COMPOSITION OF DIETARY FIBRE IN SELECTED CEREALS – HEALTH BENEFITS AND ANALYTICAL METHODS (A REVIEW)

ZLOŽENIE POTRAVINOVEJ VLÁKNINY VO VYBRANÝCH OBILNINÁCH – ZDRAVOTNÝ VÝZNAM A ANALYTICKÉ METÓDY (PREHĽAD)

MICHAELA HAVRLENTOVÁ, JÁN KRAIC

Slovak Agricultural Research Centre, Nitra
Slovenské centrum poľnohospodárskeho výskumu, Nitra

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Starch, water soluble or insoluble components of dietary fibre and several free sugars are the main carbohydrate components in cereals. Barley and oat are known as good sources of dietary fibre and mainly of its soluble part, beta-glucan. Beta-glucan is considered to be an important natural immunomodulator. The possible use of cereals is in the preparation of functional foods.

Dietary fibre has a long history. American Association of Cereal Chemists accepted in the year 2001 the term dietary fibre and the definition too. Dietary fibre consists of the edible part of plants or their extracts, or analogous carbohydrates that are resistant to digestion and absorption in the small intestine, usually with complete or partial fermentation in the large intestine. Dietary fibre promotes one or more of these beneficial effects: laxation, reduction in blood cholesterol, and modulation of blood glucose.

There are two groups of dietary fibre, soluble and insoluble. Soluble dietary fibre includes beta-glucan, pectin, inulin, arabinoxylans, and gums. It has a moderating effect on postprandial blood glucose and insulin response. Soluble fibre from cereals lowers the blood cholesterol level too. Insoluble dietary fibre (cellulose, hemicellulose and lignin) has been found to be beneficial in prevention of biventricular disease and colon cancer. Characteristics of dietary fibre such as solubility in water, viscosity and ferment ability have been explored as possible bases for their physiological effects. For dietary fibre detection three main methods are used:

1. non-enzymatic-gravimetric methods, which are used for the purpose of characterisation of animal feed
2. enzymatic-gravimetric methods, which use heat-stable alpha-amylase, protease and amylo-glucosidase for detection
3. enzymatic-chemical methods (enzymatic-calorimetric and enzymatic-GLC-HPLC).

Key words: dietary fibre, beta-glucan, cereal, barley, oat, method

The principal carbohydrate constituents of cereal grains are starch, water soluble or insoluble components of dietary fibre, and several free sugars, such as glucose, glycerol, stachyose, xylose, fructose, maltose, sucrose and arabinose. The content of these components depends on the variety, processing and the amount of water addition. Possible applications of cereals in functional food formulations could be [10]:

a) using as fermentable substrates for the growth of probiotic microorganisms, especially lactobacilli and bifidobacteria
b) promoting several beneficial physiological effects via dietary fibre
c) using as probiotics due to their content of specific non-digestible carbohydrates
d) using as encapsulation material for probiotics in order to enhance their stability.

Mgr. Michaela Havrlentová, Doc. RNDr. Ján Kraic, PhD., SARC – Research Institute for Plant Production, Department of agricultural biotechnology, 921 68 Piešťany, Bratislavská 122. E-mail:havrlentova@vurv.sk

Dietary fibre promotes beneficial physiological effects including laxation, blood cholesterol, and blood glucose attenuation.

Definition and physical properties of dietary fibre

According to definition of dietary fibre proposed by the American Association of Cereal Chemists [1] „dietary fibre is the edible parts or analogous carbohydrates that are resistant to digestion and absorption in the small intestine with complete or partial fermentation in the large intestine. Dietary fibre includes polysaccharides, oligosaccharides, lignin and associated plant substances (tab. 1). Dietary fibre promotes beneficial physiological effects including laxation, and/or blood cholesterol attenuation, and/or blood glucose attenuation."

