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A REVIEW OF DIETARY FIBER: FUNCTIONAL PROPERTIES AND APPLICATION IN THE FOOD INDUSTRY

Daniel Hermosilla
Faculty of Agricultural Sciences. University of Chile. Santiago, Chile

Marco Schwartz
Faculty of Agricultural Sciences. University of Chile. Santiago, Chile

Abstract: The elaboration of healthy products for the human population has been fundamental to improve the quality of life, nourishing and reducing diseases caused by an inadequate diet. The intake of dietary fiber has played a fundamental role as it is a functional ingredient improving digestion, reducing the probability of suffering from colon cancer, as well as the risk of cardiovascular diseases, decreasing glucose absorption and improving, among other benefits of its consumption. For this reason, it is recommended to consume a minimum of 25 g/day, mainly from plant--based foods, in order to have an equitable intake of soluble and insoluble fiber, which have different biological activity in the body. Due to the demand of demanding consumers for healthy foods, companies have become interested in producing these polymers that will be incorporated as an ingredient in the preparations, improving nutritionally these foods. The incorporation of dietary fiber into foods promotes the technological properties sought by the food industry, such as increased volume, water and fat retention, which improves their visual and sensory appearance when consuming processed products such as those based on flour, dairy, meat, pastry and confectionery. Furthermore, depending on the treatment prior to obtaining them, such as the drying method and grinding size, an improvement in these desired characteristics can be achieved. In general, the application of these polysaccharides in processed products should be tested according to the type of food, the type of dietary fiber and the amount to be used, since it can alter the acceptability of the product sensorially and/or visually, generating a lower acceptability by consumers.
Keywords: Processed food, Health, Technological properties

INTRODUCTION

Growing obesity and noncommunicable diseases (NCDs) are a global problem related to inadequate eating habits and low physical activity, associated with excessive consumption of unhealthy foods. Dietary fiber (DF), present in fruits, vegetables, and grains, offers multiple health benefits, such as improving digestion, regulating the intestinal microbiota, and preventing NCDs (noncommunicable diseases) (Arias *et al.,* 2018).

FD is a non-digestible carbohydrate polymer composed of cellulose, hemicellulose, lignin, pectins, gums and mucilages (Jha *et al.,* 2017). It is classified into soluble and insoluble, the former being beneficial for satiety and the latter useful for improving intestinal regularity (Cruz *et al.,* 2019; Almeida *et al.,* 2014).

Dietary fiber acts as a prebiotic, feeding beneficial bacteria in the intestine and promoting vitamin production and pathogen inhibition. Although the WHO recommends an intake of 25 g/day in adults, worldwide intake is only half this figure. Foods such as artichoke, spinach, kiwi and raspberry are rich in fiber, and the European Union considers foods containing more than 6g/100g as "high fiber", including some grains and cereals such as beans, chickpeas and oats (Schulz and Slavin, 2022).

Agribusiness plays an important role by incorporating fiber into food products such as sausages, burgers, ice cream, and confectionery, improving texture, creaminess, color, and reducing caloric content (Elleuch, 2011; Akalın *et al.,* 2018).

The objective of the review is to update the knowledge on the physicochemical and functional properties of dietary fiber and its application in food innovation.

RESULTS AND DISCUSSION

DIETARY FIBER

Fibers are found in all plant foods, including fruits, vegetables, grains and legumes. These structures are mainly carbohydrates that cannot be digested by the human body, because the digestive system lacks enzymes to break the beta bonds present in these polymers. The introduction of the concept of dietary fiber was incorporated in 1953 by the British physician Eban Hipsley, which refers to the non-digestible constituent of the cell walls of vegetables (Almeida *et al.,* 2014).

The CODEX Alimentarius Commission (CAC, 2009), states that FDs are carbohydrate polymers with ten or more monomeric units, which are not hydrolyzed by the endogenous enzymes of the human small intestine and belong to the following categories:

- Edible carbohydrate polymers that occur naturally in foods in the form in which they are consumed.

- Carbohydrate polymers obtained from food raw material by physical, enzymatic or chemical means, and which have been shown to have a beneficial physiological effect on health by generally accepted scientific evidence provided to the competent authorities.

- Synthetic carbohydrate polymers that have been shown to have a beneficial physiological effect on health by generally accepted scientific evidence provided to the competent authorities

The controversy over the official definition of dietary fiber refers to the inclusion of oligosaccharides with degrees of polymerization from 3 to 9, such as inulin, fructooligosaccharides, galactooligosaccharides, resistant maltodextrins and raffinose. This inclusion varies according to the health authorities of each country, which may consider these compounds individually for nutritional labeling purposes, based on their physiological benefits for human health (Villanueva, 2019).

Miller (2014) highlights that the creation of a harmonized definition of dietary fiber that includes oligosaccharides would bring benefits to consumers, science and industry alike. This would enable better identification in food labeling, facilitate comparison of fiber contents in different databases, drive the marketing of similarly labeled products in different countries, and encourage investments in research to improve fiber content in foods.

FIBER COMPOSITION DIETARY

Dietary fiber is constituted by polysaccharides containing more than twenty monomeric units, such as cellulose, hemicellulose, pectin and mucilages. There are also oligosaccharides, which are made up of 3 to 10 monomers, including inulin. On the other hand, there are products derived from starch or synthetic carbohydrates, such as polydextrose.

CELLULOSE

It is an important structural component of primary cell walls in vegetables, green plants, algae and some bacteria. Cellulose is composed of monomers of glucose that form an unbranched linear chain (Figure 1). These molecules are linked by β- (1→4) glycosidic bonds. It is insoluble in water and resistant to the action of digestive enzymes in the human small intestine. It can be fermented by colon bacteria in the large intestine after production of short-chain fatty acids (SCFA) (Popoola *et al*, 2022).

Cellulose is composed of 10,000 to 15,000 monomers per linear chain with the ability to form hydrogen bonds with each other, forming rigid microfibrils, and crystalline in nature (Mudgil, 2017).

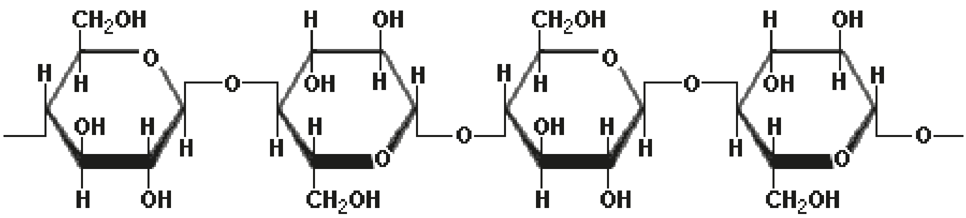

Figure 1: Chemical structure of cellulose (Paniaguar et al., 2007)

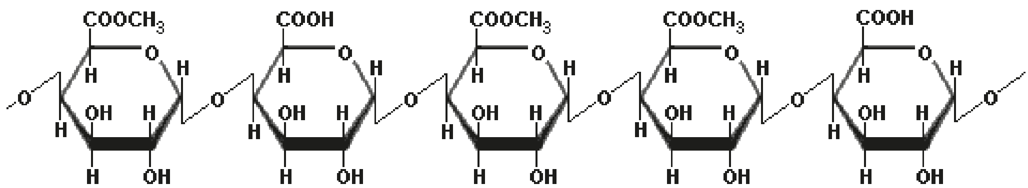

Figure 3: Chemical structure of pectins (Paniaguar *et al.,* 2007).

