Agriculture and Food Sciences Research
ISSN: 2411-6653
Vol. 2, No. 1, 1-5, 2015
http://www.asianonlinejournals.com/index.php/AESR

Dietary Fibers in Grain Species as Sources of Wholegrain Foods

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Abstract

The paper presents the results of an analysis of 20 lots of cereal products (grains and processed grains products) from different geographic regions. The samples were analyzed for dietary fibers content applying the enzymatic-gravimetric method AOAC 985.29. The differences in the amounts of dietary fibers in the individual grain varieties cover wide intervals and vary between 19 and 41% approximately, and between particular types of flour – in the interval 9 – 25% approximately. The obtained results can be used in completing and upgrading the Chemical Composition Tables of Bulgarian Foods as well as respond to the needs of medical dietology and dietetic practice in Bulgaria from the viewpoint of formulation of healthy foods and recipes. Those data can also be used to provide for informed choice through listing of nutritional information on food labels.

Keywords: Wholegrain foods, Flours, Sources, Dietary fibers, Cereals, Analysis.

Contents

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1. Introduction

The health benefits of dietary fibers are indisputably proven by medical science and practice. A number of serious diseases with broad prevalence are favorably affected by the regular consumption of dietary fibers within the frames of implemented dietary regimes. Thus, for example, it has been proven that the consumption of cereals and wholegrain foods (especially those with oats and barley fibers) is associated with protective reactions against cardiovascular diseases in adults [1-5]. They reduce the risk for coronary heart disease [1, 3-6]. A number of research studies outline that wholegrain foods intake (at least 2, 5 g daily) is associated with 21% smaller risk for cardiovascular events. The regular intake of cereals rich in soluble fibers, similar to those in oats, including beta-glucans causes significant reduction of blood cholesterol levels.

The consumption of wholegrain foods reduces the risk for development of colon cancer [7, 8]. This is associated with the effect of dietary fibers in accelerating the intestinal passage through the alimentary canal. The intake of 1 to 3 portions daily of foods rich in dietary fibers reduces the colorectal carcinoma risk in adults with 20% approximately. It has also been established that cereals and wholegrain foods decrease the probability for diverticulitis development [9].

The health effects of wholegrain foods on the risk for development of type 2 diabetes are quite important [10-13]. Studies on nurses have revealed that two portions of wholegrain foods daily could cause a 21% reduction of the risk for type 2 diabetes developments.

The above mentioned diseases are currently associated with overweight and obesity issues. Individuals with overweight tend to energy-dense diets. Foods rich in fibers, such as cereals and wholegrain bread are an adequate effective measure for bodyweight reduction as a particular amount of food introduces much less energy than the same amount of concentrated foods with low fiber content. Foods with high content of fibers need more time for digestion and create a sense of repletion which prevents surfeit.

Wholegrain foods are a constant part of healthy dietetic regimes as, besides fibers, they introduce other bioactive nutrients in the human organism too [2]. They have low natural levels of saturated fatty acids but contain polyunsaturated fatty acids, mainly linolenic acid. They do not supply cholesterol and are an excellent source of slow carbohydrates and protein, of soluble and insoluble fibers and stable starch. Wholegrain foods are also a good source of iron, magnesium, copper, selenium, phosphorus and zinc, as well as of antioxidants and phytochemicals supporting blood cholesterol reduction. They are an important source of B-vitamins including folic acid. Full meeting of folate demands is observed in population groups in fertile age on healthy diets with wholegrain foods [14].

Many plant species included in the diet of the population are natural sources of dietary fibers. Their edible parts, rich in fibers can be consumed directly or can be used as fiber sources added to other processed foods. Some plant foods contain significant amounts of both soluble and insoluble fibers. Those are grains of numerous species, whole fruits and pulses.

Soluble fibers are found in various amounts in all foods of plant origin, including wheat, oats, rye and barley and other grain species, pulses (beans, green peas, soybean, etc.), some fruits and fruit juices (including plums, forest fruits, bananas and the pulp of apples and pears); some vegetables as broccoli and Jerusalem artichoke; tuberiferous plants, such as sweet potatoes, carrots, onions, etc. Soluble fibers dissolve in water and help reduce blood glucose and cholesterol [8].