T a b l e 1

Dietary fibre constituents
Rozdelenie potravinovej vlákniny

Fibre constituents (1)	Principal groupings (2)		Fibre sources (3)
non-starch polysaccharides and oligosaccharides (4)	cellulose (5)		plants cellulose (vegetables, sugar beet, brans) (6)
	hemicellulose (7)		arabinogalactans, arabinoxylans, xyloglucans, galactomannans, beta-glucan, glucuronoxylans, pectic substances (8)
	polyfructoses (9)		inulin, oligofructans (10)
	gums and mucilage's (11)		seed extracts (galactomannans-guar and locust bean gum), tree exudates (gum acacia, karaya, tragacanth), algal polysacharides (alginates, agar), psyllium (12)
	pectin (13)		fruits, vegetables, legumes, potato, sugar beet (14)
carbohydrate analogues (15)	resistant starch and maltodextrins (16)		plants such as maize, pea, potato (17)
	synthesis (18)	chem.	polydextrose, lactulose, cellulose derivates (19)
		enzym.	neosugar or short chain fructooligosaccharides, curdlan, transgalactooligosaccharides, levan, xanthan gum, oligo-fructose, guar hydrolysate, xylooligosaccharides (20)
lignin (21)	lignin (21)		woody plants (22)
substances associated with non-starch polysaccharides (23)	waxes, cutin, tanins, suberin, saponins (24)		plant fibres (25)

chem. – chemical – chemická
enzym. – enzymatic – enzymatická

(1) Zložky vlákniny, (2) základné zoskupenia, (3) zdroje vlákniny, (4) neškrobové polysacharidy a oligosacharidy, (5) celulóza, (6) rastlinná celulóza (zelenina, cukrová repa, otruby), (7) hemicelulóza, (8) arabinogalaktany, arabinoxylany, xyloglukány, galaktonanány, beta-glukán, glukuronoxylány, pektínové zložky, (9) polyfruktózany, (10) inulín, oligofruktózany, (11) gumy a slizy (hydrokoloidy), (12) extrakty semien (galaktomanány a gumy z plodov svätojánskeho chleba), výťažky zo stromov (živice z akácie, karaya a tragacanth), polysacharidy z rias (algináty, agar), psyllium, (13) pektín, (14) ovocie, zelenina, strukoviny, zemiaky, cukrová repa, (15) analógy polysacharidov, (16) rezistentný škrob a maltodextríny, (17) rastliny a kukurica, hrach, zemiaky, (18) syntéza, (19) polydextróza, laktulóza, deriváty celulózy, (20) novovytvorený cukor alebo fruktooligosacharidy s krátkym reťazcom, curdlan, transgalaktooligosacharidy, levan, xantánová živica, oligofruktóza, hydrolyzáty guarovej gumy, xylooligosacharidy, (21) lignín, (22) drevnaté rastliny, (23) zložky spájané s neškrobovými polysacharidmi, (24) vosky, kutíny, taníny, suberín, saponíny, (25) rastlinné pletivá

The Food and Nutrition Board, Institute of Medicine of the National Academy of Sciences of the United States of America defines dietary fibre as the combination of dietary and functional fibre [49].

According to definition of *Codex alimentarius* commission [12] dietary fibre consists:

- either of edible, naturally occurring in the food as consumed, non-digestible plant composed of carbohydrate polymers with a degree of polymerisation (DP) not lower than 3
- or of carbohydrate polymers (DP≥3), which have been obtained from food raw material by physical, enzymatic or chemical means
- or of synthetic carbohydrate polymers (DP≥ 3).

Dietary fibre is neither digested nor absorbed in the small intestine and has at least one of the following properties:

- increases stools production
- stimulates colonic fermentation
- reduces blood total and/or LDL-cholesterol levels
- reduces post-prandial blood glucose and/or insulin levels.

The recommended daily intake of total dietary fibre for 50-year and younger adults was set at 38 gram for men and 25 gram for women [49]. Foods with dietary fibre include cereal bran, vegetables, fruits and legumes.