HEMICELLULOSE

They are heteropolysaccharides with β-(1→4) glycosidic linkages consisting of a backbone-shaped main chain (Figure 2), composed of 5 or 6 monosaccharides which are glucose, galactose, xylose, mannose, arabinose and glucuronic acid (alone or in combination) counting about 50 to 200 monomeric units (Mudgil and Barak, 2019).

An example is arabinoxylan which is composed of xylose and arabinose monomers, which is classified as insoluble dietary fiber. The xylose units are linked by a β-1,4-xylosidic linkage to form the backbone to which the arabinose units are attached as side chains by an α-1,3 linkage. In the human gastrointestinal tract, arabinoxylan is fermented by the colonic microflora (Mudgil, 2017).

MUCILAGOS

It is a product of vegetable origin, with a molecular weight greater than 200,000 g/mol, made up of cellulosic polysaccharides containing the same number of sugars as gums and pectins (Andrade and Rivadeneira, 2010). They are often confused with gums and pectins; while the former swell in water forming thick colloidal dispersions, pectins gel; mucilages produce low viscous colloids, which exhibit optical activity and can be hydrolyzed and fermented (Villanueva and Santamaria, 2019; Villa *et al.*, 2020).

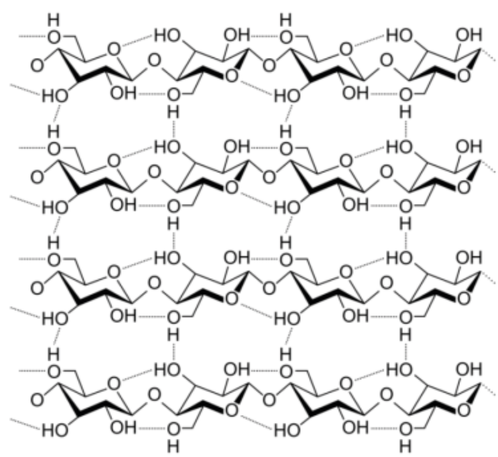

Figure 2: Chemical structure of hemicellulose (Lefty, 2014)

PECTINS

They are complex polysaccharides of the primary cell walls of all plants. They are defined as heteropolysaccharides formed by D-galacturonic acid units linked by α-(1-4) bonds, which in turn have side branches of neutral sugar chains, such as rhamnose, arabinose, xylose and galactose (Figure 3) (Paniaguar *et al.,* 2007; Baena and García, 2012). The functional properties depend on the degree of methylation and polymerization; high metho-

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xyl have 50 % or more degree of esterification and low methoxyl esterification is less than 50 % (Dalal *et al*, 2020). The high methoxyl ones form gels at acidic pH in the presence of high sugar concentrations, while the low methoxyl ones require the presence of divalent ions. The gelation capacity of pectin depends on the degree of esterification, molecular weight, temperature and concentration used, so the higher the degree of esterification, the faster the gelation (Dangi and Yadav, 2020).

RUBBERS

As any water-soluble polysaccharide, obtained by the exudation of plants, seeds, microbial fermentation products or seaweed extracts, in solution they increase viscosity and/or form gels (Pasquel, 2010).

They are long chains of uronic acid, xylose, arabinose or mannose (Figure 4), which come from the transformation of cell wall polysaccharides, such as gum arabic, carob gum, acacia, guar, karaya and tragacanth, among others (Baena and García, 2012). The composition and concentration of plant gums vary from one species to another as does their polymeric composition. Some microorganisms can also produce gums as a product of their fermentation process, such as xanthan gum, etc. (Mudgil and Barak, 2019).

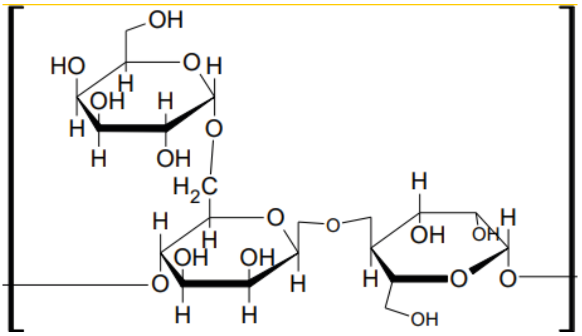

Figure 4: Chemical structure of gums (Baena and Gracia, 2012).

INULIN

It is a fructan consisting of a mixture of oligomers and polymers with 2 to 60 monomers, although the average is 10, composed of fructose units (Salas *et al*, 2019). Inulin (Figure 5) is formed by ß-(2-1)-fructosyl-fructose linkages with a terminal glucose, linked by an α-(1-2) bond known as β-D-glucopyranosyl residue (Castellanos *et al.*, 2017). Five structural classes of fructans are distinguished in nature: inulin, levanos, branched fructan mixtures, inulin neoseries and levanos neoseries (Rivera *et al.*, 2018)

The industry uses it as a thickener by incorporating water in its structure, obtaining a homogeneous consistency that makes possible the substitution of fats in dairy products, milk cream, yoghurts, etc. It also acts as a texture modifier, prebiotic and sugar substitute (Popoola *et al*, 2022).

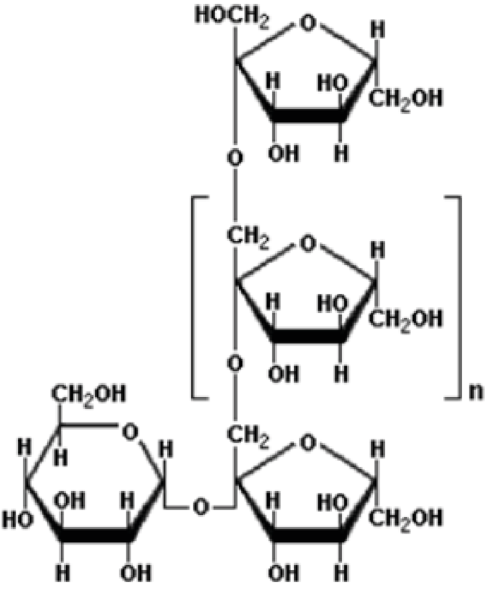

Figure 5: Chemical structure of inulin (Zurdo, 2014).

FRUCTOOLIGOSACCHARIDES (FOS)

They are linear oligosaccharides of fructose monomers with polymerization of between 2 to 20 units (Figure 6), obtained by partial enzymatic hydrolysis of inulin and composed of linear glucosyl-fructosyl chains, which ferment completely in the colon (Salas *et al.*, 2019), although commercial products usually have an average value of 9 (Chamorro and Mamamni, 2010).

Fructooligosaccharides are obtained by enzymatic processes from sucrose, starting from a syrup obtained from sugar beet that undergoes enzymatic conversion through the enzyme fructosylfuranosidase extracted from the microorganism *Aspergillus niger* (Chamorro and Mamamni, 2010)

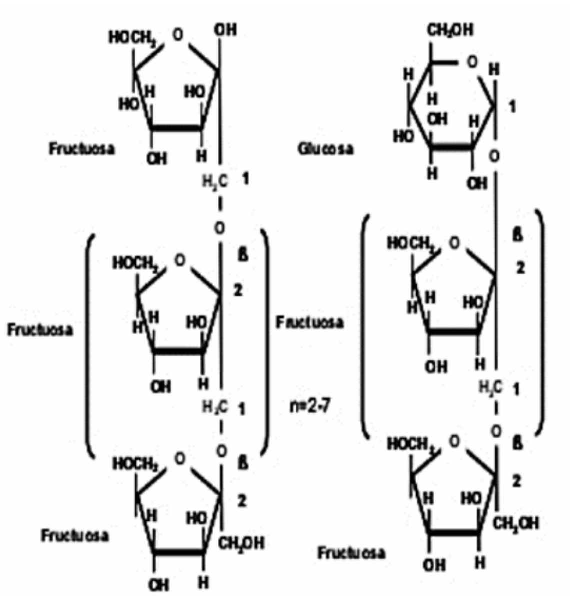

Figure 6: Chemical structure of Fructooligosaccharides (Zurdo, 2014).

