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Theoretical aspects regarding the nutritional value and methods of extracting food fibers from oats used in baking

Ramona Carmen Romînescu[1*], Adrian Riviș[1], Mariana-Atena Poiana[1]

[1]University of Life Sciences "King Mihai I" from Timisoara, Faculty of Food Engineering, Calea Aradului, No. 119, 300645, Timisoara Romania

Corresponding author: ramona_rominescu@yahoo.com

Background

Dietary fibers have an important role for human health, for a healthy diet, their presence in the daily diet in a certain proportion is necessary. Considering the nutritional value and functional properties, dietary fibers help to increase the feeling of satiety and to improve the functioning of the digestive process. Oats contain a large amount of fiber, more precisely beta-glucans - soluble fibers, which not only have beneficial effects on digestion, also having a role in controlling the increase in blood sugar, and in maintaining an optimal level of cholesterol in the blood, reducing cholesterol from low density lipoproteins. The present review presents the nutritional value and importance of oat fibers in food as well as the study of the most modern methods of fiber extraction with the aim of using them to obtain bakery products with functional potential.

Keywords: Bread, Beta-glucan, Dietary fiber, Extraction, Oats

1. The importance of dietary fibers in foods

Recently, there has been an increase in consumer interest in foods that have a beneficial effect on health. This interest is due to a better education in the field of nutrition, the care given to the state of health obtained through diet as well as the large number of people with certain conditions (cardiovascular, diabetes, allergies of various types, etc.) as well as the desire of the population to increase hope of life and improve the quality of life [1]. Among the foods with health benefits for consumers and which are consumed in fairly large quantities daily are bakery products with fiber that have a high nutritional value.

The importance of dietary fibers in maintaining the health of consumers, by combating or treating a large number of diseases of the contemporary era, has been studied and accepted by specialists. The beneficial effects of dietary fiber are presented in the figure 1 [2].

Due to these effects, fibers improve gastrointestinal health and prevent or reduce susceptibility to some diseases, as well as increasing satiety and weight loss [3].

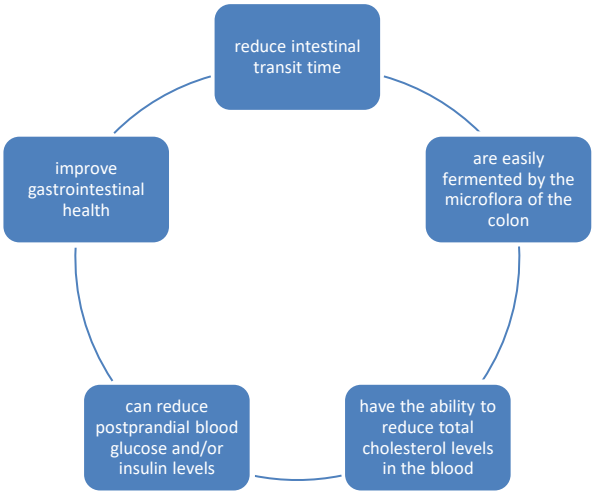

Figure 1. The beneficial effects of dietary fiber [2]

Through a hole drilled to reach the xylem in each tree, sap emerges from birch tree trunks in the early spring. A single season can yield up to 180 liters of sap from birch trees [11] and depending on the species it can typically secrete sap for two to four weeks [12]. The sap that is exuded undergoes seasonal changes in its chemical composition [11].

The effective requirement of fiber in the diet varies according to age, as is presented in the table 1.

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Table 1. The requirement of fiber ration in diet

Correspondents	Age	Ration
Ladies	1-3 years	19 g/day
	4-8 years	25 g/day
	9-18 years	26 g/day
	19-50 years	25 g/day
	Over 51 years	21 g/day
	Pregnant women	28 g/day
	Breastfeeding women	29 g/day
Man	9-13 years	31 g/day
	14-50 years	38 g/day
	Over 51 years	30 g/day

The classification of fibers from a structural point of view and depending on the source is shown in table 2, noting the large amount of fiber from cereals.