Dietary fibres differ in their water solubility. There is generally no sharp distinction between soluble and insoluble fractions and the ratio is highly dependent on the extraction conditions of soluble fibre [57]. Cellulose consists only of (1→4)-beta-D-linkages and is therefore stiff, highly crystalline and non-soluble [21]. Other insoluble parts included in dietary fibre are lignin, resistant starch, unhydrolysed proteins, tannins and cutins [1]. Soluble fibres (such as pectin, gums and beta-glucan) develop significant viscosity *in vitro* and increase the viscosity in the stomach and small intestinal contents. High-molecular weight of beta-glucan (up to 3.0 million Da) makes it viscous due to labile cooperative associations. Low-molecular fragments of beta-glucan (as low as 9000 Da) can form soft gels as the chains are easier to rearrange to increase the linkages. When exposed to physical forces and chemical or enzymatic hydrolysis in typical food preparation, molecular size of beta-glucan reduces to 0.4 – 2.0 million Da [10]. The physical structure of food may be more essential than the chemical composition in determining nutritional responses.

Ion exchange, hydration properties, and organic compounds (such as absorptive properties and viscosity) are the main physiochemical qualities of plant cell walls and play an important role in digestive flow, nutrient availability, viscosity and mixing.

D r ž í k o v á et al. [17] documented the influence of oat-based extrudates on the viscosity within the gut. Because of their content of macromolecular dietary fibre (such as beta-glucan) they have several beneficial nutritional and protective effects *in vitro*. The viscosity of different soluble fibres is important in relation to carbohydrate and lipid metabolism [28, 57]. A positive correlation (r = 0.99) was also observed between the viscosity of barley breads and the glycaemic index [41]. On the other hand, the viscous nature of barley beta-glucan may cause problems in the brewing process [24].

Two important properties of dietary fibre are the water holding capacity and the water binding capacity. The first of them is the amount of water that a unit weight (grams water/organic matter) that dry dietary fibre absorbs [43]. The second of them is the water content measured after an external force e.g. centrifugation, whereas water-holding capacity is measured without stress. Fibre with a high water holding capacity (that is partially fermented fibre) can directly influence the volume and bulk of the intestinal content. Connected with the solubility of a fibre is ferment ability. Almost all of the fibre sources are fermented to some degree by the resident micro organisms presented in the colon [55].

The ferment ability was found to be low for oat husk and cellulose, intermediate for neosugar, wheat bran, oat bran and pea fibre and the highest for linseed fibre, guar gum, low methyl-pectin, rafinose and beta-glucan [43].

Dietary fibre increases the nutritional value of bread but at the same time it usually alters rheological properties of dough and the quality and sensorial properties of bread [24]. In sensory studies, bread, pasta and muffins containing 1.9 – 8.6 % from enriched barley flours had acceptable sensory properties [59]. Functional pastas, enriched with beta-glucan and dietary fibre, were produced by substituting 50 % of standard durum wheat semolina with beta-glucan-enriched barley flour fractions. These pastas had good cooking qualities with regard to stickiness, bulkiness firmness and total organic matter released in rinsing water [33]. Dietary fibre, in general, shows good effects on dough properties yielding, higher water absorption, mixing tolerance and tenacity, and smaller extensibility in comparison to the control bread without fibre addition [24].

Today there are two reasons to add fibre to baked products: to increase the dietary fibre intake and to decrease the caloric density of foods [51, 7].

The beneficial effects of dietary fibre on the quality of life and the inevitable need of health are the reason for the food industry to develop new food products with special health-promoting characteristics. Meeting this challenge involves the identification of new sources of nutraceuticals and other nutritional and natural materials with the desirable functional characteristics. Barley and oats are examples of such sources and could be good bases for functional food products [38, 28]. The main non-starch polysaccharides of oat and barley dietary fibre are the mixed-linkage (1→3), (1→4)-beta-D-glucan, referred to as beta-glucan, arabinoxylans and cellulose [3, 26, 15]. In addition to other polysaccharides, glycoproteins and lignin they are important components of the endosperm cell wall.