OLIGOFRUCTOSE

It is obtained by partial enzymatic hydrolysis of inulin, composed of linear glucosyl-fructosyl chains. It is more soluble than inulin with a sweetness similar to sugar (Olagnero *et al.,* 2007). The degree of polymerization ranges from 2 to 8, with an average of 4. It is present in cereals, onion, garlic, banana and corn.

β-GLUCANS

They are polysaccharides with monomeric glucose units linked by β (1→3), β (1→4) and β (1→6) glycosidic bonds (Figure 7). It is found in the bran of barley, oats, fungi and some microorganisms. The β-glucans obtained from cereals are composed of glucose units with β (1→3) and β (1→ 4) linkages, whereas β-glucans from yeast and fungi contain β (1→ 6). The β-glucan obtained from bacteria and algae shows a linear structure, whereas the β-glucan extracted from yeast, fungi, oats and barley is branched (Mudgil and Barak, 2019).

GALACTOOLIGOSACCHARIDE (GOS)

They belong to the raffinose series and are made up of galactose molecules. The most frequent are raffinose, stachyose and verbascose of 2 to 5 galactoses respectively, linked by β-glycosidic bonds 1-4 or 1-6 (mainly) and a terminal glucose residue (Figure 8). They are found in legumes (Olagnero *et al.,* 2007).

LIGNIN

It is a hydrophobic and rigid material, which acts as a cementing agent for cellulose fibers in plant cells, by forming cross-links with other saccharide molecules (Mudgil, 2017). It is responsible for the structural strength of wood, showing unique opposition to enzymatic and chemical degradation by microorganisms. In turn, it exhibits is resistant to human digestive secretions, greater than any other natural compound (Baena and Garcia, 2012).

It is not a polysaccharide but a polyphenylpropane polymer, with a highly branched three-dimensional phenolic structure composed of phenylpropane units such as p-coumaryl alcohol, coniferyl alcohol and sinapyl alcohol. It is considered a highly branched phenolic compound and is the most abundant source of aromatic compounds in nature (Mudgil and Barak, 2019).

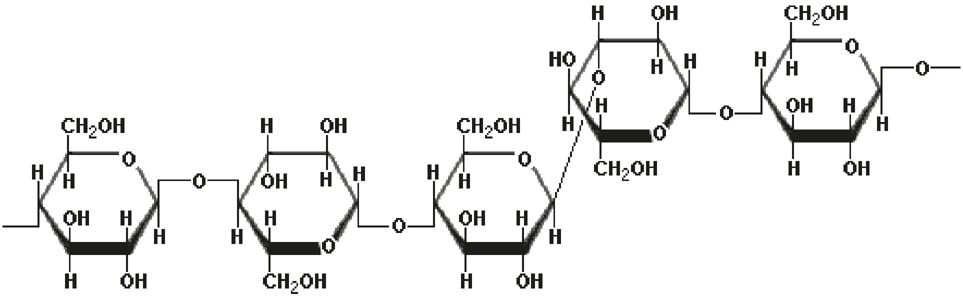

Figure 7: Chemical structure of β-glucans (Pizarro *et al.,* 2014).

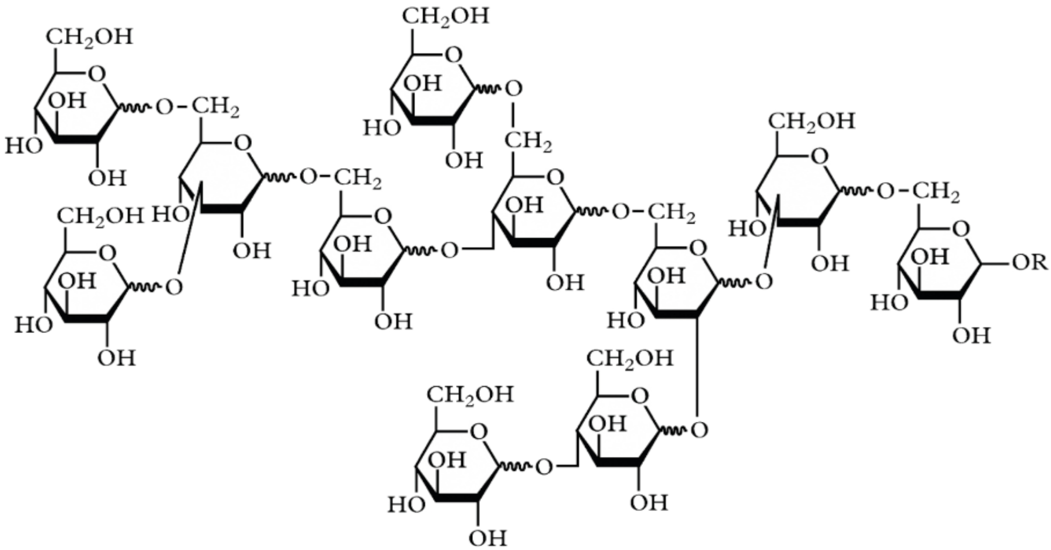

Figure 9: Chemical structure of polydextrose (Putaala, 2013).

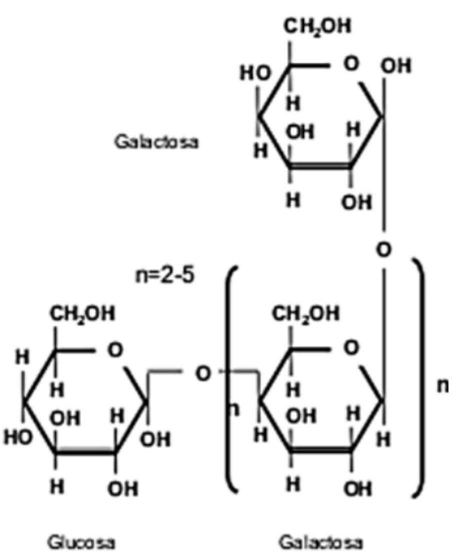

Figure 8: Chemical structure of galactooligosaccharide (Zurdo, 2014).

RESISTANT STARCH

They are starch molecules that resist the action of the enzyme amylase in the human small intestine and show some degree of bacterial degradation in the large intestine (Mudgil and Barak, 2019). The resistance to digestion is attributed to a higher amount of amylose than amylopectin, which allows for a more compact structure, less susceptible to enzymatic hydrolysis. The resistance of this starch is also explained by the size and type of granule; the increased density of starch branches and the crystalline structure contribute to its slow digestion property (Villarroel *et al.,* 2018).

Resistant starches (RA) are classified into five subtypes:

- AR1 is physically inaccessible and cannot be hydrolyzed due to the barrier effect of the cell wall found in partially milled grains and cereals.
- AR2 are characterized by B and C polymorphisms, making them highly resistant to enzymatic hydrolysis as they are intact starch granules.
- AR3 is retrograded starch, whose hydrolysis by amylase is difficult due to crystallization formed during cooling and storage after gelatinization.
- AR4 is chemically modified starch. The example is the cross-linking reaction, which modifies the structure and allows it to resist enzymatic action during the digestion process.
- AR5 is formed by combining long, unbranched starch chains with free fatty acids, forming a helical structure that is difficult to digest and resistant to maltodextrin, which is a new non-viscous type of dietary fiber produced by the intentional rearrangement of starch molecules (Wen *et al.,* 2022; Villarroel *et al.,* 2018).

