

Robert M. Kerr Food & Agricultural Products Center



FOOD TECHNOLOGY FACT SHEET

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Fiber: Bulk of Life

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Summary

Parents and grandparents called it bulk or roughage, but today it is called fiber. It gives individuals almost no energy or calories, but fiber – generally cell walls and/ or polysaccharides of plant foods not digested nor absorbed by the human gastrointestinal tract – has an important impact on bodies. It helps maintain good health and helps protect from colon cancer and heart disease, constipation, hemorrhoids, and diverticulosis. Fiber keeps individuals comfortable by helping to regulate bowel functions plus it may also contribute to regulate blood sugar levels, lower cholesterol, and control weight. That's an impressive track record for something that is not even digested!

A number of dietary fiber components are resistant to digestion. Examples are gums and mucilages and other components (i.e., cellulose, hemicellulose, lignin) that form the membranes of fruits, vegetables, and grains. Recently, products containing starch products resistant to digestion have been created and are available commercially. Resistant starches are generally made from cereal starches and when used in baked products, increase dietary fiber without drastically affecting their taste and appearance. This could be a way to increase dietary fiber in parts of the population that are more likely to choose low fiber foods. However, as will be discussed later, this is still under research.

Research has linked a high-fiber diet with reduced risk of certain chronic and life-threatening diseases. A diet rich in fiber also provides important, natural, chemical compounds, antioxidants, vitamins, and micronutrients that aid in good digestion and overall good health.

According to the American Dietetic Association, 20 to 35 grams per day of fiber is needed for bodies to work well. Most Americans get only half that amount or

about 11 grams (1). Fiber products or supplements for regularity have been around for a long time and recently have become popular as part of weight-loss programs. However, excessive use of fiber supplements can lead to serious digestive problems. The safest and most beneficial sources of fiber are in foods. Food sources are more efficient and supply additional nutrients. When the body has sufficient fiber and water, toxins and cancer-causing agents move quickly through the intestinal tract without lingering in the colon. Dietary fiber also excretes bile acids, which are used by the body to produce cholesterol.

Whole Grain Foods

When it comes to weight control, research has shown that whole grain foods containing oats, bran, and brown rice have an advantage over highly processed, low-fiber grain products. Fiber-rich whole grains foods are more filling and compared to refined grain products, consuming whole grain foods is related to better control of body weight (2). A number of Oklahoma Cooperative Extension Service publications provide additional information on carbohydrates in the diet and weight management (3).

Soluble and Insoluble Fiber – Our Bodies Need Both

Soluble fiber

Soluble fiber forms a gel when mixed with liquids and is associated with lowering cholesterol and controlling blood sugar. It is found in bran (rice, oat, rice, barley, and corn); white-flour products (white bread, bagels, pasta, etc.), and in some fruits and vegetables, especially in legumes, such as peas and beans (Table 1, Fig. 1).

Oat bran and the other soluble-fiber foods lower

The Oklahoma Cooperative Extension Service Bringing the University to You!

The Cooperative Extension Service is the largest, most successful informal educational organization in the world. It is a nationwide system funded and guided by a partnership of federal, state, and local governments that delivers information to help people help themselves through the land-grant university system.

Extension carries out programs in the broad categories of agriculture, natural resources and environment; home economics; 4-H and other youth; and community resource development. Extension staff members live and work among the people they serve to help stimulate and educate Americans to plan ahead and cope with their problems.

Some characteristics of the Cooperative Extension system are:

- The federal, state, and local governments cooperatively share in its financial support and program direction.
- It is administered by the land-grant university as designated by the state legislature through an Extension director.
- Extension programs are nonpolitical, objective, and based on factual information.

