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Dietary fibre prevalence and its role in human nutrition

Gábor Csatári* – Szilvia Kovács

University of Debrecen MÉK, Department of Applied Plant Biology, Böszörményi street 138, 4032 Debrecen, Hungary
*Correspondence: csatari.gabor@agr.unideb.hu

SUMMARY

The role of dietary fibre and its impact on health is increasing. It is worth noting that their beneficial effects on the body are becoming more widely known, but their consumption is still below the recommended daily intake from food. Dietary fibre, as a class of compounds, includes a mixture of plant carbohydrate polymers, both oligosaccharides and polysaccharides. Dietary fibre has been linked to a number of diseases, as its consumption can reduce the risk of cardiovascular disease and type 2 diabetes. They influence the composition of the bacteria present in the human gut. Consuming the right quantity and quality of dietary fibre can play a role in the prevention of certain types of cancer. Nowadays, it is common to produce various fibre-enriched foods, called functional foods, because of the beneficial effects they have previously had on the body. In the present work we want to give a general description of dietary fibre and its role in the body.

Keywords: *dietary fibre, classification, effect*

INTRODUCTION

From a plant anatomical point of view, the fiber derives from the cell wall, which gives the cell shape. The cell wall material is excreted by the cell plasma. The main materials of the cell wall: cellulose, hemicellulose, pectin, lignin (Haraszty, 1978; Turcsányi, 1995; Kovács, 2019). The food industry refers to the word fiber as „dietary fiber". What is dietary fibre? Dietary fibre is defined in many different ways, but most literature suggests that it is primarily a plant ingredient that is resistant to human digestion and absorption in the small intestine (Asp, 1987; Cho et al., 1999; Prosky, 2000). Includes indigestible non-starch polysaccharides, cellulose, hemicellulose, oligosaccharides, pectins, gums and waxes (James et al., 2003). However, they can be partially or completely fermented in the colon (Prosky, 2000) in Borderías et al. (2005).

Classification of dietary fiber according to their solubility: soluble (SDF) and insoluble (IDF) dietary fibre. The insoluble dietary fibre include cellulose, hemicellulose, resistant starch, arabinoxylan, lignin. The soluble dietary fibre are: inulin, pectin, B-glucan, galactomannan, glucomannan, psyllium, fructooligosaccharides (FOS), dietary fibre of legumes, guargum (Cho et al., 1999; Tungland and Meyer, 2002; James et al., 2003).

From the above, we can see that the concept of dietary fibre includes many compounds. Different types and amounts of fibres are found in different plants. These compounds have different chemical composition, which may explain their behaviour in different functional foods. Furthermore, the health benefits attributed to them are not negligible. This will be discussed later.

Fibres in different plants

Dietary fibre is derived from the plant cell wall and, as mentioned earlier, includes cellulose, pectin, lignin and non-starchy constituents, but other sources include seaweeds and microorganisms. Most cell walls are derived from parenchyma cells (Harris and Ferguson, 1993).

According to Osman (1990) the highest value of dietary fibre can be observed in legumes: 3.3–6.8 g/100 g, followed by leafy vegetables: 1.2–4.8 g/100 g. Last place went to vegetables and fruits: 1.5–2.9 g/100 g. He reported that the non-cellulosic fractions represented a higher proportion than the amount of cellulose and lignin fractions.

An excellent source of dietary fibre is the tuber of sweet potato (*Ipomoea batatas*), whose leaves are rich in vitamins and essential fatty acids too. Do not just eat the tuber. The consumption of its leaves is popular in Asia and Africa, but less common in the United States (Johnson and Pace, 2010). Mullin et al. (1994) measured the amount of dietary fibre in 5 sweet potato varieties, which ranged from 9.07 to 12.16%.