Table 2. The main macromolecular constituents of dietary fibers [5]

Constituents	Fruits	Cereals	Vegetabls
Cellulose			x
Hemicellulose			
xyloglucan		-	x
glucuronoxylans		-	-
Glucurono-arabinoxylans	-		-
galactomannans	-	-	x
β- glucans	-		-
Pectins			x
Lignin			-
Phenolics esters	-		-
Proteins	-		-

2. The current state of knowing the nutritional value of dietary fibers from oats used in baking

The importance of fibers in the diet and the health status of the consumer has become a current concern in the last period, their physiological effects being studied, and the correlation of their structure and properties with the mechanisms of action being realized [5].

Enzymes in the human digestive tract cannot hydrolyze the dietary fibers in plant products. Fibers are a group of substances, which differ in chemical structure, physical properties and physiological effects, being generically called dietary fibers [6].

Recently, oats (*Avena sativa L.)* have been considered the right food in the diet of celiac patients. With high nutritional value, food products containing oats are increasingly sought after. The health benefits associated with dietary fiber, such as β-glucan, functional proteins, lipid and starch components, and phytochemicals present in oat grains, have led to increased consumption of oats by the population. [7]. There are approximately 11 g of fiber in 100 g of oats (table 3). The recommended daily intake of fiber is 30 g [8].

Oat fiber, especially beta-glucans, has remarkable nutritional value due to its multiple health benefits, including lowering cholesterol, controlling blood sugar, regulating intestinal transit, inducing satiety, and supporting gut microbiome health.

Table 3. Energy value and nutrient content of oats (g/100g) [8]

Energy value (Kcal/ KJ)	Carbohy-drates (g)		Prote-ins (g)	Fats (g)	Unsaturated fatty acids (g)	Fibers (g)
357 /1499	55,7		16,9	6,9	2,2	10,6
Thiamine	**Folic acid**	**Fe**	**Mg**	**P**	**K**	**Mn**
0,8 mg (72% CR*)	56 µg (28% CR)	4,7 mg (33 % CR)	177 mg (47% CR)	523 mg (75% CR)	429 mg (21% CR)	4,9 mg (245% CR)

**CR – reference consumption*

Dietary fiber in oats is of two types: soluble and insoluble. The insoluble fibers from oats restore the microflora of the intestine and serve as a "scrub" for the stomach, having the role of eliminating residues. Soluble fiber in oats can slow the absorption of carbohydrates and, by implication, the release of glucose into the blood, helping to control blood sugar. The insoluble fiber in oats adds bulk to the stool and helps prevent constipation, promoting healthy intestinal transit. Consuming oat fiber can induce a longer-lasting feeling of satiety, thus contributing to weight control by reducing appetite and caloric consumption. Oat fiber acts as a prebiotic, feeding the beneficial bacteria in the gut and contributing to the health of the gut microbiome [9].

Oat fibers are used as a probiotic, contributing to the restoration of the intestinal flora, by feeding the intestinal bacteria and restoring them. This is also the reason why they improve digestion and help prevent constipation [10].

Oat fiber includes Beta-Glucans, soluble fibers that form a viscous gel in the gut. They are associated with lowering cholesterol levels and improving

cardiovascular health. Recommended dosage is to consume at least 3 grams of beta-glucans per day can help lower LDL cholesterol levels [11].
β-glucan, the soluble fiber from oats, is a linear, unbranched polysaccharide that has the role of reducing blood cholesterol levels, for this, the diet must contain at least 3 g of β-glucan per day [12]. Food fibers from oats are used in the manufacture of functional bakery products, biscuits, yogurts, drinks, bars [13].