Whole grains and wholegrain foods are sources of insoluble fibers [15]; wheat and corn bran; nuts and seeds, such as flax seeds; vegetables as green beans, cauliflower, vegetable marrows, celery; some fruits, including avocado and bananas; the peel of many fruits and tuberiferous plants, including tomatoes and plums – an example of fruit with thick peel [15-17]. The insoluble fibers do not dissolve in water and stimulate the peristaltic and passage of the food through the digestion tract, stimulate regular defecation and prevent constipation.

The cereal species used in human diet are numerous: wheat, rye, oats, barley, corn, rice, buck-wheat, millet, triticale, einkorn wheat, spelt. Wheat belongs to the polymorphous genus *Triticum* of the family *Graminea/Poacea*. Winter wheat (*T. aestivum L.*) and hard wheat (*T. durum Desf.*) are cultivated in Bulgaria. Emmer wheat (*T. turgidum L.*), the hybrid between wheat and rye triticale, spelt, einkorn wheat (*T. monococcum L.*) and wild emmer (*T. dicoccum Schrank)* are much less implemented. Those wheat varieties grow in weaker, eroded soils, can be cultivated in semi-mountain regions and recently have gained popularity as ecologically pure and appropriate for dietetics.

The grains consist of three main parts as follows:

- Bran and aleurone layer that in grinding separate as bran, but contain the fibers, unsaturated fatty acids, vitamins and minerals;
- Endosperm – the main internal part of the seed containing mainly starch;
- Germ – the smallest part of the seed containing vitamin E, folate, thiamin, the minerals phosphorus and magnesium.

The available literature evidence on health benefits of wholegrain foods and dietary fibers in them enable constant monitoring of the content of ballast substances in cereals, popular in the individual countries and promoted as sources of such substances, adequate for dietetic purposes. The aim of this survey is to determine the content of total fibers in cereal and flour lots used by the Bulgarian food industry in the production of dietetic foods.

2. Material and Methods

Samples of 20 lots of cereals (grain and grain products) of various geographic origins were delivered in 2014 to the Laboratory for analysis of dietary fibers content.

The analysis was made with the implementation of the enzymatic-gravimetric method AOAC 985.29 for determination of dietary fibers content.

Laboratory samples were prepared for the tasks of the analysis. The results are a mean value of three parallel samples of each type with listed standard uncertainty.

3. Results and Discussion

The results of the analysis of total fiber content in various grain types are presented in Table 1:

Table-1. Content of total dietary fibers in cereals

STUDIED CEREAL PRODUCTS	DF ± SU*, %
Wheat grain - Bulgaria	41,13 ± 0,41
Wheat grain - Bulgaria	24,82 ± 0,25
Wheat (soft) - Bulgaria	19,06 ± 0,14
Wheat (hard) - Bulgaria	19,23 ± 0,14
Wheat soft grain - USA	29,46 ± 0,29
Einkorn wheat grains – Bulgaria I	13,50 ± 0,10
Einkorn wheat grains – Bulgaria II	19,38 ± 0,14
Einkorn wheat grains – Bulgaria III (Galabovo)	31,59±0,31
Einkorn wheat grains – Italy	25,60 ± 0,26

* SU – Standard Uncertainty

In Bulgaria wheat is the major agrarian crop, cultivated on 10 – 15 million decares [18]. The most popular is the so called winter wheat used for production of bread grain and forage. Southern Bulgaria and the Northern region near the Black Sea provide good conditions for cultivation of hard wheat – adequate for the production of pasta, hulled grains, etc. Recently some wheat varieties also have gained popularity, especially einkorn wheat.

Einkorn wheat (*Triticum monococcum*) has uncultivated and cultivated forms and subtypes. Emmer wheat (*Triticum dicoccum*) is a type of wild wheat. In the mesolite - neolite period emmer wheat has been widely used as plant food, replaced later by cultivated wheat.

