain products permits also the maintenance of correct body mass index (BMI) and thus prevents epidemic occurrence of overweight and obesity [Albertson *et al.*, 2003; Barton *et al.*, 2005]. Proper balancing of diet has recently assumed particular significance also in child nutrition. Children have unlimited access to highly processed food products of high energy value, and thus are strongly exposed to the hazard of development of metabolic diseases (*e.g.* of insulin-independent diabetes).

Breakfast cereals should constitute one of the most important groups of products from the base of the nutrition pyramid. The pyramid, developed by the Harvard School of Public Health, makes a significant division of cereal products into low-processed whole-grain products (*e.g.* whole-meal bakery products, whole-meal flours) which constitute the base of the pyramid, and highly processed products (*e.g.* white bakery products, white rice, white pasta products) which have been moved to the top of the pyramid with recommendation of sporadic consumption. In spite of such recommendations, the food market is still dominated by highly processed food products. In the milling and grinding technologies cereal grain loses considerable amounts of fractions rich in proteins and dietary fibre. The most popular raw material used in the production of most of the extruded cereal breakfast products is corn grits. This raw material, obtained from "de-germed" and hulled corn grain, is poor in proteins and extremely poor in dietary fibre. Numerous authors pointed out the unfavourable changes, in terms of both quality and quantity, to which particular dietary fibre fractions are subject in the successive stages of processing of milling products [Rzedzicki, 2005]. Currently promoted by the industry multi-cereal products are advertised as healthy and positively affecting our physical well-being and general feeling.

The objective of this study was to test the most popular on the Polish market multi-cereal breakfast flakes, determining their chemical composition and basic physical properties (content of soluble components of dry mass and water absorption).

MATERIAL AND METHODS

The initial material for the study comprised nine selected assortments of breakfast cereals available in the Lublin retail network: five assortments of chocolate cereals (A1–A5), two honey cereals (B6–B7), and one assortment of caramel (B8) and cinnamon (B9) cereals. Three packs of each assortment were purchased in three different shops, and their contents were used to prepare an averaged sample. The material was fragmented using a laboratory buhr mill, applying a grinding gap of 0.2 mm.

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Chemical analysis. In the prepared samples, water content was determined with the dryer method [AACC, Method 44-15A], total nitrogen content with the Kjeldahl method [AACC, Method 46-08], crude fat content with the Soxhlet method [AACC, 30-26], crude fibre content with the Wendee method [AACC, Method 32-10], and the content of crude ash [AACC, Method 08-01]. The fractional composition of dietary fibre was determined with the Van Soest detergent method (neutral-detergent fibre - NDF, acid-detergent fibre - ADF, cellulose - CEL, hemicellulose - HCEL and acid-detergent lignin - ADL) and with the enzymatic method [AOAC, Method 991.43; AACC, Method 32-07; AACC, Method 32-21; AOAC, Method 985.29; AACC, Method 32-05] using Megazyme enzymes and methodological procedures. The determinations included the total dietary fibre - TDF, insoluble dietary fibre - IDF and soluble dietary fibre - SDF. In the samples studied also the water absorption (WAI) was determined, with the centrifuge method, and the content of soluble components of dry mass (WSI), according to the AACC Method 56-20 as modified by Rzedzicki *et al.* [2004].

Statistical analysis. The chemical analyses were made in three replications, and determinations of WSI and WAI in five. The measurement results were used to calculate the 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 analyses were repeated until the correct scatter of results was obtained.

Statistical analysis were performed using Microsoft Excel procedures (Microsoft Office XP software).

RESULTS AND DISCUSSION

The multi-cereal products under study were characterised by considerable variation of physical properties and chemical composition. The water absorption index (WAI) of the products varied within a very broad range, from 253% for A1 chocolate flakes to 452% for B6 flakes in honey coating. Such an extensive variation in WAI is the result of variation in the raw material composition; *e.g.* wheat starch does not lose its gel-forming capacity to the same degree as corn starch [Mezreb *et al.*, 2006]. Changes in water absorption were always accompanied by changes in the WSI value. Products with high water absorption were characterised by a lower value of WSI. The WSI values fell within the range from 29.7% for the A5 chocolate flakes up to 57.2% for the A1 chocolate flakes (Figure 1). Out of the nine assortments under study as many as six had WSI values above 41% d.m. The maximum level of dry mass soluble fractions content reached even up to 60% (A1 chocolate flakes). Such a high share of soluble fractions of dry mass is dependent not only by an addition of saccharose, but also on destruction of high-molecular polymers of starch in the course of intensive thermoplastic treatment and on increase in the content of low-molecular water-soluble compounds [Mezreb *et al.*, 2003]. Corn starch is more sensitive to molecular degradation as compared to wheat starch [Mezreb *et al.*, 2006], which may explain the higher values of WSI obtained for products containing corn. Such high values of WSI indicate also poor selection of parameters of the extrusion process, and of the moisture level of the extruded mass in particular. Strongly degraded polymers in cereal products of this type will be subject to very rapid digestion and very fast absorption, with consequent high increase of glucose concentration in the blood.