3. Study of modern methods of extraction of dietary fibers

Extraction of fiber from food products can be achieved by a variety of physical, chemical and enzymatic methods, each with specific advantages and limitations. The bibliographic references provide a solid basis for understanding the processes of extraction and characterization of dietary fiber from various food sources [14-15].
Physical methods includes grinding and separation of fibres and extraction with solvents.
o *Grinding and Separation:* The process involves grinding the raw material and subsequent separation of the fibers by mechanical methods such as sieving, centrifugation or the use of gravity separators.
o *Solvent Extraction:* Uses non-polar solvents to remove lipids and other soluble components, leaving the fibers insoluble.

Chemical Methods includes alkaline and acid extraction.
o *Alkaline Extraction:* Involves treating the material with alkaline solutions (eg, sodium hydroxide) to solubilize the lignin and hemicellulose, leaving the cellulose and other insoluble fibers.
o *Acid Extraction:* Uses dilute acids (e.g., sulfuric acid) to hydrolyze the soluble components, keeping the insoluble fibers.
Enzymatic methods use specific enzymes for fibre isolation and includes two methods:
o *Use of Enzymes:* Application of specific enzymes (eg cellulases, pectinases) to break down the soluble components and release the fibers in a purer form.
o *Enzymatic Hydrolysis:* The process of hydrolyzing non-cellulosic polysaccharides using specific enzymes to isolate dietary fibers.
Other methods involves combinations of physico-chemical treatments: use of a combination of physical and chemical treatments, such as grinding followed by alkaline treatment, to make fiber extraction more efficient.
The most widely used extraction methods are wet processing methods [16].
Wet milling methods for fiber extraction use water, using various reagents. The following types of wet milling methods have been identified: alkaline wet milling, conventional wet milling, modified wet milling and enzymatic wet processing (figure 2).

