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FIBER

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Dietary fiber is a plant-based nutrient found in a wide variety of foods. “Fiber” is a broad term that encompasses several types of non-digestible carbohydrates that offer a diverse array of health benefits. In recent years, significant developments have been made in our understanding of fiber and its role in the promotion of health and disease risk reduction.

A wealth of scientific evidence demonstrates that adequate dietary fiber intake has a number of health benefits, including maintenance of a healthy gastrointestinal tract and reduced risk of cardiovascular disease and some types of cancers.¹ This fact sheet will examine many topics of interest around dietary fiber, including its definitions, food sources and associations with human health.

DEFINITION OF FIBER

There are several definitions of dietary fiber worldwide, and a singular definition remains the subject of ongoing discussion. Some of the definitions have been the result of analytical methods used to isolate dietary fiber, whereas others have stemmed from the physiological benefits associated with this food component.

The National Academies of Sciences, Engineering and Medicine (NASEM) Food and Nutrition Board (formerly known as the Institute of Medicine Food and Nutrition Board) defines dietary fiber as, “nondigestible carbohydrates and lignins that are intrinsic and intact in plants,” whereas “added fiber” consists of isolated, nondigestible carbohydrates that have beneficial physiological effects in humans.” NASEM defines “total fiber” as the sum of dietary fiber and added

fiber.² The Codex Committee on Nutrition and Foods for Special Dietary Uses offers a more technical definition of dietary fiber as “carbohydrate polymers with 10 or more monomeric units...not hydrolyzed by the endogenous enzymes in the small intestines of humans.”³ Additionally, Codex includes a footnote that the “decision on whether to include carbohydrates of 3 to 9 monomeric units should be left up to national authorities” and may be based on the discretion of the organization.⁴

In 2016, the United States Food and Drug Administration (FDA) announced the Nutrition and Supplement Facts Label Final Rule, in which they declared that dietary fiber on the Nutrition and Supplements Facts label includes certain “naturally occurring fibers that are ‘intrinsic and intact’ in plants, and added isolated or synthetic non-digestible soluble and insoluble carbohydrates that FDA has determined have beneficial physiological effects to human health.”⁵ See Table 1.

TABLE 1: INTRINSIC VS. ISOLATED, SYNTHETIC, PHYSIOLOGICALLY BENEFICIAL FIBERS⁵⁻⁷

FIBER TYPE	DEFINING FEATURES	EXAMPLES
Intrinsic Fiber	• Intrinsic, intact in plants • Not removed from the food • Beneficial to human health • Manufacturers do not need to demonstrate a physiological benefit	Vegetables, whole grains, fruits, cereal bran, flaked cereal, flours
Isolated, Synthetic, Functional Fiber	• Isolated and extracted or synthetically manufactured and added to specific foods, beverages and supplements • Must meet guidance criteria showing physiological benefit	Beta glucan, psyllium husk, cellulose, pectin, inulin, short-chain fructooligosaccharides, etc.

TABLE 2: NON-DIGESTIBLE CARBOHYDRATES IN THE FDA DEFINITION OF DIETARY FIBER

Included in the FDA definition of dietary fiber	Based on its June 2018 science review ⁸ , FDA intends to propose the following be included in their definition of dietary fiber
• Beta glucan • Psyllium husk • Cellulose • Guar gum • Pectin • Locust bean gum • Hydroxypropylmethylcellulose	• Mixed plant cell wall fibers (including sugar cane, apple fiber) • Arabinoxylan • Alginate • Inulin and inulin-type fructans • High amylose starch (resistant starch 2) • Galactooligosaccharide (GOS) • Polydextrose • Resistant maltodextrin/dextrin⁵ • Cross-linked phosphorylated RS4 (resistant starch 4)⁹



The FDA continues to review various proposed isolated and synthetic fibers to be counted as dietary fiber on the Nutrition Facts and Supplement labels. Table 2 offers an overview of fibers that have been approved for inclusion by the FDA as of April 2019, as well as several non-digestible carbohydrates that the FDA, based on its science review⁸, intends to propose to be included in the definition of dietary fiber.

Whole-food sources of dietary fiber include carbohydrate-containing plant foods. Broadly, dietary fiber has often been categorized as either soluble or insoluble, but it can also be further characterized into a wide range of criteria.¹⁰ NASEM recommends phasing out the use of these terms and instead replacing them with two terms related to physicochemical properties, viscosity and fermentability, that may illustrate the benefits that they may exert on the body.²

Fiber sources that are viscous may form a thick, gel-like compound in the stomach, which may later be broken down by bacteria in the colon. Sources of fiber that are slowly, incompletely, or not at all fermented in the large intestine provide bulk to stool as it passes through the gastrointestinal tract. They may assist with laxation and do not provide a significant source of calories or energy.

