Chapter

Introductory Chapter: The Basics of Dietary Fibers

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1. Introduction

The purpose of this chapter is to set the stage to the remainder of the content of the book by providing an overview about dietary fibers, their uses, benefits, chemistry and biochemical aspects. While the chapters are specific, in-depth and detailed, the contents of this particular chapter are kept general, so that readers of the book may gain an understanding of dietary fibers at the very beginning—especially if they are not familiar with this area of study, and go into a deeper understanding thereafter.

2. A brief overview of dietary fibers

Dietary fibers are considered a non-digestible form of carbohydrates, due to the inability of the digestive enzymes to break them down into monomeric units. The amount of dietary fiber in the diet varies based on the type of food and quantity consumed by an individual. The solubility of fibers has a significant impact on their function and therefore, they are classified into two main categories as shown in **Figure 1**.

Dietary fibers that are insoluble, such as cellulose, lignin and hemicellulose have distinct characteristics such as filaments resembling threads, and most insoluble dietary fibers such as numerous vegetables have a rough feel. Dietary fibers that are insoluble are less prone to fermentation as compared with soluble dietary fibers [1]. Sources of soluble and insoluble dietary fibers are shown in **Table 1**. The solubility of some of the commonly sourced dietary fibers is shown in **Table 2**. An overview of non-starch polysaccharides which come under dietary fibers is shown in **Table 3**.

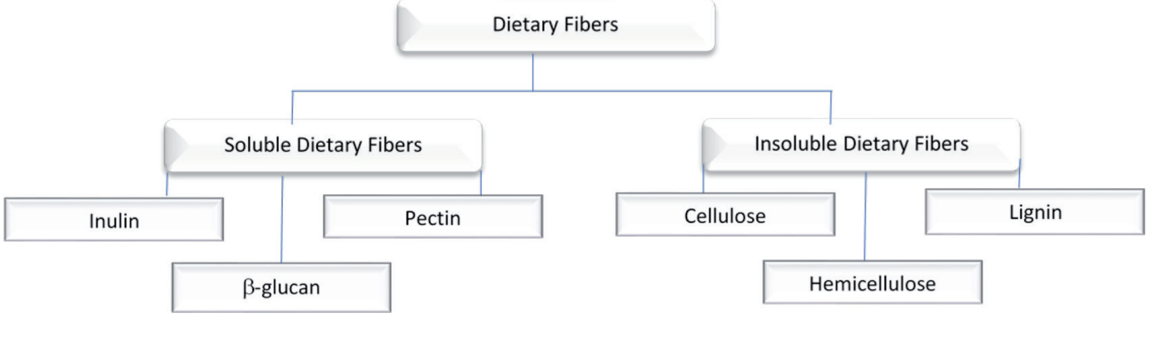

Figure 1.
The classification of dietary fibers (insoluble and soluble dietary fibers).

	Soluble dietary fibers			Insoluble dietary fibers	
Main constituent	Pectin	Gums	Lignin	Cellulose	Hemicellulose
Common food source	Citrus fruits	Oats	Strawberries	Green pepper	Bran cereals
	Apples	Cauliflowers	Pears	Peas	Mustard greens

Table 1.
Chemical constituents and common food sources of dietary fibers.

Polysaccharides / food Ingredients	Solubility
Locust beans—commonly extracted from carob trees	Only soluble in warm water
Carrageenan (Iota type)	Soluble both in room temperature and warm water
Carbohydrate gum also generally known as hydroxypropyl methylcellulose (HPMC)	Soluble in water in room temperature, but not in warm water

Table 2.
Common dietary fibers and their solubility.

Non-starch polysaccharides	Dietary fibers
Polyglucose	Beta-glucan, cellulose and hemi-cellulose
Polyfructose	Inulin

Table 3.
Overview of non-starch polysaccharides and their form of dietary fibers.

3. Dietary fibers of importance

Out of all soluble and insoluble fibers, there are some which are of high importance from a nutritive as well as an industrial perspective which are introduced in brief as below.