POLYDEXTROSE

It is a synthetic branched polysaccharide by random polymerization of glucose in the presence of sorbitol and an acid catalyst at elevated temperature. Figure 9 shows the chemical structure, composed of a mixture of glucose oligomers, with an average polymerization of 12 units (Putaala, 2013; Zurdo, 2014). The structure is complex, resistant to human digestive enzymatic hydrolysis. It is fermented in the colon, about 50% and has digestive and prebiotic properties (Gray, 2006). Polydextrose is an excellent body agent, being a substitute for sugar and fats. Its ability to retain water gives it a flour-like texture when compared to other fibers (Olagnero *et al.,* 2007).

CLASSIFICATION OF DIETARY FIBER

The term FD includes non-starch polysaccharides, oligosaccharides, lignin, associated plant substances (cutin, suberin, phytic acid, etc.) and resistant starches (Mudgil and Barak, 2019).

There are two methods to distinguish dietary fiber, which are based on water solubility and fermentation produced in the human colon. Fermentable dietary fiber is considered water soluble in nature, while non-fermentable or less fermentable is considered water insoluble (Mudgil, 2017). Both types have specific effects on human metabolic activities.

SOLUBLE DIETARY FIBER

SDS avoid the digestion process inside the small intestine and are easily fermented by the microflora of the large intestine. When dissolved in water, it can generate viscosity effects by forming a viscous gel. There are two categories: viscous fiber and non-viscous fiber. Viscous soluble fiber includes pectin, galactomannan, β-glucan, psyllium, etc., while non-viscous soluble fiber includes FOS, resistant dextrin and inulin (Mudgil, 2017). Almeida *et al*. (2014) comment that, by forming these gels, it improves transit time in the human digestive tract causing a delay in gastric emptying, leading to a reduced rate of glucose absorption. In addition, it is associated with the ability to bind nutrients, preventing their absorption in the intestine, thus modifying the metabolism of fats and carbohydrates (Rosa *et al.,* 2017)

INSOLUBLE DIETARY FIBER

FDI does not have the capacity to form gels due to its insolubility in water, and fermentation is null or limited to the interior of the large intestine. As it passes through the colon unchanged, it increases the weight of the stool due to its ability to absorb water. Consequently, bulky and soft feces decrease intestinal transit time and increase bile acid excretion (Rosa *et al.,* 2017; Almeida *et al*., 2014). FDI includes celluloses, hemicelluloses and lignin (Mudgil, 2017).

BENEFICIAL PHYSIOLOGICAL EFFECTS ON HUMAN HEALTH

Dietary fiber is the main driver of the composition of the intestinal microbiota, due to the prebiotic function that acts at the level of the digestive system, some examples are galactooligosaccharide, fructooligosaccharides (fructans). In general a prebiotic is a non-digestible ingredient that beneficially affects the organism, by stimulating the growth of beneficial bacteria over harmful ones improving the health of the host (Slavin, 2013). Thus, prebiotics have the following characteristics:

- Resistance to digestion in the small intestine, i.e. they overcome the digestive processes occurring in the first section of the digestive tract almost undamaged and in adequate quantity.

- Partial fermentation by bacteria in the large intestine; that is, they are nutritional fermentable substrate for the intestinal microflora, in order to selectively stimulate the growth and/or metabolism of one or a few bacterial species.

- Positive change in intestinal bacterial composition, increasing acidophilic fermentative bacteria (mainly bifidobacteria and lactobacillus), decreasing putrefactive bacteria and including systemic and/or local effects in the intestine in benefit to health (Hdez *et al.,* 2015).

STOMACH MICROBIAL ACTIVITY

The large intestine is one of the organs with the greatest diversity of metabolically active colonized organisms in the human body. The colonic environment is favorable for bacterial growth due to its slow transit time, readily available nutrients and favorable pH. Bacteria considered probiotic such as bifidobacteria and lactobacilli have a saccharolytic metabolism and are considered potentially beneficial (Slavin, 2013).

Bifidobacteria constitute 25% of the intestinal bacterial population of a healthy adult, showing beneficial effects, such as the synthesis of vitamin B, inhibition of the growth of pathogenic germs, decrease of intestinal pH, decrease of cholesterol, protection from intestinal infections, stimulation of intestinal function and improvement of the immune response (García and Velasco, 2007). **Lactobacilli** also show healthful effects, such as inhibition of pathogens, lowering of intestinal pH and prevention of bacterial overgrowth of *Candida, Pseudomonas, Staphylococcus and Escherichia coli* (Garcia and Velasco, 2007; Rivera *et al.,* 2018).

SDS is fermentable by colonic bacteria, promoting bacterial diversity, mucosal barrier maintenance and favoring the production of SCFA, such as acetate, propionate and butyrate, which are produced in a ratio of 60:25: 15 , respectively. These SCFA benefit the maintenance of intestinal homeostasis and the promotion of immune tolerance by increasing the production of regulatory T lymphocytes (Escaffi *et al.,* 2021). The most important physiological effects of SCFA are to decrease intraluminal pH, stimulate water and sodium reabsorption, mainly in the ascending colon, and enhance the absorption of divalent cations in the colon (García and Velasco, 2007).

Table 1 shows the microorganisms in the gut, linked to the type of fiber ingested .

Carbohydrates	Species
Fructooligosaccharides	↑ *Bifidobacterium spp, Lactobacillus spp.*
Inulin	↑ *Bifidobacterium spp, Lactobacillus spp.*
Fructans	↓ *Bacteroides spp, Clostridium spp.*
Galactooligosaccharide	↑ *Bifidobacterium spp, F. prausnitzii*
Resistant starch 2	↑ *Ruminococcus spp, Eubacterium rectale, Bifidobacterium adolescentis*
Resistant starch 3	↑ *Eubacterium rectale, Roseburia spp, Ruminococcus bromii*
Complex carbohydrates	↑ *Bifidobacteria spp, Prevotella spp.*
Diet rich in soluble fiber	↑ *Bacteroides spp. and E. rectale*
Low fiber diet	↓ *Roseburia spp, Eubacterium rectale*

Table 1. Effect of dietary fiber consumption on microbiota.
Source: Bibbò *et al.* (2016)

APPETITE REGULATION

The consumption of foods rich in dietary fiber prolongs the sensation of satiety by requiring more chewing time, which favors the production of saliva and gastric acid, increasing gastric distension. Soluble fibers absorb water, increasing the volume of the food bolus and activating fullness signals. During gastrointestinal transit, hormones such as ghrelin, polypeptide YY and glucagon-like peptide, which regulate satiety, food intake and energy balance, are released.