- It provides practical, problem-oriented education for people of all ages. It is designated to take the knowledge of the university to those persons who do not or cannot participate in the formal classroom instruction of the university.
- It utilizes research from university, government, and other sources to help people make their own decisions.
- More than a million volunteers help multiply the impact of the Extension professional staff.
- It dispenses no funds to the public.
- It is not a regulatory agency, but it does inform people of regulations and of their options in meeting them.
- Local programs are developed and carried out in full recognition of national problems and goals.
- The Extension staff educates people through personal contacts, meetings, demonstrations, and the mass media.
- Extension has the built-in flexibility to adjust its programs and subject matter to meet new needs. Activities shift from year to year as citizen groups and Extension workers close to the problems advise changes.

blood cholesterol in some people when eaten as a part of a low-fat diet and so decrease the risk of heart disease. Soluble fiber can help control blood sugar in people with diabetes and could reduce their insulin requirement. Diabetics should follow a high-fiber diet only under medical supervision.

Insoluble fiber

Insoluble fiber absorbs water, but does not form a gel, and passes through the digestive tract largely intact. Foods high in insoluble fiber include wheat bran, popcorn, brown rice, cereals, pastas, and whole-grain breads. Legumes, fruits, and vegetables are also high in insoluble fiber (Table 1, Fig. 1).

High-fiber foods take longer to chew and provide a feeling of fullness. Insoluble fiber consumed from fiber-rich foods instead of high-fat, high-calorie foods has helped in weight control. Snacking on dried or fresh fruit, whole grain bread, roasted soybeans, or popcorn (without butter) can satisfy cravings without adding much calories.

Regularity can be improved by increasing the insoluble fiber in diets. Eat whole-grain breads and cereals and fruit and vegetables on a daily basis. Whole-wheat bread provides two or more grams of dietary fiber per slice, while white bread supplies about 0.5 gram per slice (4). White bread is the most common source of dietary fiber for many Americans. In fact, a recent food consumption study showed bread is the top fiber source for children, with white bread supplying about half of the usual fiber intake.

Starches that Escape Digestion

The portion of starch that escapes digestion is known as resistant starch. This type of starch is naturally present in all foods that contain starch. The amount of resistant starch varies according to a number of factors including its origin or source, how the food was processed, stored and eaten. Researchers estimate that about 3 to 7 grams of resistant starch are eaten daily in Europe and Australia (5). Resistant starch acts as dietary fiber because it is not digested by healthy humans. Its physiological benefits, compared to dietary fiber, are currently subject of intensive research.

Several forms of resistant starch ingredients made from corn with high percentage of amylose, are available commercially. Resistant starch ingredients have a dietary fiber content ranging from 30 to 60 percent. These products are fine white powders that do not affect the color, texture, and flavor of baked products at levels lower than about 10 to 15 percent of the total flour.

Some of the baked products marketed as low carbohydrate may contain resistant starch among other ingredients. These products are made with higher quantities of proteins and non-caloric polysaccharides like gums and resistant starch. The net carbohydrates are presently calculated by subtracting dietary fiber and sugar alcohols from the total carbohydrates. Sugar alcohols are added as humectants to improve baked products texture and mouth feel. They generally are not digested in the human intestinal track, therefore, do not contribute to the total calories in a product. By the end of 2004, the Food and Drug Administration suggested the parameters used for calculating net carbohydrates in food labels, as well as defined specific thresholds for carbohydrate claims on package labels (6).

Recommended Daily Dietary Fiber for Adults

The recommended intake of dietary fiber varies depending on age and gender with a range from about 25 to 38 grams per day (7). The Dietary Reference Intake is 14 grams per 1,000 kilocalories. Nutritionists recommend getting dietary fiber from fruits, vegetables, seeds, whole-grain foods, popcorn, brown rice, and whole grain cereals, pastas, and bran. Food sources are more efficient than fiber supplements and will supply additional nutrients. About 65 to 85 percent of the vitamins, minerals, and micronutrients in grains are found in the bran and germ. When grain is refined (processed), as in white flour and white rice, the outer parts of the grains are removed. Some vitamins and minerals are added back to some refined grain products, but fiber and other micronutrients are not restored. Micronutrients have important biological functions that contribute to good health, but are needed in small amounts (8). The diagram in Figure 1 shows examples of foods rich in soluble and insoluble fibers. Table 1 shows total, soluble fiber and insoluble fiber content of selected foods and food products per serving size.