3.1 Inulin

Inulin acts as a storage polysaccharide. Inulin has been a component of the human diet since ancient times. According to BeMiller [2], ancient humans have consumed a variety of tubers and roots, some of which contain starch and others which contain inulin or a related gluco-fructan, on all five continents. Thus, it is very likely that incorporation of inulin in the modern-day diet is of importance as well due to consistency and exposure.

3.2 Pectin

The proportion of methylation, or the fraction of carboxyl groups bonded with methanol, is used to categorize pectin products. Pectins are utilized for a range of jellies and jams in the food industry, due to their unique ability to produce spreadable gels [2].

3.3 Beta-glucan

Beta-glucan has been identified as a supportive food ingredient in lowering cholesterol levels in the blood [3]. In addition, studies have showed that beta-glucan has the capability to reduce stress level at occasions [4, 5]. The variety of beta-glucan structures depends on environmental sources. It is a key component of plant cell walls. Cereal-glucan has been associated with lowering the risk of heart disease, whereas yeast-glucan has been observed to primarily boost the immune system's ability to fight cancer and infections [4, 5].

3.4 Cellulose

As the most well-known dietary fiber of all categories, there are several health benefits associated with cellulose including reduction of constipation, decrease in the incidence of diverticulitis, and weight reduction. Owing to its abundance in plant sources, cellulose is the most common form of dietary fiber that is present in the mammalian diet and, therefore, is also the most researched dietary fiber component of all.

3.5 Hemicellulose

Xylose, pentose sugars, and arabinose are components of indigestible hemicellulose [6]. These fibers absorb water while being insoluble and are found in a variety of fruits and vegetables.

3.6 Lignin

Lignin is thought to have gained its name from the Latin word "lignum," meaning "wood." Lignin is composed of phenolic compounds that are covalently linked to polysaccharides. As lignin-rich food are indigestible, they have a distinct feel than other food and are sometimes referred to as "woody." Lignin is an insoluble dietary fiber that helps prevent the formation of bile stones and lower cholesterol [7]. It also has aromatic properties.

4. Health benefits of dietary fibers: a summary

Dietary fibers are a very complicated collection of food components. The consumption of dietary fiber as a whole has several health advantages as it is linked to lower risk of diabetes, gastrointestinal problems, stroke, and hypertension [3, 4]. In the small intestine, dietary fibers have an inherent ability to bind to cholesterol and bile acids, and this ability is hypothesized to be the cause of the hypolipidemic action [5]. The high fiber content of vegetables, food rich in protein, various fruits and whole grains make them appealing targets for the prevention of diseases such as cardiovascular disease and atherosclerosis. Due to the general importance of food fibers, a huge and prospective market for fiber-rich foods and components has developed within in the recent years, and there has been a tendency in recent years to identify specific sources of dietary fiber that could be utilized in the food industry [8]. Soluble dietary fibers are currently used as an ingredient in beverages, and it is becoming a global trend in the food industry at present replacing traditional and other food products that are less in nutritional value [9].

In the study of colon cancer formation, the effects of fiber rich diets on microbial population and fecal matter sterol ratios in the colon have received much interest at present. This is mainly due to the vital properties of dietary fibers [10]. Among the shared effects of soluble and insoluble dietary fibers, weight loss is one of the main benefits that one can experience in addition to decreasing energy density and inflammation [11]. In addition, dietary fibers prevent syndromes such as bowel syndrome and metabolic syndrome [12]. Adequate dietary fiber is necessary for the human body to operate properly and to be healthy, free of NCDs and other diseases and conditions. It is critical that individuals pay closer attention to their daily fiber intake since fiber plays a vital role throughout the human body systems.

5. Physiochemical properties of dietary fiber

Dietary fiber is a polysaccharide mixture with several functional abilities that activates while it moves further in the mammalian gastrointestinal tract. These actions are a result of its physiochemical structure. Some structural properties of dietary fiber that helps in its optimal functionality are discussed in the subsequent sections.