Soya (*Glycine max* L.) seeds are rich in dietary fibre. Yellow soy has a fibre content of 13.7–16.5 g/100 g, while green soy has a fibre content of 9.19–9.45 g/100 g. Differences between the two soybeans were significant in galactose content (Redondo-Cuenca et al., 2007). The fibre content of yellow soybean hulls was investigated. Yang et al. (2014) using AOAC 2011.25, where it was found that insoluble fibres represented a higher proportion of water insoluble fibres compared to soluble fibres. The extruded soybean residue has higher water retention capacity, fat retention capacity than the unextruded (Jing and Chi, 2013). Li et al. (2019) found in their experiment that the autoclaving process in soybean curd residue increases the soluble fiber content. After treatment, the total sugar and uronic acid content in soluble fiber increased. From what has been described, it can be concluded that the pre-treatment of the plant material can affect the recoverable fibre content.

Tekes et al. (1992) measured the percentage of fibre fractions (cellulose, hemicellulose, lignin) of different apple varieties with and without skin, and vegetables, and found that no significant differences were observed between apple varieties. The values measured for the

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individual fractions in vegetables show results almost similar to those reported in previous literature.

Jerusalem artichokes (*Helianthus tuberosus* L.) are an important source of inulin. The amount of inulin that can be extracted from the tuber is 75–80 g/100 g dry matter (Khuenpet et al., 2017). Praznik et al. (2002) describe that the inulin content of tubers harvested during autumn harvest is higher than during spring harvest. The genotype of the varieties used and irrigation also significantly influence inulin content (Puangbut et al., 2015). There is a lack of literature on the composition of fibre in the green biomass of Jerusalem artichokes. The large leaf mass and its insensitivity to environmental factors could justify an investigation of the values of green biomass.

Consumption of dietary fibres

According to the American Dietetic Association, you should consume 25–30 g of fibre a day or, to put it another way, 13 g of fibre for every 1000 Kcal of energy. In Europe, the average fibre consumption is 20 g/day, but in developing countries it can be as high as 60–120 g (Borderías et al., 2005). Fári and Popp (2016) cites a daily amount of 25–35 g of fibre for optimal metabolism in the human diet. The typical European diet currently contains 12–15 g of fibre. From the data reported above, we can see that several literatures cite nearly similar values for the required daily fibre intake. Reynolds et al. (2020) cites 35 g too.

Glycaemix index

Over the past 200 years, diabetes and other heart diseases have become common. High-fibre foods can significantly reduce the risk of developing these diseases, in part due to the reduced insulin response that occurs after eating them (Brennan, 2005; Kendall et al., 2010). Björck and Elmståhl (2003) and Reynolds et al. (2020) recommend eating foods with a low glycaemic index (glycaemic impact: "the weight of glucose that would induce a glycemic response equivalent to that induced by a given amount of food" (American Association of Cereal Chemists Glycemic Carbohydrate Definition Committee, 2007)).

Among dietary fibres, water-soluble fibres are highly influential in regulating plasma glucose levels (Giacco et al., 2002). Incorporating dietary fibre into the diet may play an important role in weight control and may also reduce the risk of developing diabetes in older age (Riccardi et al., 1984; Smith 1987; Gunness and John Gidley 2010; Salas-Salvadó, 2010; Reynolds et al., 2020).

Cholesterol and dietary fibre

Dietary fibre has an effect on the body's fat metabolism. Many fibres reduce cholesterol by binding cholesterol (Jiménez-Escrig and Sánchez-Muniz, 2000) and help to reabsorb bile salts from the small intestine (Gunness and John Gidley, 2010). Vuksan et al. (2011) describes that high viscosity fibres when incorporated into the diet reduce plasma lipid levels.

The relationship between macro- and microelements and fibres

There is a correlation between the amount of mineral elements and dietary fibre (Kiewlicz and Rybicka, 2020).

The ability of dietary fibre to bind elements is influenced by the pH of the medium, which is optimally between pH 5–7, according to an experiment by Nair et al. (1987). This is important information because the pH of the intestinal tract ranges from 6 to 7. It has also been found that high and low methoxylated pectin have different mineral-binding capacity. For low methoxylation: Cu>Zn>Cd; for high methoxylation: Zn>Cu>Cd. Pectin has little effect on Ca^{2+} availability (Wang, 2020).