The major food sources of dietary fiber, accounting for 85 percent of the fiber in the U.S. food supply, are grain products, vegetables, legumes, nuts, soy, and fruits.¹¹ Dietary fiber is not found in animal-derived foods like beef, pork, poultry, eggs, fish and seafood. Most minimally processed dairy products, including milk, ice cream, cheese and yogurt, are fiber-free, although some may be fortified with added fiber.¹²

TABLE 3: FOOD SOURCES OF FIBER, GRAMS OF FIBER AND ENERGY PER STANDARD FOOD PORTIONS^{6,13,14}

Food	Standard Portion Size	Calories in Standard Portion	Dietary Fiber in Standard Portion (g)
Beans (navy, adzuki, pinto)	1/2 cup	122–148	6.7–8.4
Wheat bran flakes ready-to-eat cereal (various)	3/4 cup	98–113	4.9–5.5
Pumpkin seeds, whole, roasted	1 ounce	126	5.2
Avocado	1/2 cup	120	5.0
Berries (raspberries, blackberries)	1/2 cup	31–32	3.8–4.0
Pumpkin, canned	1/2 cup	42	3.6
Popcorn, air-popped	3 cups	93	3.5
Orange	1 medium	62	3.1
Banana	1 medium	105	3.1
Oat bran muffin	1 small	178	3.0
Pearled barley, cooked	1/2 cup	97	3.0
Nuts (almonds, pistachios, pecans, hazelnuts, oil-roasted peanuts)	1 ounce	162–196	2.7–3.5
Quinoa, cooked	1/2 cup	111	2.6
Potato, baked, with skin	1 medium	145	2.3
Whole wheat spaghetti, cooked	1/2 cup	87	2.3

FIBER RECOMMENDATIONS AND CURRENT INTAKE

In 2002, the Institute of Medicine, now known as NASEM, established an Adequate Intake (AI) level for fiber as part of the Dietary Reference Intakes (DRIs) for macronutrients. The AIs for total fiber are based on amounts that have been observed to protect against heart disease. Generally, recommendations are that people of all ages consume 14 grams of fiber for each 1,000 calories. In adults, the AI for fiber is 38 grams per day for men under age 50 and 25 grams per day for women under age 50. For adults over the age of 50 years, the AI is 30 grams of dietary fiber per day for men and 21 grams of dietary fiber per day for women (Table 4). These AIs are reduced to align with decreased food consumption that often accompanies the aging process.¹⁵

Most Americans consume about half the amount of fiber recommended by NASEM and only about five percent of the population actually meets the recommendations for dietary fiber intake.¹⁶ According to the National Health and Nutrition Examination Survey (NHANES 2015–2016), the mean fiber intake for adults 20 years and older was 17.3 grams per day.¹⁷ In Canada, the average dietary fiber intake was 19.1 grams per day for men and 15.6 grams per day for women.¹⁸ A study of European adults noted that intakes of dietary fiber in males ranged from 18 to 24 grams per day and from 16 to 20 grams per day for females.¹⁹

For U.S. adults, the primary sources of dietary fiber are vegetables (22.6%), other foods (14.3%), grain mixtures (12.0%), and fruits (11.1%).²⁰ The 2015 U.S. Dietary Guidelines Advisory Committee noted that the U.S. population should continue to increase consumption of foods rich in fiber and that consuming a variety of nutrient-dense foods like fruit, vegetables and whole grains will help to improve intakes of dietary fiber.²¹

TABLE 4: DAILY FIBER RECOMMENDATIONS²

	Age (years)	Dietary Fiber Adequate Intake (g/day)
Children	1 to 3	19
	4 to 8	25
Female	9 to 13	26
	14 to 18	26
	19 to 50	25
	50+	21
Male	9 to 13	31
	14 to 18	38
	19 to 50	38
	50+	30