Interest in barley and oat bran production has increased since the acceptance of barley and oat bran as a food than can lower the risk of heart disease due to physiological effects of beta-glucan on the mammalian digestive system, which lowers serum cholesterol [19, 20]. In the next two chapters we will describe the structure of dietary fibre of barley and oat.

Barley

Barley (*Hordeum vulgare* L.) is our significant feeding cereal. Barley grains are an important source of energy and proteins for poultry, piggery or horses. Recently there has been registered a renaissance of barley use in human nutrition all over the world.

Among cereals, barley is the main cereal grain for the development of functional foods, as it contains two classes of compounds of strong nutritional interest: tocols (vitamin E) and beta-glucan [23]. The barley grain contains 15–20 % of dietetically beneficial fibre, of which 86 % falls on non-starch polysaccharides. Approximately 23 % of these are arabinoxylans and 56 % are beta-glucans [44]. The two primary uses of beta-glucan are to enhance the immune system and to lower blood cholesterol levels. Numerous experimental studies in test tubes and animals have shown beta-glucan to activate white blood cells [13, 14, 18].

The beta-glucan content is significantly influenced by the environment. There is a number of reports documenting significant differences in barley beta-glucan amount between locations [60, 29], influence of climatic conditions during the test year [4] and effect of nitrogen and irrigation treatments on the level of beta-glucan [25]. Genotype also influences beta-glucan content [45, 42]. High beta-glucan content is reported in hull-less cultivars [8] and in cultivars having 100 % amylopectin (waxy) starch [56, 58, 52].

Oat

Oat (*Avena sativa* L.) can improve human nutrition by providing good biological value proteins and dietary fibre (soluble and insoluble), without disregarding the contribution of other important compounds, such as unsaturated lipids. Oat bran is enriched in proteins and beta-glucan and contains less starch than whole groats flour [35]. The neutral sugar content of insoluble dietary fibre was composed of glucose, arabinose, xylose and galactose. The neutral sugar content of insoluble dietary fibre was composed of glucose, arabinose and xylose.

The amount of dietary fibre can be affected by both genetic and environmental factors. Large range of genetic variation was observed for protein, beta-glucan and dietary fibre evaluated on seeds regenerated in the same year at the some location [29, 46]. Soluble and insoluble dietary fibre differed with genotype and with growing year.

Significant differences for the total dietary fibre and beta-glucan content in oat were found between two growth conditions – in biological (no chemical input, marked bio) and conventional system (normal control of weed, marked conv) [48]. The conventional system lightly seemed to favour the accumulation of total dietary

T a b l e 2

Main methods of dietary fibre analysis
Hlavné metódy analýzy potravinovej vlákniny

Name of the method (1)	Type of the analysis (2)	Measures (3)	References (4)
crude fibre or Weende method (5)	grav.	cellulose and lignin (6)	AOAC, 1980
Van Soest method (7)	grav.	cellulose, acid insoluble hemicellulose and lignin (8)	Van Soest and Wine, 1967
total dietary fibre (9) AOAC 985.29	enzym.-grav.	soluble and insoluble polysaccharides and lignin (10)	Prosky et al., 1985
Englyst method (11)	enzym.-chem., GLC or HPLC (12)	non-starch polysaccharides	Englyst and Hudson, 1987
Uppsala method (13)	enzym.-chem.	neutral and uronic residues and Klason lignin (14)	Theander et al., 1994
AOAC 995.16 AACC 32-23	enzym.	beta-glucans (15)	McCleary and Codd, 1991
resistant starch (16)	enzym.	resistant starch (16)	Englyst et al, 1992
AOAC 2002-02 AACC 37.42	enzym.	resistant starch (16)	McCleary and Monaghan, 2002
AOAC 997.08	enzymatic and ion-exchange chromatography (17)	oligofructan, inulin, fructo-oligosaccharides (18)	Hoebregs, 1997
	ion-exchange chromatography (19)	oligofructan, inulin, fructo-oligosaccharides (18)	Ouarne et al., 1999
AOAC 2000.11	HPLC	polydextrose (20)	Craig et al., 2001