Spelt (*Triticum spelta*) known in Bulgaria also as “dinkel” is a type of ancient wheat. It has been a major food in some parts of the near East and Europe since the Bronze Age until the Middle Ages [19]. Nowadays it is perceived as healthy food as it has a higher content of proteins than wheat as well as more fibers, vitamins and minerals. It contains almost twice more vitamin A and B vitamins, fats, phosphorus and proteins, but minimal gluten amounts. The flour obtained from spelt is fine and the bread, biscuits and pasta made of it are very tasty.

Our studies refer to wheat and einkorn wheat grain. The results are an example for significant differences in the total fibers content in the various grain types. This content in the various grain varieties from Bulgaria varies in a very broad interval (approximately 19 – 41%). Soft wheat grain, imported from the USA is a medium fiber source. Yet greater differences are shown by the individual einkorn wheat lots – the fiber content in them varies from 13 to about 31 %, and the Italian lot contains 25% of ballast substances.

Flours are powder-like food products obtained by grinding certain grains. Most often they are produced from wheat and its varieties, oats, rye, corn, millet, rice, buck-wheat, etc. Flours are used for production of traditional cereal foods – bread and bakery, confectionery, pasta, cereals, etc.

The technological processing of grains causes a significant loss of micronutrients. When it is ground into flour, most useful components are removed with the bran. High-quality white flours contain significantly less vitamins and minerals than dark and wholegrain flours. Currently the modern mills produce various flour types with/without removal of the bran and germ.

Refined white flours are produced from the endosperm with elimination of the bran and germ. This process causes loss of fibers, vitamins, minerals, antioxidants and other bioactive substances. The latter can be added back in refined flours but similar actions cannot compensate for the losses fully. Refined flours are used for the production of white bread, pasta, bakery, sweet or salty biscuits, wafers, pizza, cakes and pastry. Those products usually contain high levels of added sugar, fats or salt, their glycemic index is higher than that of their wholegrain equivalents. The consumption of refined cereal products causes sharp elevation of blood sugar and a strong pancreatic reaction.

Wholegrain flours are natural products obtained by grinding of the whole grain without removal of any fractions from it Duleva [20]. The bran of the grain contains great amounts of minerals, iron, copper, selenium, magnesium, B-vitamins, and also has a substantial amount of ballast substances. When the whole grain is ground to wholegrain flour, we achieve a product that has all substances from the composition of wheat, corn or rye preserved [20]. From medicobiological point of view flours of whole grains, produced by the so-called simple grinding are the most valuable. They are rich in vitamins, minerals, cellulose and proteins. From technological point of view, though, they are of low quality as they are unstable for storage and have poor bakery qualities.

Wholegrain flours and their products contain the three parts of the grain – bran, germ, endosperm. Wholegrain cereal products are very diverse – various types of wheat, rye and combined bread, pasta, wholegrain cereals, croup, oatmeal, brown rice, extruded products, variegated combined grain mixtures. The dietetic practice implements also the grain fragments rich in fibers and bioactive substances – wheat bran, germs etc.

Rye flours have different chemical composition and bakery qualities from those of wheat. The bread made of rye flour is dark, with small volume, poor porosity, sticky, wet inner part. The proteins in the rye flour contain basic fractions – gliadin and gluten in almost equal amounts. The amino acid composition of rye flour proteins is close to that of wheat proteins but they have greater content of the essential amino acids lysine and threonine. Rye flour contains more own sugars and easily soluble polysaccharides and trisaccharides that are hydrolyzed to hexoses.

Corn flour contains a large amount of carbohydrates, where the amount of starch is the greatest reaching up to 85%. It is poor in proteins and amino acids and relatively richer in fats, which determines its short shelf-life. The corn flour bread has coarse, solid, non-elastic and quickly drying inner part, small volume and crackled crust. Because of those bakery qualities corn flour is not used individually but as an additive (up to 15%) to wheat flour.