FIBER AND HUMAN HEALTH

Dietary fiber first began to make health news when researchers observed that certain populations with a high fiber intake had lower rates of certain health conditions, including gastrointestinal issues, some types of cancer and heart disease.²² Dietary fiber consumption has been linked to a host of potential health benefits including reduced risk of cardiovascular disease (CVD), coronary heart disease (CHD), stroke, hypertension, certain gastrointestinal conditions, obesity, metabolic dysfunctions like prediabetes and type 2 diabetes, and some types of cancer.¹ Additionally, the benefits of dietary fiber may encompass other conditions and disease states affecting all-cause mortality. The National Institutes of Health-AARP Diet and Health Study (a large prospective cohort study) validated that intake of dietary fiber, especially dietary fiber from cereal grains, is inversely associated with total death rates, specifically cardiovascular, infectious, and respiratory deaths in both men and women, as well as cancer deaths in men.²³



CANCER

While the science continues to emerge regarding the specific role of dietary fiber and cancer, many studies have shown that diets high in fiber-containing foods may be associated with reduced risk of certain types of cancer (including colon, breast, ovarian and pancreatic) although results are mixed and may be dependent on the specific type of fiber being studied.¹ After reviewing the available evidence, the FDA has found sufficient scientific support to issue a health claim stating that diets low in fat and high in fiber-containing grain products, fruits and vegetables may reduce the risk of some types of cancer.²⁴

Although not all of the evidence between dietary fiber and cancer risk has been favorable,²⁵ some of the research does support a potential benefit. A meta-analysis of 15 studies examining the associations between dietary fiber and all cancers suggested that high dietary fiber intake is associated with a reduced risk of mortality from all cancers.²⁶

The World Cancer Research Fund has noted abundant evidence that consuming foods containing dietary fiber may decrease the risk of colorectal cancer.²⁷ The association between higher intakes of dietary fiber and reduced risk of colon cancer may be due to larger fecal bulk size, which may help “sweep” carcinogenic substances from the large intestines. A systematic review and meta-analysis of 11 prospective cohort studies reported that the risks for proximal colon cancer and distal colon cancer were decreased in populations with the highest dietary fiber intake, with reductions of 14 and 21 percent respectively, versus those with the lowest fiber intake.²⁸

Many studies have examined the link between fiber or higher-fiber dietary patterns and types of cancer; all require additional investigation to determine to what extent intake of dietary fiber may help prevent the development of this disease.



WEIGHT MANAGEMENT

The impacts of dietary fiber on measures of weight management are not fully understood. Several mechanisms of action have been suggested; however, much of the research into appetite, short- and long-term energy intake, and body weight has been completed in studies of individual isolated fibers, rather than whole foods or fiber blends.

Meals providing meaningful sources of dietary fiber tend to be processed more slowly by the body, contribute more volume compared with low-fiber meals, and may produce a greater feeling of fullness with fewer calories. Additionally, high-fiber foods require more chewing and may take longer to eat, thus potentially limiting total energy intake. These qualities are believed to be involved in the relationship between dietary fiber intake and the control of energy balance and body weight.

Higher intakes of dietary fiber are correlated with lower body weight³¹ and body mass index (BMI).¹⁵ Observational studies have found that populations with greater intakes of dietary fiber often have lower body weights; and obese people tend to have lower fiber intakes.¹ Results from a 20-month prospective cohort study showed a 0.25 kg decrease in body weight with every additional gram of dietary fiber consumed.³²

HEART DISEASE

Higher intakes of dietary fiber may improve serum lipid levels, reduce blood pressure, and lower inflammatory marker levels and indicators of inflammation, which may help to explain dietary fiber's protective benefits against CVD. Another potential mechanism by which viscous fibers in particular may affect CVD risk is through the lowering of blood cholesterol levels by reducing reabsorption of the bile acid pool, since bile acids are derived from cholesterol.¹

A meta-analysis of 15 prospective cohort studies documented that the highest rates of mortality from CVD and CHD were associated with the lowest dietary fiber intake.²⁶ A separate systematic review and meta-analysis of cohort studies reported an inverse association between intake of total dietary fiber and the risk of CVD and CHD. Study outcomes noted a nine percent reduction in risk for each seven gram per-day increase in dietary fiber.²⁹ Results from studies assessing fiber's effect on risk factors, for CVD have been mixed, but total fiber intake, particularly from food sources (versus supplements), seems to exert a benefit on serum cholesterol levels and other CVD risk factors, including blood pressure.³⁰



TYPE 2 DIABETES

Intake of dietary fiber is associated with improved glycemic control, which is an important dietary approach to help manage diabetes.³³ This association has been confirmed with several meta-analyses documenting a reduction in risk of type 2 diabetes with an increasing intake of total dietary fiber, cereal fiber, fruit fiber and insoluble fiber.^{1,34} Proposed mechanisms of action that accompany the intake of viscous dietary fibers include slowed rates of gastric emptying and digestion and reduced glucose absorption. However, additional research is needed to fully understand the intricacies of this process.¹