5.1 Particle size and bulk volume

Digestion itself means breaking down of complex molecules into simpler structures. Equally, for dietary fiber, the size of the molecule plays a major role in exhibiting its primary functions such as the time taken for fermentation, bacterial degradation and hydration process.

An experiment conducted on the period of time used for coconut residue to fully undergo the hydration process showed that reduction of particle size from 1127 μm to 550 μm enabled them to retain the hydration properties [13]. In addition, it was observed that the capacity of fat absorption had increased.

5.2 Surface area

The geometrical linkage is an important factor of any molecule, especially in the instance of dietary fiber as it is capable of resisting digestion unlike other starch-based molecules. A major reason for this is its characteristic higher surface area.

The availability of dietary fiber to microbial breakdown in the colon is influenced by porosity and accessible surface, whereas the regiochemistry of the surface layer may play a role in some cases. Moreover, physiochemical characteristics (certain types of adsorption or binding molecules) are also responsible for some of the physiological effects of fiber in the diet. The porosity of the material and the surface area available to bacteria, use of molecular probes such as enzymes or other molecular probes are all dependent on its surface area. However, the fiber's architecture is an aspect that is linked to its origin and history of processing [14].

5.3 Solubility and viscosity

Solubility has a significant impact on the functionality of fiber. It is widely known that soluble, viscous polysaccharides can obstruct nutrient digestion and absorption in the stomach. The polymer is anticipated to be more energetically stable in the solid state than in solution if the polysaccharide structure allows molecules to fit together in a crystalline array [15].

5.4 Cationic binding and organic molecules

While charged polysaccharides (which including pectins *via* their carboxylic acid groups) and related compounds such as phytates in wheat fibers have been demonstrated to bind metal ions *in vitro*, fiber has been associated with limiting absorption of nutrients. Charged polysaccharides have little influence on mineral and trace element absorption, although related compounds such as phytates can be harmful. The capacity of different fibers to sequester and even chemically bind bile acids has been proposed as a possible mechanism by which dietary fibers rich in uronic acids and phenolic compounds may have a hypocholesterolemic effect [16].

5.5 The process of hydration

The hydration characteristics of dietary fiber influence their fate in the digestive tract and explain some of their physiological consequences. Swelling and water retention capacity give a broad picture of fiber hydration and are relevant for fiber-fortified diets. Bulk density reveals more about the fiber, including the substrate pore volume. It contributes to the existing knowledge of how fiber behaves in food and during the gastrointestinal transit. The physical processes that the fibers go through before entering the body alter the physical characteristics of the fiber matrix as well as the hydration properties [17].

6. Physiochemical mechanism of dietary fiber

Dietary fiber metabolizes only through the process of microbial fermentation. It is a plumber of carbohydrates. This is essentially due to the lack of enzymatic matter that is essential for breaking the glycosidic bond. The mammalian gastrointestinal (GI) tract consists of gut micro-biota, which is capable of fermenting. As the fiber moves through the GI tract, the gut micro-biota metabolizes it through fermentation.

Different species of gut bacteria act upon these large polymers of glucose in order to break them into monomers. Primary degraders such as *Bifidobacterium*, *Bacteroides* and *Ruminococcus bromii* that have the ability to ferment glucose from glucose polymers act upon these large polymers of glucose in order to break them into monomers [18].

Due to the lack of enzymes that initiate the cleavage of glucose from glucose polymers, a secondary degrader names *Firmicute* species rely on primary degraders to release glucose monomers. This process takes place in the lumen. After degradation the glucose short-chain fatty acid (SCFA—by-product of fermented dietary fiber), specifically butyrate is absorbed by the colon epithelial cells (bolonocytes). Later, the remaining SCFA enters the circulation by the portal vein (blood that transports to liver) [19].

7. Concluding remarks

The study of dietary fibers remains a vital area of study when it comes to food, nutrition and health. They have been added to a variety of food products as a whole as a food ingredient that imparts several health benefits, especially when it comes to the GI tract and the gut microbiome. As a highly studied area, it is hoped that the contents of this chapter has provided a general understanding of this food component and thereby demonstrated its essentiality as a nutrient, bioactive and ingredient.

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