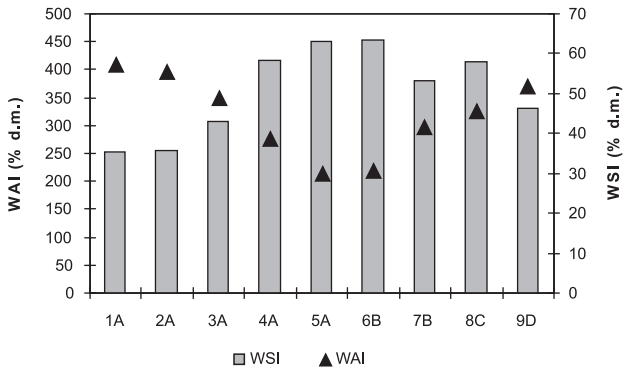

FIGURE 1. Water solubility index (WSI) and water absorption index (WAI) in multi-cereal breakfast cereals.

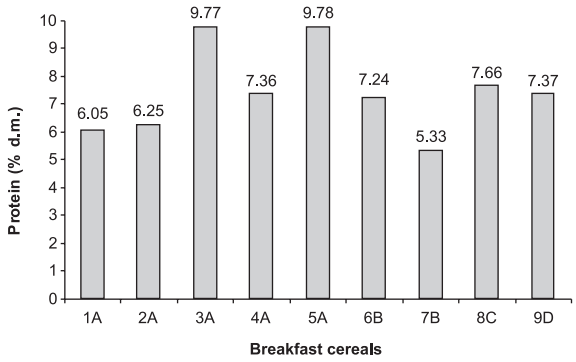

FIGURE 2. Content of protein in multi-cereal breakfast cereals (% d.m.).

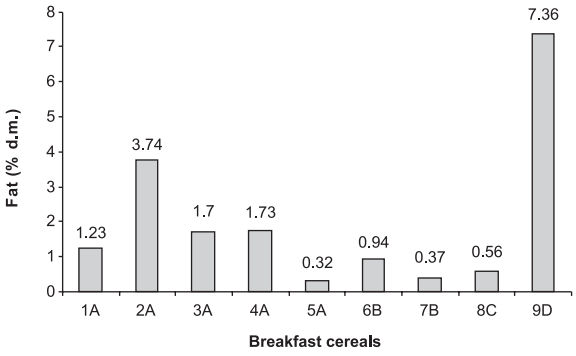

FIGURE 3. Content of crude fat in multi-cereal breakfast cereals (% d.m.).

The multi-cereal flakes under study demonstrated a very low content of proteins (Figure 2). The values recorded fell within the range from 5.33% d.m. for the B7 honey-coated flakes to 9.77% d.m. for the A3 chocolate flakes. Only in two

TABLE 1. Moisture content, crude ash and crude fiber content in multi cereal breakfast cereals (% d.m.).

Breakfast cereals	Moisture content (%)	Crude ash (% d.m.)	Crude fiber (% d.m.)
1A	3.79	2.14	0.17
2A	5.4	1.41	0.08
3A	4.98	1.79	0.08
4A	6.04	1.41	0.38
5A	6.54	1.14	0.18
6B	6.09	0.89	0.12
7B	5.00	0.85	0.17
8C	5.39	1.02	0.10
9D	3.06	1.34	0.21

The results were calculated as mean values of three replications

products the content of proteins was near the level of 10% d.m.: in the A5 chocolate flakes – 9.78% and in the A3 chocolate flakes – 9.77%. Such a low protein content results from the application of low-protein materials in the production technology (*e.g.* corn grits) and from the high share of sugar in the recipe, which corresponds to the very high WSI values observed. Similar levels of protein content were also obtained by Rzedzicki & Wirkijowska [2006] in their study on breakfast corn cereals. It should also be kept in mind that nitrogen content determined with the Kjeldahl method is only a measure of total protein content. The content of digestible protein is surely lower, as in the course of production the tested products are subjected to highly intensive thermal or thermoplastic treatment during which there appear the products of Maillard reaction, increasing the fractions of ADL lignins. Particularly high losses in products of this type are observed in the case of lysine amino acid [Delgado-Andrade *et al.*, 2007]. The content of proteins in this group of products is drastically low compared to other assortments of breakfast cereals. In oats breakfast products the content of proteins exceeded even 15% d.m. [Rzedzicki, 2006].