Results from the European Prospective Investigation into Cancer and Nutrition (EPIC)-InterAct study (with a total of 340,234 participants including 11,559 with type 2 diabetes followed for 10.8 years) support a recommendation for a high intake of dietary fiber due to



an associated lower risk of type 2 diabetes after adjustment for lifestyle and dietary factors.³⁵

Current guidelines for the prevention and dietary management of diabetes from the American Diabetes Association recommend consuming a variety of fiber-containing foods such as legumes, fiber-rich cereals, fruits, vegetables and whole-

grain products.³⁰ The recommended intake of dietary fiber is 14 grams per 1000 kcal and one-half of grain intake as whole grains, proportions that are consistent with fiber and whole-grain intake goals set for the general population. Evidence is lacking to recommend a higher fiber intake for people with diabetes than that for the general population.³⁰



GASTROINTESTINAL HEALTH

Fiber is known for its beneficial effects on digestion and digestive health. Dietary fiber helps to promote digestive health by adding bulk to the stool, which then can move through the gut faster and improve regularity. Dietary fiber also plays a role in affecting the composition of the gut microbiota.^{1,16} Some of these outcomes are impacted by dietary fiber's ability to bind water and increase bulk (bran and other fruit and vegetable fibers can contribute to bulking), whereas others are related to its role in fermentation, which can change osmotic balance and increase fecal mass.¹ When fermentable dietary fiber reaches the colon, the body experiences a range of physiological effects. Fermentable fibers, including oligosaccharides, beta-glucans, gums, some hemicelluloses and some resistant starches, yield the short-chain fatty acids (SCFAs) acetate, propionate and butyrate. The presence of these SCFAs decreases the pH in the colon, increasing the bioavailability of certain minerals while also inhibiting the growth of certain pathogenic bacteria.¹

As with all of the above health effects of dietary fiber, additional investigations are required to fully understand the mechanisms of action. However, the results of both randomized controlled trials and observational studies support an overarching recommendation to increase dietary fiber intake due to the wealth of benefits associated with its regular consumption.

FIBER AND THE GUT MICROBIOME

Nearly 20 years ago, a group of compounds in foods were identified as “prebiotics” based on their ability to manipulate the microbes living in the gastrointestinal tract. In late 2016, the International Scientific Association for Probiotics and Prebiotics (ISAPP) defined a prebiotic as “a substrate that is selectively utilized by host microorganisms conferring a health benefit.”³⁶

While most prebiotics are considered dietary fiber, all dietary fibers are not prebiotic. Human enzymes are unable to digest prebiotic fibers and as such, they serve as a food or fuel source for the beneficial colonizing microbes found in the gastrointestinal tract. By fueling this “good” bacteria, these microbiota are able to grow and metabolize foods more efficiently.³⁷

In order for a fiber(s) present in foods to be classified as prebiotic, it requires substantiation that it:

- Resists gastric acidity, hydrolysis by mammalian enzymes, and absorption in the upper gastrointestinal tract;
- Is fermented by the intestinal microflora; and
- Selectively stimulates the growth and/or activity of intestinal bacteria potentially associated with health and well-being³¹ (i.e., compounds called fructans (fructooligosaccharides and inulin) and galactans (galactooligosaccharides) have met the defining criteria as prebiotic fibers based on their effects on *Lactobacillus* and/or *Bifidobacterium*³⁶).



Prebiotic fibers are naturally found in certain plant foods like onions, garlic, banana, chicory root and Jerusalem artichokes. They may also be added to specific food products like yogurts, cereals, breads, biscuits, cookies, desserts and drinks. In the latter case, the ingredients label may show galactooligosaccharides (GOS), fructooligosaccharides (FOS), oligofructose, chicory fiber or inulin.³⁷ Fiber ingredients such as pectins, gums, inulin, polydextrose, oligofructose, and others may offer multifunctional benefits, including prebiotic functions.



METHODS / STRATEGIES TO INCREASE FIBER INTAKE

There are a few important steps to remember when working toward the goal recommendations for dietary fiber:

- Emphasize whole grains in place of refined grains. Aim for at least half of all grains to be whole grains.
- Include whole fruits and vegetables (not juices) at meals and snacks.
- Drink plenty of fluids while increasing fiber intake.
- Increase fiber intake gradually over time.
- Remember that moving too quickly to increase fiber or failing to consume adequate fluids may contribute to nausea or constipation.

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