INTERACTION WITH ANTIOXIDANT COMPOUNDS

Dietary fiber has the ability to bind, adsorb or trap other dietary compounds, such as phenolic compounds. These compounds have hydrophobic rings and hydrophilic groups capable of binding at different sites on the dietary fiber (Suharoschi *et al.,* 2019). A large number of compounds such as phenolic acids, xanthones, coumarins, acetophenones, flavonoids, etc. belong to this group. Phenolic compounds, especially polyphenols, have potential health benefits, associated with their biological properties as antioxidant, antiestrogenic, immunomodulatory, anticarcinogenic and cardioprotective. Although polyphenols have shown many potential bioactivities, their bioaccessibility, bioavailability and bioactivity are highly dependent on the food matrix and food processing (Das *et al*., 2020). The presence of dietary fiber within the food matrix has been observed to have a significant influence on the bioaccessibility of phenols (Merve, 2022)

FOODS HIGH IN DIETARY FIBER

The Western diet, characterized by high consumption of red meat, fats and simple carbohydrates, is low in fiber and water. A study revealed that fast foods such as hamburgers, pizza and fried chicken have less than 2 g of fiber per 100 g, except for pizza (3 g/100 g). Dietary fiber, mainly from fruits, vegetables, cereals and legumes, varies according to the food and the part consumed (peel, pulp, roots) (Cáceres *et al*., 2021).

Legumes stand out for their high fiber content (7.5-54.8 g/100 g), especially soybeans. Cereals and pseudocereals have lower levels (1.1-17.3 g/100 g). Fruits and vegetables have moderate to low content (0.3-8 g/100 g), with raspberry, avocado and artichoke as the richest in fiber in their categories (Food and Drug Administration (FDA), 2017).

The total dietary fiber of legumes (Table 2) ranged from 7.5 g/100 g to 54.8 g /100 g, where the content of soybeans was higher than that of other legumes. In cereals and pseudocereals (Table 3), a lower level of dietary fiber was generally observed, ranging from 1.1 g/100g to 17.3 g/100g.

In fruits (Table 4), the dietary fiber contents are low with respect to the aforementioned foods, fluctuating in a range of 0.3g/100 g to 6.7g/100 g, where raspberry and avocado stand out. Vegetables (Table 5), like fruits, have low dietary fiber contents that fluctuate between 1g/100 g to 8g/100 g, among which artichoke dominates.

	FDT	FDI	SDS	References
Beans	7,5	-	-	USDA (2022)
White Bean	26,3 - 27	20,4 -21,2	5,8 - 5,9	Rosa *et al.* (2017).
Bean found	23,3	19,8	3,5	Rosa *et al.* (2017).
Peas	29,7	27,6	2,1	Rosa *et al.* (2017).
Lentil	16,5 - 24,3	15,6 - 21,6	0,9 - 2,7	Benítez *et al.* (2013).
Chickpea	18,0	22,0	4,0	BEDCA (2022)
Soy	46,9 - 54,8	38,9 - 52,1	2,7 - 8,0	Rosa *et al.* (2017).
Cowpea	31,2 - 34,1	29,8 - 31,0	0,9 - 4,0	Rosa *et al.* (2017).

Table 2. Portion of dietary fiber in 100 g of edible legumes s

TDF: Total dietary fiber TDF: Total dietary fiber TDF: Total dietary fiber TDI: Insoluble dietary fiber SDF: Soluble dietary fiber

	FDT	FDI	SDS	References
Oats	10,3 - 10,6	6,5	3,8	Rosa *et al.* (2017).
Corn	13,4	-	-	Rosa *et al.* (2017).
Rice	1,1 - 1,3	1,0	0,3	Rosa *et al.* (2017).
Barley	14,8 - 17,3	-	-	USDA (2022)
Rye	14,6	-	-	Rosa *et al.* (2017).
Wheat	10,3 - 12,6	10,2	2,3	BEDCA, (2022)
Wheat bran	42,8	-	-	Rosa *et al.* (2017).
Millet	8,5	-	-	BEDCA (2022)
Quinoa	15,07	12,08	2,89	Das *et al.* (2020)

Table 3. Portion of dietary fiber in 100 g of cereals and edible pseudocereals s

TDF: Total dietary fiber TDF: Total dietary fiber TDF: Total dietary fiber TDI: Insoluble dietary fiber SDF: Soluble dietary fiber

	FDT	FDI	SDS	References
Apple	2	1,8	0,2	Chamorro and Mamani (2010)
Orange	1,0 - 2,4	0,7 - 1	1,1 - 1,4	BEDCA (2022)
Banana	1,0 - 3,4	1.2	0,5 - 0,6	Rosa *et al.* (2017).
Kiwi	1,6 - 3,4	2.6	0,8	Rosa *et al.* (2017).
Melon	0,6 - 1,0	-	-	BEDCA (2022)
Nectary	2,0	-	-	BEDCA (2022)
Figs	2,5	1,1	1,0	Rosa *et al.* (2017).
Pear	1,0 - 3,2	2,0 - 2,2	-	BEDCA (2022)
Raspberry	6,7	-	-	Rosa *et al.* (2017).
Mandarin	1,8 - 1,9	1,4	0,4	Rosa *et al.* (2017).
Watermelon	0,3 - 0,5	0,3	0,1 - 0,2	Rosa *et al.* (2017).
Avocado	1,8 - 6,7	5,5	1,2	Rosa *et al.* (2017).
Grape	0,7 - 2,2	0,3 - 0,7	0,5 - 0,6	Rosa *et al.* (2017); BEDCA (2006).

Table 4. Portion of dietary fiber in 100 g of edible fruit.

TDF: Total dietary fiber TDF: Total dietary fiber TDF: Total dietary fiber TDI: Insoluble dietary fiber SDF: Soluble dietary fiber

	FDT	FDI	SDS	References
Lettuce	1,0 - 1,5	0,9	0,1	INTA, (2016)
Asparagus	1,7			Rosa *et al.* (2017).
Celery	1,7			INTA, (2016a)
Artichoke	8,0			INTA, (2016a)
Green cabbage	2,2 - 2,7	1,8	0,5	Rosa *et al.* (2017);
Onion	1,2 - 1,6			USDA, (2022)
Broccoli	3,0 - 3,3	3,0	0,3	Rosa *et al.* (2017).
Spinach	2,2 - 3,3	2,1 - 2,8	0,1 - 0,8	INCAP (2012)
Carrot	2,8	2,3 - 2,4	0,2 - 0,5	INCAP (2012)

Table 5. Portion of dietary fiber in 100 g of edible vegetables.

TDF: Total dietary fiber TDF: Total dietary fiber TDF: Total dietary fiber TDI: Insoluble dietary fiber SDF: Soluble dietary fiber

In general, FD consumed from natural foods has a 3:1 ratio of FDI to SDF (Rosa et al., 2017). Those high in FDI are wheat flour, bran, peas, cabbage, root vegetables, cereals, and ripe fruits. Foods high in SDS are oats, plums, carrots, citrus fruits, dried green beans and other legumes (Escudero and Gonzalez, 2006).

RECOMMENDED INTAKES

Table 6 shows the recommendations for dietary fiber intake for adults, which range from 18 to 40 g/day depending on the entity or country that establishes it. The WHO/FAO recommend 25 g/day. Despite the consensus on the beneficial health effects of fiber consumption, intake worldwide is only half of the recommended amount (Miller, 2020).

Constipation may be more common during childhood because of an inverse relationship with dietary fiber intake (Jha *et al.,* 2017; Miller, 2014) (Table 7).

TECHNOLOGICAL CHARACTERISTICS OF DIETARY FIBER

The functional properties of FD depend on the SDS/FDI ratio, particle size, extraction condition, polysaccharide structure and plant source (Pathania and Kaur, 2022). Mugdil and Barak (2019) add that fiber length and porosity behavior are associated with its microstructure. Both the source of dietary fiber and the conditions of processing operations affect the microstructure of dietary fiber.