Table 2 presents the results from our analysis of total fibers in various wheat, rye, einkorn wheat and spelt flour types.

Table-2. Content of total dietary fibers in flours

Analyzed Cereal Products	**DF ± SU*, %**
Wholegrain wheat flour - Bulgaria I	16,41±0,30
Wholegrain wheat flour - Bulgaria II	23,40 ± 0,23
Wheat flour type 400 - Bulgaria	9,01 ± 0,07
Wheat flour type "dark" - Bulgaria	16,12 ± 0,12
Wholegrain rye flour - Bulgaria	20,10 ± 0,15
Rye flour type 1000 - Bulgaria	13,47 ± 0,10
Einkorn wheat flour - Bulgaria I	16,39 ± 0,12
Einkorn wheat flour - Bulgaria II	15,92 ± 0,12
Wholegrain wheat flour - USA	25,35±0,25
Wholegrain wheat flour "PASTRY" - USA	18,52 ± 0,14
Spelt flour - USA	12,41±0,09

* SU – Standard Uncertainty

The main criterion for determination of the wholegrain extent of flours is the ash content – the higher the ash content, the higher wholegrain extent the flour has. The value of the ash content specifies the flour type and is specially marked when writing the flour type. The number specifying the flour type corresponds to its ash content in mg/100 g, transposed in percents [20]. For example, flour "type 1150" has ash content of 1.15%.

Flours with high ash content contain a big relative rate of the grain bran, they have darker color, more vitamins, minerals and enzymes. Flours with higher ash content contain more proteins but their bakery qualities are worse. The flours that are most widely used in Bulgaria are:

- Wholegrain wheat flour, ground from whole grains, not sieved in any way – type 1850 (also called "Graham");
- Type 2000 – wholegrain einkorn wheat flour;
- Type 1750 – wholegrain rye flour;
- Type 1000 – partially refined rye flour;
- Type 1150 – partially refined wheat flour, called in Bulgarian practice "tipovo";
- Type 500 and type 400 are white wheat flours.

The obtained results concerning wheat flours show a relatively high content of total fibers but too large differences between various lots declared as wholegrain. The differences established between the two rye lots are absolutely explicable – the wholegrain one contains a much greater percentage of fibers compared to the partially refined of type 1000. The imported USA lots of wholegrain wheat flour have high fiber content.

According to international literature sources [21, 22] lower content of total dietary fibers is detected in analogous products analyzed by the same enzymatic-gravimetric method 985.29, respectively:

- For wholegrain wheat flour the values vary in the interval 9,9 – 13,8% [22];
- For wholegrain rye flour the fibers are from 12,9 to 16,7% [1.1]; 14,8 % [21]
- For wholegrain wheat the total fibers content is 12,0% [21];
- For flour made of wheat and rye, 40% wholegrain - 7,5 % [21].

The differences in the quantities of fibers in those cases could be substantiated by the characteristic features of the geographic regions as well as by the type and variety of cultivated wheat types [15].

There are no specified standard requirements to the content of dietary fibers in flours. The producers of dietetic bread and dietetic cereals, though, must be well informed about the composition of flours, produced by the mills and especially about those flour assortments, declared as wholegrain. The quality certificates of the flours have to contain mandatory clauses stating the dietary fibers content. This also requires unification of the analytical methods. Our opinion is that AOAC 985.29, implemented in this study, is the most appropriate referent method for determination of total fibers. Only in the presence of those conditions the dietetic bread and cereals assortments would be able to maintain constant composition and quality and to comply with the stated health pretensions for wholegrain dietary products.

4. Conclusion

We should confirm the advice of experienced specialists in dietetics:

- "Substitute white rice, white bread and white pasta with brown rice and wholegrain products";
- "For your breakfast chooses those cereals that have a wholegrain component as their first ingredient".

The current agrarian policy and food industry present broad possibilities for production of variable high quality cereals, rich in dietary fibers and relevant vitamins, minerals and essential bioactive substances, necessary for the healthy diet and high life quality of the contemporary people.

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