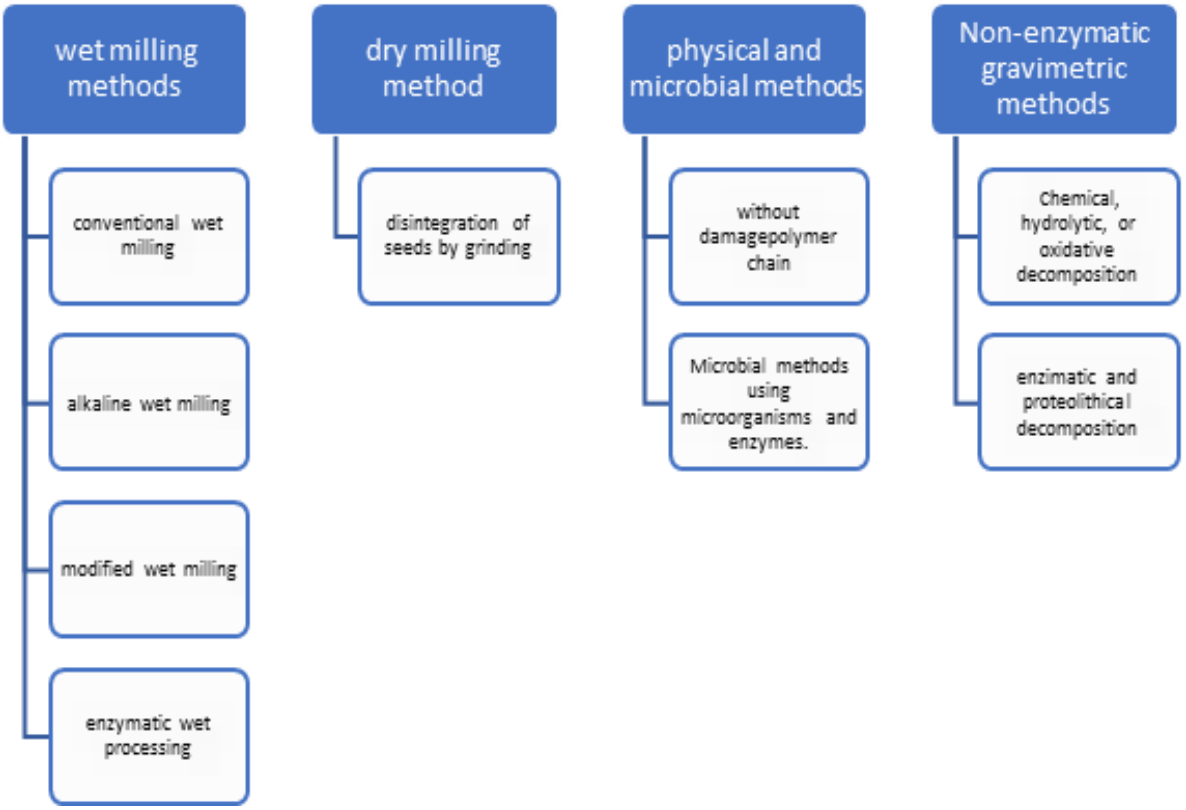

Figure 2. Methods for fibers extraction

In the conventional wet milling method, dehulled seeds are used [17]. These are ground into flour which is treated with an alkaline solution to extract proteins. Proteins are removed by acid precipitation or ultrafiltration. In this method, the softening of the raw materials is carried out with the help of sulfuric acid solution, this process, due to the large amounts of sulfur dioxide (SO2) required during the softening stage, is unfriendly to the environment [18].

As an alternative to reduce the problems associated with SO2, enzymatic wet milling has been developed, in which SO2 is reduced to a minimum, and the enzymes used are protease enzymes (alcalases) that hydrolyze and solubilize the protein that gelatinizes, hydrolyzes and depolymerizes starch, and amyloglacosidase, that cleaves starch fragments into glucose. Unmodified non-starch polysaccharides are recovered by ethanol precipitation, then washed and dried. Fibers are separated and recovered by removing free starch and proteins by passing over a sand sieve [16]. Alkaline wet milling consists of using NaOH (pH 13) and the residue is collected as a fine fiber [19].

Compared to products derived from wheat or rye, oat products are more valuable from a nutritional point of view, able to bring significant health benefits. Oats contain 2-3 times more lipids than other cereals, and have a high protein content that can be an excellent source of amino acids [20]. Compared to other cereals, oats have a lower carbohydrate content, being much more abundant in dietary fibers [20].

The extraction of fiber from oats can be done by various methods, which include physical, chemical and enzymatic methods.

1. Physical methods includes grinding and sieving method. Oats are finely ground and then passed through sieves of different sizes to separate the components based on particle size. This method is simple, but may not be very specific in separating dietary fibers from other components [21].

2. Chemical methods using alkaline extraction method. Oats are treated with alkaline solutions, such as NaOH, to solubilize the non-fibrous components, leaving the insoluble fibers behind. This method can be effective, but requires strict control of conditions to prevent fiber degradation [22].

3. Enzymatic methods. Oats are treated with specific enzymes, such as amylase and protease, to break down starch and proteins, leaving dietary fibers behind. This method is very specific and can produce high purity fibers [23].

4. Combined chemical-enzymatic method. Oats undergo a preliminary chemical treatment to solubilize certain components, followed by an enzymatic treatment to break down other components, leaving behind a fiber-rich fraction.This method combines the advantages of the two approaches for a more efficient extraction [24].

5. Solvent extraction methods usinf ethanol. Oats are treated with ethanol to remove lipids and other components soluble in organic solvents, leaving behind the insoluble fibers.This method is useful to remove fats and other lipophilic substances [25].

4. Conclusions

Following the studies done, we can say that dietary fibers from oats have properties that make them almost indispensable in a healthy diet. The dietary fiber extraction methods developed so far allow the fiber to be obtained from quality agro-food sources such as wheat, rye, barley, oats, potatoes, carrots, lettuce and peas. These soluble fibers can be used in the food industry.These methods offer various ways to extract the fibers from oats, depending on the desired application and the available resources. The selection of the optimal method depends on the specific purpose of the extraction and the required purity of the fibers obtained.

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