Effect of Processing on Dietary Fiber

Processing, such as boiling, microwave, and pressure cooking, decrease the dietary fiber content of foods. Cooking legumes can reduce dietary fiber around 20 to 25 percent (9), and extrusion cooking of cereal brans reduces the insoluble fiber but increases the soluble fiber (10). The decline of insoluble fiber is due to a decrease in the molecular size of the dietary fiber components. A report pointed out reduction of the molecular weight of the soluble fiber in oats after it was dried, exposed to semi-dry heat treatment, or frozen storage (11).

Table 1. Dietary Fiber in Selected Foods*¹

	<i>Serving Size</i>	<i>Total Fiber (grams)</i>	<i>Soluble Fiber (grams)</i>	<i>Insoluble Fiber (grams)</i>
BREAKFAST CEREALS				
All-Bran	1/3 c (28 g)	8.43	0.59	7.84
Cornflakes	1 1/4 c (28 g)	1.20	0.14	1.06
40% Bran-type	3/4 c (28 g)	5.46	0.56	4.90
Oatmeal, regular, cooked	1 c (234 g)	4.45	1.64	2.81
Puffed rice	1 c (28 g)	0.53	0.14	0.39
Shredded Wheat	2/3 c (28 g)	3.16	0.31	2.86
Wheat germ	1/4 c (56 g)	7.84	0.62	7.22
FRUITS				
Apple, no skin	1 med (138 g)	2.07	0.28	1.79
Apple, with skin	1 med (138 g)	2.76	0.28	2.48
Banana	1 med (114 g)	1.94	0.57	1.37
Cantaloupe	1/4 (133 g)	0.93	0.13	0.80
Grapes	20 (100 g)	1.00	0.10	0.90
Orange	1 med (131 g)	2.49	0.79	1.70
Pineapple, canned	1/2 c (125 g)	0.88	0.13	0.75
Raisins	1/4 c (36 g)	1.51	0.22	1.30
Strawberries	1 c (149 g)	2.68	0.60	2.09
Beans, green	1/2 c (67 g)	1.27	0.34	0.94
Broccoli, raw	1/2 c (78 g)	2.57	0.23	2.34
Cabbage, raw	1 c (70 g)	1.19	0.07	1.12
Carrots, raw	1 med (72 g)	1.80	0.14	1.66
Corn, frozen, cooked	1/2 c (83 g)	1.74	0.08	1.66
Potato, no skin	1 med (156 g)	2.03	0.47	1.56
Potato, with skin	1 med (202 g)	5.05	1.21	3.84
Turnip greens, frozen	1/2 c (82 g)	2.05	0.08	1.97
LEGUMES				
Kidney beans, canned	1/2 c (128 g)	6.66	1.41	5.25
Pork and beans, canned	1/2 c (128 g)	5.63	1.79	3.84
Peas, green, frozen	1/2 c (80 g)	2.80	0.24	2.56
BREADS, PASTA				
Bread, white	1 sl (25 g)	0.65	0.15	0.50
Bread, whole wheat**	1 sl (28 g)	2.59	0.57	2.02
Rice, regular, cooked	1/2 c (102 g)	0.41	0.10	0.31
Spaghetti, cooked	1 c (140 g)	2.10	0.56	1.54

*Most of the values in this table were adapted from Marlett, J.A. Content and composition of dietary fiber in 117 frequently consumed foods. *J. Am. Diet. Assoc.* 92:175-186, 1992.

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Recommended Daily Dietary Fiber for Children

Research shows that children who had eight servings of ready-to-eat cereal over 14 days were 75 percent less likely to be overweight than children who ate three servings or less (12). Experts suggest children older than the age of two eat grams of fiber equal to their “age + 5” each day up to the Dietary Reference Intake value. That means that a three-year-old needs eight grams of fiber daily, while an 18-year-old should eat 23 grams a day (1). Additional general information about food and young children is available at OSU Cooperative Extension Service publication T-3155 by Dr. Janice Hermann (13).