AACC – American Association of Cereal Chemics – Americká asociácia cereálnych chemikov
AOAC – Association of Official Analytical Chemists – Asociácia oficiálnych analytických chemikov
GLC – gas liquid chromatography – plynová chromatografia
HPLC – high performance liquid chromatography – vysokoúčinná kvapalinová chromatografia
grav. – gravimetric – gravimetrická
enzym.-grav. – enzymatic-gravimetric – enzymaticko-gravimetrická
enzym.-chem. – enzymatic-chemical – enzymaticko-chemická
enzym. – enzymatic – enzymatická

(1) Názov metódy, (2) typ analýzy, (3) základné skupiny meranej zložky, (4) doporučenia, (5) hrubá vláknina alebo Weendyho metóda (podľa autora), (6) celulóza a lignín, (7) Van Soestova metóda, (8) celulóza, v kyslom prostredí nerozpustná hemicelulóza a lignín, (9) celková potravinová vláknina, (10) rozpustné a nerozpustné polysacharidy a lignín, (11) Englystova metóda, (12) neškrobové polysacharidy, (13) Uppsala metóda (podľa názvu pracoviska), (14) neutrálne a urónové zvyšky a Klasonov lignín, (15) beta-glukány, (16) rezistentný škrob, (17) enzymatická alebo iónovo-výmenná chromatografia, (18) oligofruktán, inulín, fruktooligosacharidy, (19) iónovo-výmenná chromatografia, (20) polydextróza

fibre and beta-glucan in comparison with the biological one. The mean values for bio and conv systems were 23.2 and 24.8 % for total dietary fibre, 4.3 and 4.8 % for beta-glucan in the naked genotypes and 3.5 % compared to 3.6 % for beta-glucan in the husked cultivars.

Health benefits of dietary fibre

A rapidly growing epidemiological literature has associated decreased risks of cardiovascular disease, diabetes, and a number of cancers with the diets rich in dietary fibre. Insoluble dietary fibre has been found to be beneficial in the prevention of biventricular disease and colon cancer. The most obvious benefit of increased intake of insoluble dietary fibre is the feeling of well being resulting from increased legation. Insoluble dietary fibre generally has a high water binding capacity which results in the formation of softer stools that pass through the system faster. The softer stools reduce the pressure necessary for elimination, thus, less constipation, and lower incidence of maladies such as biventricular disease, varicose veins, haemorrhoids, hernias, appendicitis and phlebitis. The more rapid movement of the faecal bulk through the colon results in increased scrubbing action.

The soluble dietary fibre has beneficial effects on cholesterol and insulin metabolism. Soluble dietary fibre fermentation also generates significant quantities of gases which exercise the colon during transit and with the increased production of short chain fatty acids. They help to remove bile salts from the system and depress cholesterol production [16].

Characteristics such as solubility in water, viscosity, ferment ability and the kinds and amounts of carbohydrates have been explored as possible bases for this physiological effect [34].

Lipid metabolism and risk of coronary heart disease

Both barley and oat have been reported to be effective in lowering total serum- and LDL-cholesterol in humans and animals, the effect being attributed to the content of beta-glucan [6, 32, 36, 37, 39, 5].

Approximately 3 grams of soluble dietary fibre from oat products per day lower the total cholesterol level, and furthermore, the reduction is greater in individuals with initially higher blood cholesterol levels [47, 41]. Similarly, in a study by McIntosh et al. [36], it was demonstrated that plasma LDL-cholesterol concentrations were lowered by 7 % in mildly hypercholesteronaemic men, who consumed 8 grams per day of barley beta-glucan for four weeks.

Fibre sources containing predominantly insoluble fibres such as corn bran, cellulose and wheat bran have little effect on serum cholesterol levels. Possible mechanisms proposed for the hypolipidaemic action of soluble fibres are [43]:

- binding to bile acids, because cholesterol replenishes the acid pool and decreased level of serum cholesterol results in reduced bile acid pool
- different binding to various bile acids, causing changes in the circulating bile acids and thus inhibition of cholesterol synthesis
- fermentation of fibre by colonic bacteria, thereby producing short chain fatty acids, which may inhibit hepatic cholesterol synthesis
- increased catabolism of LDL-cholesterol
- indirect effect as fibre replaces some dietary saturated fats and cholesterol.