Fat content in the products under examination was highly varied. In seven out of nine products the mean fat content did not exceed 1% d.m. (Figure 3). The lowest levels of fat content were observed in the honey and caramel flakes. Apolar hexane was used for the determination of fat content, hence the values obtained relate to free fats. It may be assumed that the total fats content in the studied products is notably higher than the determined value, as considerable binding of fats is observed in products subjected to thermal and thermoplastic treatment. A very high content of determined fat was obtained for the cinnamon flakes D9 (7.36% d.m.). The high fat content in the cinnamon flakes A9 may result from their "enhancement" through intensive oiling after the process of extrusion. In the technology of production of breakfast cereal products it is an accepted practice to apply product oiling through glazing after the completion of thermoplastic treatment. This results in considerable increase in fat content and in the energy value of the products. High fats content is observed also in many other cereal products, *e.g.* in oats products (even up to 10% d.m.); which however results from the high level of that component in the initial raw material [Rzedzicki, 2006].

In most of the samples tested an increased level of moisture was observed; it fell within the range from 3.06% for the D9 cinnamon flakes to 6.54% for the A5 chocolate flakes (Table 1). Such products, after properly conducted technological process, should be characterised by moisture content of approx. 2-3%. The increased moisture content in the tested breakfast cereals indicates incorrect packing conditions or improperly performed operation of toasting.

Also varied is the content of crude ash, varying within the range from 0.85% d.m. for the B6 flakes with honey glazing to 2.14% d.m. for the A1 chocolate flakes (Table 1). Ash content is certainly dependent on the initial raw material and on the content of seed cover.

Dietary fibre is the primary determining factor for the quality of products constituting the base of the nutrition pyramid. Therefore, a comparative study of the content of structural elements was performed using three different analytical methods: the Wendee method, the detergent method, and the enzymatic method. Irrespective of the method applied, the studied products were characterised by very low fibre content.

Especially low levels of structural elements were observed in the case of crude fibre: from 0.08% in the A2 and A3 chocolate flakes to 0.38% in chocolate flakes (Table 2). In numerous published studies the Wendee method gave the lowest results of determined fibre content in cereal products [Rzedzicki & Zarzycki, 2005; Rzedzicki, 2006; Rzedzicki & Kondzielska, 2006; Rzedzicki & Wirkijowska, 2006] and was accepted as unsuitable for the determination of structural elements in products subjected to thermoplastic treatment.

The values of NDF fell within the range from 1.19% for the A2 chocolate flakes to 2.83% for the A4 chocolate flakes (Table 2). Also a high content of hemicellulose fraction was noted here, which is strongly characteristic of highly-processed products. Determined in that fraction, among other things, are formed low-molecular compounds as products of degradation of polymers. In the case of each of the tested products the hemicellulose fraction was higher than that of ADF, and fell within the range from 0.75% for the A2 chocolate flakes to 1.78% for the A4 chocolate flakes. In the multi-cereal breakfast products under study also a significant content of lignin was observed. That fraction was surely magnified by products of the Maillard reaction formed in the course of intensive thermal or thermoplastic treatment.

The above methods for structural component determination do not reflect the physiological definition of dietary fibre as formulated and updated in 2001 by the Dietary Fiber Definition Committee. The definition defined dietary fibre as edible parts of plants or analogues of carbohydrates resistant to digestion and absorption in human small intestine, with full or partial fermentation in the large intestine of a healthy human being [AACC Report, 2001]. The Committee indicated also enzymatic methods for the determination of dietary fibre (AAOC and AACC) as correct and conforming to its definition. Using those methods, the content of total dietary fibre in the tested products was determined within the range from 5.03% d.m. for the C8 caramel flakes to 10.21% for the A4

TABLE 2. Content of detergent fiber fraction (NDF, ADF, HCEL, CEL, ADL) in multi-cereal breakfast cereals (% d.m.).

Breakfast cereals	NDF	ADF	HCEL	CEL	ADL
	(% d.m.)				
1A	2.23	0.54	1.69	0.12	0.42
2A	1.19	0.44	0.75	0.27	0.17
3A	1.44	0.49	0.95	0.28	0.21
4A	2.83	1.05	1.78	0.62	0.43
5A	1.79	0.77	1.02	0.44	0.33
6B	1.76	0.34	1.42	0.26	0.08
7B	1.57	0.34	1.23	0.1	0.24
8C	1.25	0.27	0.98	0.03	0.23
9D	1.62	0.49	1.13	0.35	0.21

The results were calculated as mean values of three replications.