Fiber Products

One tablespoon of a fiber product or supplement will give approximately 10 grams of additional dietary fiber. There are several fiber components in these products:

- Cellulose and hemicellulose, which are insoluble compounds that absorb water and have a laxative effect.
- Lignin, which is insoluble, absorbs little water and lowers cholesterol.
- Gums and pectin, which are soluble compounds and decrease fat absorption, lower cholesterol, and slow sugar absorption.

Among the fiber products is psyllium, a mucilaginous material prepared from the seed husk of *Plantago* genus (*Plantago psyllium* and *P. ovata*) commonly known as plantain. Psyllium contains approximately eight times more soluble fiber than oat bran on a per weight basis and is known as an excellent dietary source of both soluble and insoluble fibers (14, 15). It is an ingredient used in some products such as Metamucil. To promote bowel movement some functional foods have been developed using psyllium and marketed for reducing total serum and LDL cholesterol (14). Psyllium containing products absorb large quantities of liquids and require the consumption of plenty of water. Fiber-containing foods, such as whole grain cereal foods, have advantages over purified fiber supplements. One example is the presence of antioxidant compounds, such as phenolic compounds, that prevent oxidative stress initiation and progression.

Potential Problems

Increased dietary fiber eaten is to lower the amount of minerals the body absorbs (bioavailability). Foods containing fiber also contain phytates and oxalates, which bind minerals and prevent them from being absorbed by the body. When increasing fiber intake, ask your physi-

cian if a mineral supplement is needed and for advice on pre-existing gastrointestinal problems and consumption of adequate amounts of water.

Guidelines for Daily Fiber in Diets

Daily intake of fiber is important. The following guidelines have been widely published by health agencies and nutritionists.

Maintain a Balance

Balance is a key concept in getting enough dietary fiber for good health, regularity, and weight loss. Placing too much emphasis on one type of fiber or fiber-rich food is risky. Excessive amounts of insoluble fiber (such as wheat bran) to the exclusion of soluble fibers will result in a bulky diet and the benefits of the soluble fiber will be lost. Be careful about getting too much fiber too soon. Eating too much can cause bloating, constipation, or diarrhea. Start adding fiber to your diet slowly, increase the amounts gradually, from a variety of fiber-rich foods.

Eat a Variety of Fiber-Rich Foods

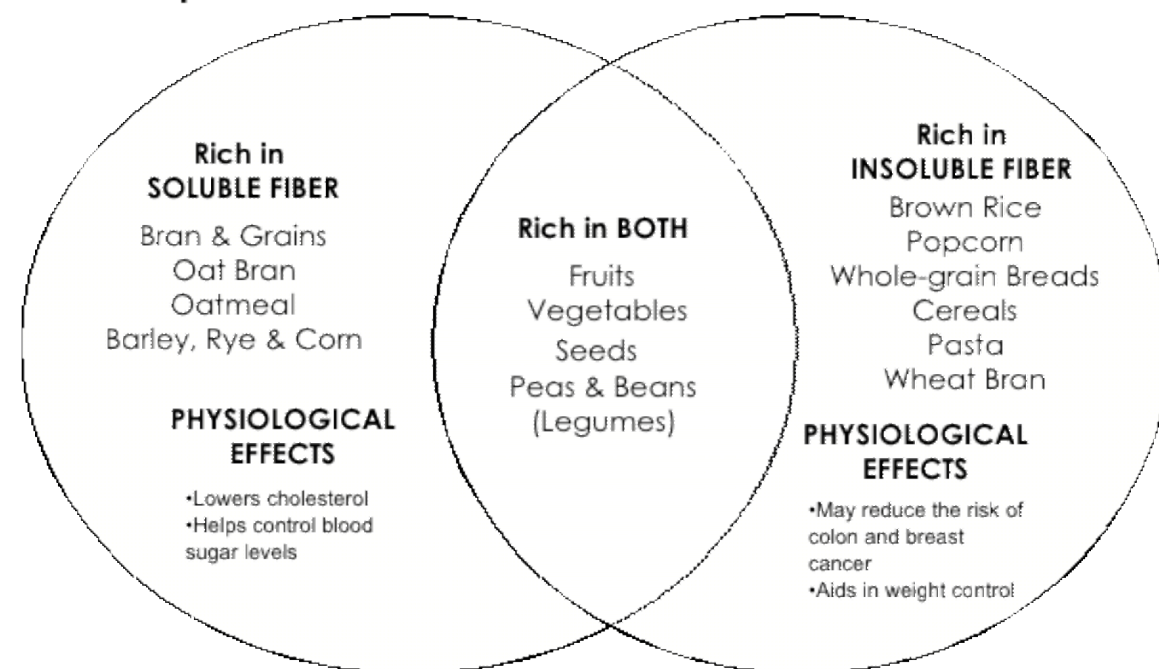
The Dietary Guidelines of Americans recommend eating fiber in the following ways:

Every day

- **Eat three or more servings of various vegetables.** It takes one cup of raw leafy greens or ½ cup of other vegetables to make one serving. Eat dark-green leafy and deep-yellow vegetables, as well as dry beans and peas often. One-half cup of cooked dried beans or peas counts as a serving of vegetables and may also count as one ounce of a meat serving.
- **Enjoy two or more servings of various fruits.** Examples of serving sizes are one medium apple, orange, or banana; ½ cup of canned fruit; or ¾ cup of juice. Include citrus fruits or juices, melons or berries in diets regularly to get vitamin C. Select fruits as desserts.
- **Have six or more servings of grain products** such as breads, cereals, pasta, and rice. A serving is one slice of bread, ½ bun, bagel or English muffin; one ounce of dry cereal; and ½ cup of cooked cereal, rice, or pasta. To boost fiber, have several servings of whole-grain breads and cereals daily and eat products from a variety of grains.
- **Drink plenty of water: 6 to 8 glasses or 3 to 4 bottles of liquids (20-24 ounces)** to reduce the risk of abdominal discomfort and intestinal

Figure 1

Snapshot of foods rich in soluble and insoluble fiber



blockage caused by too much fiber.

- **Make food choices that enrich the fiber in daily diets.**
- **Choose whole-grain and bran breads.** Whole grain should be the first listed ingredient.
- **Choose a high-fiber breakfast cereal every day.** Look for cereals with more than 3 grams of dietary fiber per serving. There are many in the store and many new ones appearing all the time, so be sure to read the labels.
- **Serve whole fruits and vegetables and eat the skins and membranes.**
- **Experiment with dried beans and peas,** such as pinto beans, black beans, and lentils.
- **Sprinkle seeds over salads, casseroles, and vegetable dishes.** Include sunflower seeds; sesame seeds; flax seeds; pumpkin seeds; and spice seeds, such as caraway, dill, celery, cumin, etc. Snack on seeds instead of chips.
- **Snack on high-fiber foods** such as popcorn, soybeans, sunflower and pumpkin seeds, and fresh and dried fruits (figs, raisins, and prunes).

Conclusion

In today's society with increasingly busy schedules, bodies are not getting the nutrition that they were designed for and need. People are tempted to eat whatever takes the least time and effort: frozen dinners, fast food, and snacks grabbed off the shelf. Not many individuals get the fiber their bodies need to work efficiently and feel comfortable. Even people who consider their diets to be healthy and balanced rarely get enough fiber on a daily basis. If people plan their meals and snacks to include increased amounts of high-fiber foods, they will also be increasing overall health and well-being, and helping to prevent common disorders and catastrophic diseases.

Americans have the opportunity make healthier food choices and contribute to the health and nutritional education of present and future generations by encouraging children, teens, and young adults to make healthier food choices, too.

The consumer voice counts. People can use their buying power and restaurant food choices to influence the food industry and make healthier foods more easily and readily available. An achievable goal may be to start consuming three serving of fiber rich foods on a daily basis.