SDS acts as a thickener, gelling agent, filler, emulsifier, fat replacer, in production of edible films and coatings and foam stabilizer. On the other hand, IDF is most useful for stabilizing and texturizing, as well as retarding oxidation, controlling moisture and increasing food stability.

WATER ABSORPTION CAPACITY (WAC)

The hydration or water absorption properties of FD are related to the chemical structure of its constituent polysaccharides, porosity, particle size, ionic form, pH, temperature, ionic strength and type of ions in solution . In addition, the ability of dietary fiber to retain water is related to the source from which originates (Elleuch *et al.,* 2011). Cereal derivatives present the lowest affinity.

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Country	Source	Fiber recommendation
United States	Dietary Guidelines for Americans 14 g / 1000 kcal	28 g / day (per 2000 kcal)
Australia	Eat for Health, Dietary Guidelines	Between 25 and 40 g / day for women and men, respectively.
Canada	Health Canada	25 and 38 g/day for women and men, respectively.
Mexico	Mexico Secretary of Health	25 g / day
United Kingdom	Food Standards Agency, UK British Nutrition Foundation	18 g /
European Union	European Food Safety Authority	30 g / day
India	Indian Council for Medical Research, National Institute of Nutrition	40 g (per 2000 kcal)
Norway	Helsedirektoratet kostråd	Between 25 - 35 g / day
South Africa	Department of Health, Republic of South Africa	Recommended range 18 - 38 g / day, in adults

Table 6. Recommended dietary fiber intake in adults

Source: Miller (2020)

Country/ region	Source	Daily fiber recommendation
USA	National Academy of Medicine	From 1 to 3 years old: 19 g/day From 4 to 8 years old: 25 g/day From 9 to 13 years: 31 g/day (H) 26 g/day (M)
United Kingdom	UK Scientific Advisory Committee on Nutrition	From 2 to 5 years old: 15 g/day 5 to 11 years: 20 g/day From 11 to 16 years: 25 g/day
Europa	European Food Safety Authority	From 1 to 3 years old: 10 g/day From 4 to 6 years: 14 g/day From 7 to 10 years old: 16 g/day

Table 7. Recommended dietary fiber intake in

Source: Schulz and Slavin (2022)

WATER RETENTION CAPACITY (WRC)

Water holding capacity is defined as the maximum amount (mL) of water retained, per 1 g of dry fiber at a certain temperature, soaking time and centrifugation speed, depending on the method used to determine it (Elleuch *et al.*, 2011).

Water retention affects the viscosity of products, making them easier or more difficult to process. Among the factors that influence retention capacity are particle size, pH and ionic strength. This property confers a freshness and smoothness effect on baked products. SDS, given their high water holding capacity, form viscous solutions or gels when combined with water (Zurdo, 2014).

OIL RETENTION CAPACITY (CRAC)

Oil holding capacity measures the maximum amount of oil that can be retained by 1 g of dry fiber after mixing, incubation and centrifugation. This property depends on the surface area and porosity of the fiber rather than its chemical composition (Table 9). IDF, with a greater capacity to retain fat, improve the juiciness and texture of meat products, while low retention avoids greasy sensations in fried products. The variation in fat absorption according to the matrix makes it possible to select fibers for different food applications (Chamorro and Mamani, 2010; Baena and García, 2012).

SWELLING CAPACITY (CH)

Refers to the capacity of the product to increase its volume in the presence of excess water. This property is influenced by the amount, porosity and particle size of the fiber (Baena and Garcia, 2012). A high swelling value of dietary fiber can increase the sensation of satiety, leading to the prevention of obesity.

Products	CRAg (g water/g)	CRAc (g oil/g)
Orange dietary fiber concentrate	7,3	1,27
Peach Dietary Fiber Concentrate	12,1	1,09
Dietary fiber concentrate from dates	15,6	9,75
Lemon peel	6,96 - 12,84	-
Defatted rice bran	4,89	4,54
Sugar cane bagasse (>0.3 mm)	7,5	11,3
Mango dietary fiber concentrate	11	1
Carrot dietary fiber	18,6	5,5
Asparagus by-products	11,4 - 20,3	5,28 - 8,53

Table 9. Water and oil holding capacity of some dietary fiber concentrates and by-products from fruit and cereal processing .

Source: Elleuch (2011)

VISCOSITY

Viscosity is a key property of dietary fiber that influences rheological characteristics in the digestive system. Long-chain fibers, such as guar gum and β-glucan, generate high viscosity and act as thickeners at low concentrations. Soluble fibers with low viscosity, such as gum arabic and inulin, are used to improve the texture and functionality of meat products. Viscosity increases with fiber concentration, but decreases with heat, with water-soluble fibers being mainly responsible for this effect (Pathania and Kaur, 2022; Elleuch *et al.,* 2011).

METHODS OF OBTAINING FIBER

Methods for determining FD are divided into gravimetric and enzymatic-chemical methods, each with subgroups depending on the analysis. Gravimetric methods remove non-fibrous components by enzymatic or chemical solubilization, including chemical-enzymatic, enzymatic-gravimetric and chemical-enzymatic-gravimetric treatments (Table 10).

Enzymatic-chemical methods isolate dietary fiber residues by enzymatic action and release monomeric sugars by acid hydrolysis. These sugars are measured by high pressure liquid chromatography (HPLC), gas chromatography (GC) or calorimetry. Acid sugars are determined calorimetrically or by decarboxylation, while lignin is measured gravimetrically. Table 18 shows the enzymatic-chemical methods and their scope.

PRELIMINARY OPERATIONS TO INCREASE TECHNOLOGICAL PROPERTIES

There are various extraction methods and preliminary operations for obtaining FD from plant resources. Extraction techniques, such as drying, grinding size, solvent extraction and the intensity of the treatments, influence the composition and technological characteristics of the fibers obtained.

RAW MATERIAL DRYING

Drying FD at high temperatures can degrade some components and alter their properties, such as hydration and fat absorption capacity. Different drying methods, such as sun, oven, or freeze-drying, affect physicochemical properties, such as flavor, color, and phytochemical retention (Yang *et al*., 2020). Freeze-drying significantly improves water holding capacity and oil absorption compared to other methods (Rana *et al*., 2015). In addition, controlled temperature and humidity are crucial to maintain the quality of final products, espe-

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Analytical determination technique	Method	Comment
Gravimetric chemist	Crude fiber	Little physiological significance in human nutrition, no relation to the true value of FD.
	Acid detergent fiber	This method gives a good estimate of cellulose and lignin.
	Neutral detergent fiber	Good estimate of IDF. The big disadvantage is that SDS is lost.
	Simplified total dietary fiber	Suitable for FDT analysis in products with low starch content. Overestimates FDT content.
Enzymatic gravimetric	Determines SDS and FDI, but without detailed information on TDF components.	
Chemical-enzymatic-gravimetric	Total dietary fiber (neutral detergent fiber + soluble fiber)	Only for FDT determination and not for SDS and FDI determinations.

Table 10. Gravimetric methods according to the type of dietary fiber to analyze

Source: (Pak, 1997)

Analytical determination technique	Method	Comment
Calorimetric	Southgate Method	It shows the profile of the fiber components. It is complex and overestimates the FD value. Fractionation of FD into soluble and insoluble non-cellulosic polysaccharides.
Gas Chromatography (GLC)	Method of Englyst et al.	Determines non-starch polysaccharides, non-cellulosic polysaccharides and insoluble non-starch polysaccharides. It does not measure lignin.
	Method of Theander et al.	Describes 3 methods to determine FDT or classified into soluble and insoluble. Uronic acids by decarboxylation and lignin by gravimetry. Includes resistant starch and lignin.
High pressure liquid chromatography (HPLC)	Determine residual monosaccharide composition of FD using HPLC. This method seems promising, its accuracy needs to be evaluated in collaborative studies.	