Fibres that lower blood cholesterol levels include foods such as apples, barley, beans and other legumes, fruits and vegetables, oatmeal, oat bran and rice hulls and purified sources such as beet fibre, guar gum, karaya gum, konjac mannan, locust bean gum, pectin, psyllium seed husk, soy polysacharide and xanthan gum.

Galactomannans (non-starch polysaccharides) lowered the concentration of cholesterol in liver and blood plasma and decreased the rate of hepatic synthesis of cholesterol [22]. These effects, significantly influenced by chemical composition and structure of glucomannans, were most evident when the proportion of galactose in the galactomannan was the highest.

Dietary fibre and glucose metabolism

Cereal fibre consumption is inversely correlated with the risk of type II diabetes in men and women [9]. A habitually low intake of dietary fibre and elevated fat intake are correlated with reduced insulin sensitivity and high carbohydrate; and high fibre diets are correlated with increased insulin sensitivity.

A concept that ranks foods on the basis of their acute glycaemic impact is called glycaemic index. It is an important factor in determining insulin sensitivity of a diet in the long term. Low glycaemic index diets have been suggested to be more beneficial in the management of diabetes as well as for healthy humans [43]. Glycaemic index of the food is dependent on the nature and processing of the starch, food particle size, the presence of viscous fibre, and the interaction of other nutrients with starch [38]. However, isolated cereal fibre does not appear to reduce the rate of carbohydrate absorption when the integrity of the whole grain is destroyed, for example when ground [27]. Contemporary research on dietary fibre and diabetes is mostly focussed on the potential benefits of dietary fibre in the management (through glycaemic control) of both insulin dependent and non-insulin dependent diabetes. Diabetics exhibit substantially higher risk for cardiovascular diseases than their non-diabetic counterparts. Hyperinsulinaemia, insulin resistance and overtreatment of the diabetic with insulin have all been claimed as contributors to the development of a premature atherosclerosis.

The diet supplementing with 15 grams per day non-starch polysaccharide from arabinoxylan rich fibre proved to be effective in improving metabolic control in people with diabetes of type II [30]. Consumption of arabinoxylan-fibre was associated with significant improvement in fasting blood glucose and fructosamine concentrations, and in 2 hours blood glucose and insulin concentrations.

The mechanisms by which soluble fibres influence glycaemic control are not yet well elucidated. They may affect plasma glucose by delaying gastric emptying [54] or effect by lowering the rate of diffusion of nutrients from the intestinal lumen to the absorptive membrane [31] or by mediating increased intestinal mobility [11].

Fibre and colon cancer

Whole grains seem to be protective against cancer, especially gastrointestinal cancers such as gastric and colonic cancer and hormone dependent cancers including breast and prostate [9]. The protective effect is attributed to dietary fibre and other fermentable carbohydrates (oligosaccharides, resistant starch) but also to quantitatively minor substances such as antioxidants; trace minerals, phenolic compounds and phytoestrogens.

Recently the regular consumption of low glycaemic index carbohydrates has been proposed to have an impact; starchy unrefined foods such as wholegrain cereals are proposed to be beneficial for the aetiology of the colorectal cancer. Slavin et al. [50] similarly affirms that insoluble „dietary fibre" showed to have protective effects against cancer. Stool weight also influences the risk of the colon cancer [34]. A study of twenty populations in twelve countries showed that the stool weight is inversely related to colon cancer risk.

Several mechanisms by which dietary fibre may protect against colon cancer have been proposed [2]:

- decreased production of secondary bile acids
- reduced exposure to carcinogens by increasing stool bulk and/or decreasing intestinal transit times
- direct binding of carcinogens by fibre
- lowered colonic pH
- production of butyric acid.