Appendix

Highlights from reports on the health effects of fiber.

Cancer

Researchers have consistently found a reduced incidence of colon cancer in people who have low total fat and high fiber intake, and studies suggest people who eat the most fiber have the lowest risk of developing colorectal cancer (16). Men who consumed 12 grams of fiber per day were twice as likely to develop pre-cancerous colon changes as men whose daily fiber intake was about 30 grams (17). In one study, researchers asked about the diets of 33,971 Americans without colorectal adenomas (growths that can lead to colorectal cancer) and 3,591 Americans with such growths. Adenoma risk decreased steadily with increased fiber intake. In another study of almost 520,000 Europeans, it was reported that those who ate the most fiber had a 25 percent lower chance of developing colorectal cancer than those who ate the least. A lower risk of colorectal cancer is only one of several health benefits associated with fiber (16).

Digestive disorders

Constipation

Insoluble fiber aids digestion and adds bulk to stool, hastening the passage of fecal material through the intestines. *Insoluble fiber helps prevent or relieve constipation.*

Diverticulitis

Fiber also may help reduce the risk of diverticulosis, a condition in which small pouches form in the colon wall, usually from the pressure of straining during bowel movements. People who already have diverticulosis often find that *increased fiber consumption can relieve symptoms, which include constipation and/or diarrhea, abdominal pain, gas, and mucus or blood in the stool.*

Diabetes

Soluble fiber traps carbohydrates to slow their digestion and absorption. In theory, this may help prevent wide swings in blood sugar level throughout the day. Research suggests that a high-sugar, low-fiber diet more than doubles women's risk of Type II (non-insulin-dependent) diabetes. *Cereal fiber was associated with a 28 percent reduced risk of contracting Type II diabetes,*

with fiber from fruits and vegetables having no effect. In comparison, cola beverages, white bread, white rice, and French fries increased the risk (1).

Heart Disease

A heart-healthy diet is a diet low in saturated fat and cholesterol and high in fruits, vegetables and grains containing soluble fiber. A high-fiber, heart-healthy diet can lower blood cholesterol. In these studies, cholesterol levels dropped between 0.5 percent and 2 percent for every gram of soluble fiber eaten per day (1). As it passes through the gastrointestinal tract, soluble fiber binds to dietary cholesterol, helping the body to eliminate it. This reduces blood cholesterol levels, which in turn reduces cholesterol deposits on arterial walls that can eventually choke off the blood flow.

Findings from two longterm, large-scale studies of men suggest high fiber intake can significantly lower the risk of heart attack. According to a Finnish study of 21,903 male smokers aged 50 to 69, men who ate the most fiber-rich foods (35 grams per day on average) suffered one-third fewer heart attacks than those who had the lowest fiber intake (15 grams a day). Results of a U.S. study of 43,757 male health professionals (some of whom were sedentary, overweight, or smokers) suggest that those who ate more than 25 grams of fiber a day had a 36 percent lower risk of developing heart disease than those who consumed less than 15 grams daily. In the Finnish study, each 10 grams of fiber added to the diet decreased the risk of dying from heart disease by 17 percent, while in an U.S. study, risk was decreased by 29 percent (1).

Obesity

Because insoluble fiber is indigestible and passes through the body virtually intact, it provides few calories. And since the digestive tract can handle only so much bulk at a time, fiber-rich foods are more filling than other foods – so people tend to eat less. Also, *insoluble fiber may hamper the absorption of calorie-dense dietary fat.* So, reaching for an apple instead of a bag of chips is a smart choice for someone trying to lose weight.

Weight Control

In a study of more than 74,000 middle-aged women, “those who ate more fiber-rich grains – such as oatmeal and whole-grain breakfast cereals – gained less weight over the 12 years of the study than did women who ingested the least amount of fiber.” Also, *women on*

fiber-rich diets were half as likely to become obese as the women who ate little fiber (18). The opposite was true if the diets were heavy in refined-grain products like white bread and pasta (2).

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