Table 11. Enzymatic-chemical methods according to dietary fiber to analyze

Source: (Pak, 1997)

cially in flour production, where higher temperatures can lead to nutrient losses and lower water holding capacity. In summary, drying at low temperatures, such as freeze-drying, better preserves the functional properties of dietary fiber (Santos *et al.,* 2022).

METHODS OF OBTAINING

The method of extraction of dietary fiber (DF) affects its performance in food applications and in the human body. Factors such as liquid to solid ratio, contact time, temperature, and elicitation method influence its performance, especially in SDS (Hussain *et al.*, 2020). Wen *et al.* (2020) show that ultrasonic microwave-assisted extraction achieves a higher recovery rate of SDS compared to conventional methods. In addition, enzymatic treatments combined with ultrasound offer the best dietary fiber yields, suggesting their potential as alternative low-calorie density thickeners (Kurek *et al.*, 2017).

Liu et al. (2021) demonstrated that enzymatic cellulase treatment of rice bran increased porosity and improved physicochemical and functional properties, such as cholesterol and glucose absorption. Li et al. (2014) found that microwave-, ultrasound-, and cellulase-assisted extraction gave higher yields (14.9%, 16.4%, and 18.7%, respectively) compared with acid hydrolysis (10.3%). Wang et al. (2021) indicated that acid and enzymatic extraction methods in kiwifruit resulted in better cholesterol and glucose uptake capacities than alkaline extraction. In addition, Yan et al. (2019) found that ultrasound-assisted subcritical water extraction in aqueous citric acid provided SDS with higher yield, lower molecular weight, and better thermal stability, although it reduced viscosity and viscoelasticity, which could affect food performance.

PARTICLE SIZE OF

Particle size reduction can affect the structure, porosity, and surface area of FD, resulting in changes in its physicochemical and functional properties (Ma and Mu, 2016). For example, the swelling and water-holding capacity of pea shell fibers decreased, while water absorption slightly increased by grinding, and hydration was faster in the ground product compared to the unground one (Cui et al., 2013).

On the other hand, in lemon residues, particle size reduction resulted in lower water holding capacity and swelling, but at the physiological level decreased the glycemic index and bile acid index (Peerajit et al., 2012). Ma and Mu (2016) observed similar effects in cumin fiber extraction, where particle size had significant effects on these physiological indices.

In a study by Cho et al. (2017), soybean meal with superfine fiber in patties produced less loss during cooking and maintained the texture profile in terms of toughness, gumminess, elasticity, and chewiness. However, the addition of coarse and fine SDS significantly increased toughness and chewiness.

The finer wheat bran induced a higher production of short-chain fatty acids (SCFA) due to its higher accessible surface area. However, superfine milling decreased its water holding capacity, and although it improves nutritional potential, it does not always benefit the quality of the final product (Lin, 2022).

HEAT TREATMENT

When a thermal process is applied to the FD in general, they can behave in a way that varies their structure and final content. Thed and Phillips (1995) investigated the effects of cooking on total FD content in potatoes by evaluating boiling, microwave heating, baking, and frying. The authors found that deep frying (8.92 % m.s.) and microwave heating (9.08 % m.s.) significantly increased total dietary fiber content as opposed to the control (7.60 % m.s.). Chantaro *et al.* (2008) studied the dietary fiber of fresh carrot peels and the effect of blanching. TDF significantly increased from 45.45% m.s. which was the control (untreated) to 73.32% m.s. after blanching. Cui *et al.* (2013) explain that, for wheat bran and apple fiber-based products, boiling slightly increased water holding capacity, while steaming and roasting showed no significant effects; water absorption kinetics were also different for various products

Heat treatments that can alter the chemical composition and the nutritional and functional properties of FD from fruit and vegetable by-product meal are normally used to stabilize a food. A sterilization treatment applied to by-products in onions (autoclaving at 115 °C for 17-31 min), reduced the FDI content and increased the SDS content, improving the SDS: FDI ratio from 1:9, 1: 6, 1:5, 1:4 or 1:3 (depending on the by-product) to 1:2 in all cases (Santos *et al.*, 2022).

INCORPORATION DIETARY FIBER IN THE INDUSTRY

The incorporation of FDs in foods modifies their textural, appearance, rheology, nutritional and sensory properties. Both FDI and SDS are used in solid products such as bread, cakes and cookies, and mainly the soluble one in beverages, smoothies and drinks due to its better dispersion (Marić *et al*, 2018).

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Various fibers are available to the industry, such as inulin, which retains water and forms gels, providing moisture and creaminess, and also replacing fats in low-calorie products. High methoxyl pectins are used in jams and jellies, while low methoxyl pectins replace fat in products such as pastas, ice cream and diet drinks. Oligofructose, a short-chain inulin, is highly soluble and sweet, ideal for baked goods and cereals (Fundación Chile, 2017).

Polydextrose is low in calories and is used as a substitute for sucrose in low-calorie products such as confectionery, bakery and dairy products. Resistant starch, on the other hand, has functional properties as a thickener and stabilizer, improving the viscosity and texture of semi-viscous products.

It is important to consider the functional properties of different fibers when incorporating them into foods, as the amount and type of fiber will affect the color, texture and consumer acceptance of the product.

MEAT PRODUCTS

The addition of FD in meat products generates healthier products; FD reduces and/or replaces fats, which together with antioxidant activity would provide benefits to the health of the consumer as well as to the product, by delaying lipid oxidation. Thus, the FD of vegetable by-products improves CRAg and CRAc and stabilizes both emulsion and cooking yield (Table 12).

DAIRY PRODUCTS

Yogurt and ice cream contain high levels of fat. Replacement with fiber-contributing ingredients such as cellulose gels, guar gums and alginates can be a good substitute for fat, which also improve emulsification, viscosity and foam, reduce syneresis, control melting properties and stimulate ice crystal formation, in ice cream where it reduces fluid loss (Hussain *et al.*, 2020) (Table 13) (Table 13).

FLOUR-BASED PRODUCTS

The addition of lignocellulose and fiber--rich products, such as wheat bran, oat bran, potato peel, has been applied to replace wheat flour in bread production. For bakery products it is widely used as a texturizing agent giving good results. One of the reasons is that FD produces a wide variety of flavors making them attractive and tastier (Popoola *et al*, 2022) (Table 14).

CONFECTIONERY PRODUCTS

Confectionery products lack nutritional value, so SDS plays this role . It is used as a food additive, as a thickening agent giving firmness and adhesiveness to finished products, adding color and aroma (Table 15).

BEVERAGE PRODUCTS

Adding fiber to beverage products is more common than it seems due to the emergence of new dietary fiber-based ingredients. In the case of beverages and drinks, the addition of SDS increases their viscosity and stability, being more widely used because it is more dispersible than IDF in water (Pathania and Kaur, 2022). For example, shorter chain inulin (approx. 10 GP) is suitable for aqueous beverages (Table 16).

CONCLUSIONS

The balanced consumption of foods high in dietary fiber (soluble and insoluble) generates health benefits, reducing non-communicable diseases, improves the quality of the intestinal microbiota and stimulates the immune system.

The fiber intake recommended by WHO/FAO is 25 g/day in adults, varying according to the institution or country that declares other recommendations.