Dietary fibre and mineral or vitamin bioavailability

Structural cell wall polysaccharides may influence absorption of minerals from the digestive tract. On the other side, no effect of pectin was observed on Ca, Mg, Fe and Zn balance in human beings. Soluble fibre has only a very slight influence on mineral excretion in faeces. It is unlikely too, that healthy adults who consume fibre in amounts within the recommended ranges will have problems with nutrient absorption [35].

Insoluble fraction of dietary fibre from various sources significantly increased excretion of Ca, Mg, Fe, Mn, Zn and Cu in faeces [22].

Potential negative effects of dietary fibre include reduced absorption of vitamins, minerals, proteins and calories. Certain fibre sources from fruits and vegetables that have cations exchange capacity from unmethylated galacturonic acid residues and phytic acid from cereal fibres, have been found to depress the absorption and retention of several minerals. However, certain highly fermentable fibres have resulted in improved metabolic absorption of certain minerals such as Ca, Mg and Fe, even when phytic acid is presented at lower concentration. These compounds include pectin, various gums, resistant starch, cellulose and certain oligosaccharides like soy- and fructo-oligosaccharides, inulin, lactose and related sugars. The short chain fatty acids and lower pH may, in turn, dissolve insoluble mineral salts, especially Ca, Mg and Fe in the luminal content and increase their diffusive absorption via the paracellular route. In particular, the accumulation of calcium phosphate in the large intestine and the solubilization of minerals by short chain fatty acids are likely to play essential role in the enhanced mineral absorption in the colon [55].

Results from test meals indicated that there may be an increase in bioavailability of vitamin A, thiamine and riboflavin in the presence of dietary fibre, although the lack of comparability of study protocols made interpretation of the findings difficult. There is evidence from laboratory rodents that soluble fibre such as pectin and guar gum may decrease the availability of vitamins F and B_{12} [2]. Vitamins bound to fibre or some other carbohydrates or glycoproteins in food are not as available as the vitamins given in the pure form (beta-carotene in carrots, niacin in cereals and thiamine in bread).

Analytical measurement of dietary fibre

Main methods of fibre analysis are summarised in table 2.

1. Non-enzymic-gravimetric methods

This category of methods includes the so-called Weende method, which quantifies the crude fibre (cellulose + lignin) and the Van Soest method, which quantifies successively the neutral-detergent fibre (cellulose + hemicelluloses + lignin) and the acid-detergent fibre (cellulose + lignin). These methods are used for the purpose of characterisation of animal feeds [9].

2. Enzymic-gravimetric methods

In the early 1980s an enzymic-gravimetric method (Prosky et al.) was developed. The sum of soluble polysaccharides, insoluble polysaccharides and lignin were quantified as the total dietary fibre. The procedure was later extended to the determination of insoluble and soluble dietary fibre. All these methods use the same three enzymes (heat-stable alpha-amylase, protease and amyloglucosidase). Proteins and starch are digested through enzymes. The starch digestion step requires the use of a heat-stable α-amylase and amyloglucosidase. Addition of ethanol to the mixture results in precipitation of moderately soluble non-starch polysaccharides. The insoluble and ethanol-precipitated material is separated from the soluble fraction by filtration and quantified gravimetrically. Final corrections are applied to take into account the ash and residual protein content of both, soluble and insoluble fractions. Dietary fibre recovered with this procedure includes cellulose, hemicellulose, pectin, some other non-starch polysaccharides, lignin and a portion of resistant starch. Some indigestible polysaccharides that are soluble in 78–80% ethanol such as inulin and polydextrose, oligosaccharides such as raffinose or stachyose are not detected by this method [2]. However, new procedures have been proposed to quantify some of these compounds individually:

- beta-glucan
- resistant starch
- oligofructan, inulin, fructo-oligosacharides
- polydextrose.

Although specific methods are available to quantify compounds that are not properly (or not at all) detected by the AOAC (American Organisation of Analytical Chemist) approved dietary fibre procedure, none of these methods is able to measure simultaneously all non-digestible oligosaccharides [9].