chocolate flakes (Figure 4). All the examined breakfast cereals were characterised by low content of soluble dietary fibre, at 32% of total dietary fibre o average. Similar values apply also to many other cereal breakfast products available on the market [Rzedzicki, 2005]. Comparing the obtained results with the content of dietary fibre and its soluble fraction in oats products [Rzedzicki, 2006] one should conclude that multi-cereal flakes are not a good source of dietary fibre in the diet. In several samples a considerable content of soluble dietary fibre in the total dietary fibre was observed. One can suppose that those products have a favourable fractional composition of dietary fibre, with a high share of prebiotic soluble fraction. However, that is a misleading interpretation. In the course of thermoplastic treatment of highly-processed cereal products there occur high shear stresses, leading to the degradation of a part of insoluble dietary fibre to short-molecule compounds. They do not dissolve in water, but form a suspension. During the determination of dietary fibre, they are included in the soluble fraction [Camire *et al.*, 1993; Martin-Cabrejas *et al.*, 1999]. It should be emphasized, however, that in spite of the determination of those compounds in the soluble fraction they do not possess probiotic properties, characteristic of native soluble dietary fibre.

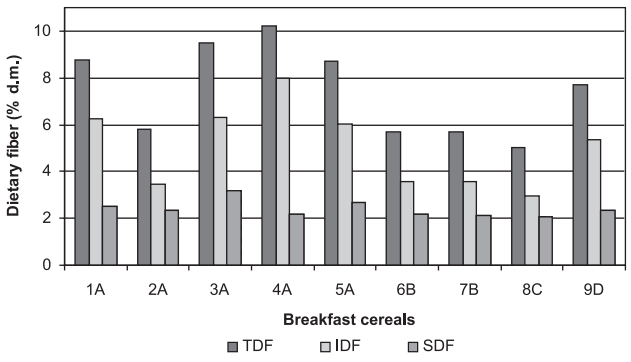

FIGURE 4. Content of total dietary fiber, insoluble dietary fiber and soluble dietary fiber in multi-cereal flakes (% d.m.).

The obtained results, determined with the detergent method (NDF) are several times lower than those obtained with the enzymatic method (TDF). It should be emphasized that in the detergent method the soluble dietary fibre totally "disappears". In the case of products with high content of soluble fractions that method is totally inapplicable. It has one advantage, though – it is inexpensive. It can be recommended, however, only as an approximate method for comparative purposes, and only for use with samples of a slight content of soluble dietary fibre.

In relation to highly-processed products subjected to thermal or thermoplastic treatment credible results of determination of the content of dietary fibre are obtained only through the application of the enzymatic AACC and AOAC methods.

CONCLUSIONS

1. The tested assortments of multi-cereal breakfast products do not meet the requirements for the base of the nutrition pyramid.

2. Due to high values of WSI (exceeding even 60%) and considerable amounts of fat (even above 7% d.m.), some of the tested multi-cereal breakfast cereals should be classified in the top part of the nutrition pyramid.

3. Very high levels of insoluble fractions of dry mass indicate incorrect thermoplastic treatment.

4. The tested assortments of multi-cereal breakfast cereals were characterised by a low content of proteins (average of 7.42% d.m.) and very low content of dietary fibre.

5. For the determination of the content of dietary fibre and of its fractional composition the enzymatic AACC and AOAC methods are recommended.

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BADANIA WYBRANYCH ASORTYMENTÓW PŁATKÓW WIELOZBOŻOWYCH

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Badania przeprowadzono w celu dokonania oceny składu chemicznego oraz właściwości fizycznych dostępnych na krajowym rynku wielozbożowych płatków śniadaniowych. Zbadano dziewięć asortymentów wielozbożowych płatków śniadaniowych, oznaczając w nich zawartość suchej masy, popiołu surowego, białka surowego, tłuszczu surowego oraz włókna surowego. Skład frakcyjny błonnika pokarmowego oznaczano metodą detergentową (NDF, ADF, HCEL, CEL, ADL) oraz enzymatyczną (TDF, IDF, SDF). Przeprowadzono także badania zawartości rozpuszczalnych składników suchej masy (WSI) oraz wodochłonności (WAI). Badane wielozbożowe asortymenty zbóż śniadaniowych charakteryzowała niska zawartość białka (rys. 2), niska zawartość błonnika pokarmowego TDF (rys. 4), podwyższona wilgotność (tab. 1) oraz wysoka zawartość rozpuszczalnych składników suchej masy sięgająca nawet 60% (rys. 1). Ponadto stwierdzono duże różnice w zawartości tłuszczu (rys. 3), sięgającego nawet powyżej 7% s.m. Ze względu na ubogi skład chemiczny i wysoką zawartość rozpuszczalnych składników suchej masy, badane asortymenty zbóż śniadaniowych nie mogą być traktowane jako produkty zbożowe podstawy piramidy żywienia. Takie produkty powinny być zdecydowanie kwalifikowane do szczytowej części piramidy z zaleceniem spożywania sporadycznego.