Consumer demand for nutritious and health-promoting foods has generated innovative products in the food industry.

Product	Source of fiber	Results	Source
Mortadella sausages	Black quinoa flour	It increased emulsion stability, decreased lipid oxidation, decreased water activity and changed the color of the sausage. In addition, the addition of nitrite may not be necessary when the quinoa product was added.	Fernández-López *et al.* 2020
Chicken nuggets	Banana flour and soy hulls	It improved the nutritional value, maintained the desired cooking yield and emulsion stability, and helped to improve the instrumental values of texture and color. Lipid oxidation was not affected during storage. Microbial quality and sensory attributes were comparable with the control.	Kumar *et al.* 2011
Chicken sausage	Inulin	Increased inulin reduced hardness, cohesiveness, gumminess and stringiness, but increased elasticity and chewiness up to 25% inulin substitution. Sensory evaluation showed that increased inulin improved mean scores for factors including color, appearance and texture, but decreased mean scores for odor and mouthfeel.	Alaei *et al.* 2018
Beef hamburger	Carrot fiber (FZ) and lemon fiber (FL)	FL increased moisture and cooking performance, while FZ resulted in higher fat and cholesterol contents. Hardness, gumminess, elasticity and chewiness decreased when the level of use of both fibers increased, but FZ performed better compared to FL. Burgers that included FZ were rated with higher sensory scores.	Soncu *et al.* 2015

Table 12. Meat products with added fiber

Product	Source of fiber	Results	Source
Low fat ice cream (Strawberry)	Pitaya shell red	Improved the sponginess and rheological behavior of the sample with a 73.5% reduction in fat. It had a high acceptability.	Utpott et al. (2020)
Yogurt	Inulin	The addition of long-chain inulin to low-fat yogurt improved its brightness and decreased its firmness. But it increased whey separation and did not influence creaminess. The acceptability of low-fat yogurt with added inulin was similar to that of whole yogurt.	Pimentel et al. (2013)
Yogurt	Soluble dietary fiber from carrots	It increased water holding capacity, cholesterol absorption, with more reddish and yellowish coloration. Yogurts with SDS showed higher shear stress, viscosity, consistency index and pH, and lower fluidity index, titratable acidity and syneresis percentage than the control yogurt.	Dong et al. (2022)
Milk Beverage	Inulin (GP ≥ 10 and GP ≥ 23)	Inulin contributed to the physical stability mainly in the particle size distribution. The results of the rheological behavior were essential to demonstrate the better efficiency of inulin with higher GP for the stabilization of milk beverages.	Guimaraes et al. (2018).

Table 13. Dairy products with added fiber

Product	Source of fiber	Results	Source
Cookies	Apple pomace (50%)	Increased TDF and total phenolic content. Consumer acceptance up to 50% incorporation replacing wheat flour, maintaining a pleasant apple flavor and crunchy texture for 12 months.	Zlatanović et at. (2019).
Cake	Potato peel (10%)	It reduced cake hardness, dough color, breaking strength and elasticity values to 10%. Good sensory quality was observed by substituting wheat flour.	Jeddou et al. (2017).
Bread	Guar gum and xanthan gum (0.8%)	It showed better results in frozen storage. It showed an increase in specific volume, porosity, moisture content, and a decrease in crumb hardness. It had good sensory acceptance.	Hejrani et al. (2017).
Pasta	High fiber oat flour	Increased water absorption and swelling index. Decreased cooking loss. It showed a darker color than traditional pasta	Piwińska et al. (2015).
Pasta	Inulin Frutafit HD; GP 12-14; substitution: 2.5, 5, 7.5, 10 and 20%. Inulin LV-100; GP 7-8 substitution: 2.5, 5, 7.5 and 10%.	HD: The impact on technological and sensory properties was minimal, with a significant deterioration of properties when 20% of the product was incorporated. LV-100: Negative impacts on dough firmness, cooking loss, sensory acceptability and a significant reduction in starch hydrolysis were observed only at the 10% level, but the dough was of inferior quality.	Aravind et al. 2012

Table 14. Flour-based products with added fiber

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Product	Source of fiber	Results	Source
Gelatin	Banana peel fiber 5% y 10%	Effects on the hardness, adhesiveness and chewiness of gelatin prepared with 10% fiber extract. On the other hand, the elasticity and cohesion of the gelatin were inversely proportional to the amount of fiber added. Ten percent was preferable because of its stiffer texture, lower water loss and decreased syneresis.	Radzi (2020)
Gummy candies	Pineapple and papaya fiber	The inclusion of 5 g/100g of each powdered fruit peel resulted in candies with stable acidity, soluble solids, water activity and pH. It improved the instrumental color and texture of the powder-free candies, as well as reducing the caloric content and the addition of flavorings to the products.	Romo-Zamarrón *et al.* (2019).
Sucrose-free chocolate	Inulin and β-glucan (25g/100g)	Substitution of 25 g/100 g of the total weight of cocoa butter with an equal amount of inulin resulted in a diet chocolate (without sucrose) with similar acceptability to standard chocolate (with sucrose). The maximum β-glucan concentrate content tested (10 g/100 g chocolate) had a negative impact on rheological and sensory characteristics, with adhesiveness and stronger uncharacteristic chocolate flavor parameters.	Rezende *et al.* (2015)
Gummy candies	Chia Fiber (0.5%; 0.8%; 1.0%)	It presented effect on crude fiber, phenolic compounds, color, firmness and general acceptability in gummy candies. It was determined that the best treatment was the gummy candy with the addition of 15% passion fruit juice and 0.8% chia flour, which presented the highest acceptability, with a crude fiber value of 8.84%.	Amaranth (2019)

Table 15. Confectionery products with added fibers

Product	Source of fiber	Results	Source
Wine fining agent	Grape pomace (OU) and apple (OM)	The use of OU and OM generated positive effects in red wine. Wine tannins were maximally reduced by the application of an OM fiber and an OU fiber, removing 42 and 38 %, respectively. The fibers reduced anthocyanins, total phenols and wine color density. Changes in wine coloration were minor.	Guerrero *et al.* (2013)
Fruit-based beverage	Basil seeds (0.25% and 0.5%)	Increased the amount of nutrients and especially the fiber content. Increased hydrocolloid concentration and improved beverage stability as well as appearance satisfaction, but in cases above 0.25%, mouthfeel satisfaction was reduced.	Hajmohammadi *et al.* (2016).
Diet drink	Chia seed mucilage (0,5; 1,0; 1,5 %)	Acceptance was high in attributes of aroma, viscosity, appearance, acidity, flavor and general acceptance for all trials.	Quispe (2016)
Drink	Oat bran (SDS and FDI)	FDI concentrations above 2% gave the beverage a gritty taste. Samples with β-glucan gave rise to perceptions of smoothness, viscosity, and sticky residue, whereas the sensations of thickness, mouth coating, and cloying were driven by total fiber concentration, regardless of fiber solubility.	Chakraborty *et al.* (2019).

Table 16. Drinkable products with added fiber

The food industry applies dietary fiber as an ingredient to improve technological properties such as water retention and absorption capacity, fat retention, swelling and viscosity, properties that are required to generate a food. In addition, the process prior to its obtaining could generate modifications in the quality and performance of fibers as other compounds.

In general, its application in processed foods improves the quality of meat, dairy, confectionery, bakery and beverage products in terms of texture, nutritional value and increased shelf life, but the result varies according to the type of fiber and the amount applied.

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