3. Enzymatic-chemical methods

This section also includes enzymatic-calorimetric and enzymatic-GLC-HPLC methods. The Uppsala method [53] concerns the quantification of neutral and uronic acid residues and Klason lignin. After removal of starch, soluble fibre is precipitated in 80 % ethanol. Soluble and insoluble fibres are hydrolysed with sulphuric acid. Neutral sugars are then quantified by GLC whereas uronic acids are determined by a colorimetric method. Klason lignin is quantified gravimetrically.

The Englyst method quantifies non-starch polysaccharides. Starch is first solubilised with dimethylsulfoxide and then hydrolysed enzymically. After addition ethanol, non-starch polysaccharides are measured in the soluble, ethanol-precipitated fraction. For quantification starch and NSP are subsequently hydrolysed and the sugars are quantified by calorimetry, GLC (gass chromatography) or HPLC (high performance liquid chromatography) [2, 9].

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SÚHRN

Hlavnými sacharidovými zložkami obilnín je škrob, rozpustná a nerozpustná vláknina a niekoľko voľných cukrov. Jačmeň a ovos sa zo všetkých obilnín vyznačujú najvyšším obsahom potravinovej vlákniny a hlavne jej rozpustnej zložky beta-glukánu, účinného prírodného imunostimulátora. Vzhľadom k významnému obsahu zdraviu prospešných zložiek je cereálie možné využiť pri príprave tzv. funkčných potravín, to znamená potravín, do ktorých sa cielene pridáva zdraviu prospešná zložka (prípadne sa redukuje zložka zdraviu škodlivá).

Pojem vláknina má svoju dlhú a bohatú históriu. Americká asociácia cereálnych chemikov (AACC) prijala v roku 2001 obsiahlu definíciu pre vlákninu stravy a pojem potravinová vláknina. Potravinová vláknina predstavuje jedlé časti rastlín alebo podobné sacharidy, ktoré sú rezistentné voči tráveniu a absorpcii v tenkom čreve a zároveň sa vyznačujú úplnou alebo čiastočnou fermentáciou v hrubom čreve. Potravinová vláknina má najmenej jednu z nasledovných vlastností:

- zvyšuje tvorbu stolice
- stimuluje fermentáciu v hrubom čreve
- redukuje hladinu cholesterolu
- redukuje hladinu krvného cukru a inzulínu.

Podľa rozpustnosti vo vode sa vláknina delí na rozpustnú a nerozpustnú.

- Rozpustná forma, ktorú tvoria beta-glukány, pektín, inulín, arabinoxylány a rastlinné gumy, je fermentovaná baktériami hrubého čreva. Viaže na seba vodu a pozitívne ovplyvňuje hladinu glukózy i tuku v krvi.
- Nerozpustnú formu vlákniny predstavuje celulóza, hemicelulóza a lignín. Hrubým črevom prechádza skoro bez zmeny. Výživnú hodnota má nízku, ale pre probiotické baktérie je dobrou živnou pôdou. Význam tejto vlákniny je predovšetkým v prevencii ochorenia na rakovinu hrubého čreva a konečníka.

Jednou z najdôležitejších fyzikálnych charakteristík vlákniny je viskozita, tvorba gélu. Okrem toho má vláknina aj vysoko cenený technologický význam – zlepšuje kvalitatívne a senzorické vlastnosti pekárenských výrobkov.

Na stanovenie vlákniny sa využívajú tri základné metódy stanovenia:

- neenzymaticko-gravimetrické metódy (určené hlavne na stanovenie vlákniny v krmivách)
- enzymaticko-gravimetrické, ktoré využívajú tri enzýmy: termostabilnú alfa-amylázu, porteázu a amyloglukozidázu
- enzymaticko-chemické metódy, ktoré môžeme rozdeliť na enzymaticko-kalorimetrické a enzymaticko-chromatografické.

Kľúčové slová: potravinová vláknina, beta-glukán, obilniny, jačmeň, ovos, metódy