Torre et al. (1995) investigated the relationship between dietary fibre and Fe(II), Fe(III), and Ca(II). In vitro experiments have shown a correlation between mineral element fixation and dietary fibre during complex formation, but have not been able to simulate the processes in the human small intestine.

From the above, we can see that dietary fibre can influence many processes in the human body.

Effect of each fibre on the body

The soluble fibers increase viscosity and decrease glycemic index. Insoluble dietary fiber increases bulk weight and reduces intestinal transit time (Mudgil and Barak, 2013). The effects of different fibres on the body are shown in *Table 1*.

Functional foods

Functional foods are "Foods or food components that may have health benefits that reduce the risk of specific diseases or otherhealth concerns" (National Institute of Nutrition, 2000). Nowadays, the addition of dietary fibre to various foods is becoming increasingly common (Vuholm et al., 2014; Alkalin et al., 2018). We have already discussed the positive effects of dietary fibre on the body.

Dietary fibre can bind fat and water in foods (Caprez et al., 1986; Gyawali and Ibrahim, 2016), so they can affect the rheological properties of the product (Soukoulis et al., 2009). By adding fibre to different meat dishes, lower cooking losses can be achieved due to improved water binding capacity. Dietary fibre can play an excellent fat replacing role (Møller et al., 2011; Han and Bertram, 2017). Sáyago-Ayerdi et al. (2009) and Viuda-Martos et al. (2010) found that after adequate dietary fibre in adequate proportions is ingested, it has an effect on lipid stabilisation, with increased shelf-life. Kim et al. (2016), on the other hand, reported a decrease in lipid oxidation stability after soy dietary fibre addition in beef patties following freezing and thawing.

It is not negligible that the addition of dietary fibre can lead to the production of reduced calorie foods, which can form the cornerstone of a diet (Choe et al., 2013; Choi et al., 2014; 2016; Henning et al., 2016; Carvalho et al., 2019; Pietrasik et al., 2020).

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Table 1: **The effects of different dietary fibres on the body**

Fibre	Solubility	Monomer	Positiv effect on the body	References
B-glucan	Soluble	Glucose	Prevention against overweight Prevention of cardiovascular diseases Antioxidant effect Anticarcinogenic effect	(Manzi, 2000; Maheshwari et al., 2019)
Pectin	Soluble	Galacturonic acid	Positiv effect on immun system Induces apoptosis in prostate cancer cells	(May, 1990; Yamada et al., 2003; Jackson et al., 2007)
Inulin	Soluble	Fructosyl-fructose	Anti-inflammatory effect SCFA production Reduces intestinal carcinogenesis Prevention of cholesterolaemia	(Flamm et al., 2001; Guarner, 2005; Roberfroid , 2005)
Cellulose	Insoluble	Glucose	SCFA production	(Brown, 2004; Mudgil and Barak, 2013)
Hemicellulose	Insoluble	**Pentoses**: *arabinose*, *xylose* **Hexoses**: *glucose*, *galactose*, *mannose*, *ramnose*	SCFA production Cholesterol binding in the gut	(Mudgil and Barak, 2013)
Resistant starch	Insoluble	Glucose	Reduces cholesterol levels Prevention of diabetes	(Sajilata et al., 2006; Fuentes-Zaragoza et al., 2010)
Arabinoxilane	Insoluble	Xylopyranosil	Positiv effect on immun system Prebiotic effect Prevention of diabetes	(Grootaert et al., 2007; Mendis and Simsek, 2014)

CONCLUSIONS

The concept of fibre is defined differently in different disciplines. In this research, we refer to fibre as dietary fibre as used in food science. Dietary fibres are carbohydrate polymers of at least 3 monomeric units that are resistant to human digestive enzymes, but at the same time can be partially or fully fermented by microbes in the large intestine. The role of dietary fibre and its effect on health is well established, depending on the type of dietary fibre.

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