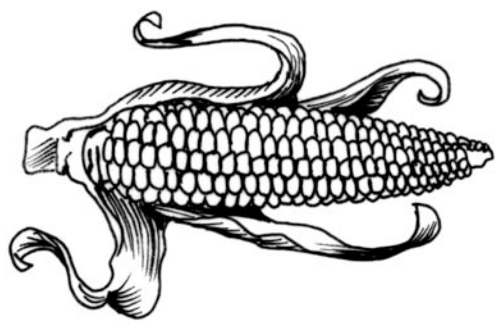
The New Fiber Story



The New Fiber Story:
Natural Resistant Starch
September 29, 2007, Philadelphia

Oldways
Hi-maize® Resistant Starch

References to resistant starch are proliferating, in the press and online. It's time to understand the health benefits of this newly-discovered type of fiber.

The New Fiber Story: Natural Resistant Starch

We all know the basics of the fiber story: There are two kinds of dietary fiber, soluble and insoluble, and fiber's main role is in promoting regularity. What more is there to know?

A great deal, as it turns out. New research has uncovered a third kind of dietary fiber called resistant starch, which offers some of the benefits of both soluble and unsoluble fiber – as well as some benefits not found in either of the traditionally-recognized kinds of fiber. And we now know that the benefits of dietary fiber go way beyond regularity – with additional benefits, once again, from natural resistant starch.

So here's the new fiber story, at a glance:

NEW! ***There are more than two kinds of dietary fiber.***

NEW! ***Fiber does more for our bodies than simply promote regularity.***

NEW! ***Resistant starch is increasingly recognized by health professionals as a key component in a healthy diet.***

Quality of Fiber Matters – not just Quantity

Research on the health benefits of fiber has yielded inconsistent results. One study, it seems, shows that fiber reduces the risk of colon cancer or some other disease, while the next shows no significant benefit.

Increasingly, we're learning that different types of fiber have very different benefits, helping to account for the inconsistencies that result from lumping all fibers together in studies. Recent research, for example, has shown that cereal fiber has different protective benefits from fruit and vegetable fiber.

The increasing body of research on natural resistant starch – more than 160 studies and growing all the time – is deepening our understanding of the unique role that resistant starch plays in health, a role not duplicated by other kinds of fiber.

Resistant Starch in Government Recommendations

IOM Recognizes and Defines Resistant Starch

The US Institutes of Medicine, in its 2002 report on "Reference Intakes for Energy, Carbohydrates, Fiber, Fat, Protein and Amino Acids (Macronutrients)" officially recognized resistant starch as a type of fiber, saying,

"Resistant starch that is naturally occurring and inherent in a food or created during normal processing of a food … would be categorized as *Dietary Fiber. …* RS1 and RS2 are classified as *Dietary Fiber* while RS3 and RS4 may be classifed as *Functional Fiber…*"

This recognition was significant, as earlier sources had considered only non-starch polysaccharaides (NSPs) as dietary fiber, when it was not yet understood that some kinds of starch could function as dietary fiber. All of the sources of resistant starch discussed in this symposium, such as legumes, potatoes, pasta, rice and Hi-maize, would be included in the IOM definition.

Australian Government Issues Reference Values for Resistant Starch

Some of the world's top research on resistant starch is being carried out by Australian scientists. Because of the high level of understanding of the health benefits of resistant starch in that country, Hi-maize natural resistant starch has been added and co-branded in foods commonly sold in Australian supermarkets since 1994.

In Australia, the National Health and Medical Research Council (NHMRC) plays roughly the same role as the US Institutes of Medicine (IOM), making science-based determinations of appropriate daily values for essential nutrients. In 2006, the NHMRC published its latest recommendations for Nutrient Reference Values indicating that in comparison to traditional fiber,

"…resistant starch may be as significant if not more so for many health conditions."

Dr. Katrine Baghurst, Chair of the Nutrient Reference Values Working Party, explained her government's decision saying,

"We considered the scientific evidence showing a positive impact of resistant starch on digestive health convincing and warranted inclusion in the new fiber intake recommendations."

The decision by the NHMRC to include resistant starch as part of its dietary fiber recommendations reinforces the need for health professionals to appreciate the science supporting resistant starch's role in health, and to readily identify food sources of resistant starch for their patients.

All About Dietary Fiber

Dietary fiber is the part of plant foods that resists digestion. Grandma knew that "roughage" was important, but most of us are still confused about why something that isn't even digested is so key to human health. This FAQ explains the types of fiber, fiber's benefits and what to eat to get enough fiber.

Q What's the big deal about fiber? Why do I need it?

A Fiber promotes healthy intestinal function, influences weight control and is a critical part of a balanced diet in many ways.

Q I'm not constipated; my bowels work fine. So I don't need fiber, right?

A There's more to intestinal and digestive-tract health than avoiding constipation. Recent studies have found that certain types of fiber –

- slow the absorption of glucose and reduce insulin requirements[1],
- remove bile acids from the intestines and block synthesis of cholesterol, lowering cholesterol levels[2],
- reduce the likelihood of colorectal cancer[3], and
- discourage overeating, by filling the stomach[4].

In fact, your intestines are a major component of your immune system. Adequately maintained and nourished, your intestines can help protect you against scores of pathogens and diseases. It is important to eat a variety of fibers to obtain the optimal benefits of each.

Q I've heard there are different kinds of fiber. Which is better?

A It's long been thought that there were only two kinds of fiber – soluble and insoluble. Now there is a third kind – resistant starch. All three kinds of fiber are essential to health, so we can't say that one is "better" than another.

- Soluble Fiber (e.g., pectins, gums, mucillages, and some hemicellulose) helps lower blood cholesterol levels and controls blood sugar.
- Insoluble Fiber (e.g., cellulose, lignan and hemicellulose) provides bulking and helps keep us "regular."
- Resistant Starch – the newest form of dietary fiber – is insoluble but is fermented like soluble fiber, giving us some of the health benefits of both – plus some unique advantages of its own.

Q What should I eat to get all three kinds of fiber?

A Fiber comes only from plant foods; it isn't found in meats, fish or dairy products.

In general, soluble fiber is found in oatmeal, barley and rye; beans, peas and lentils; fresh and dried fruits, and most vegetables.

Insoluble fiber is found in the skins and seeds of fruits and vegetables; in wheat bran; and in whole grains – including popcorn.

Resistant starch is found in whole grains, seeds, legumes, under-ripe fruit, and is especially prevalent in cooked starches that have been cooled – such as pasta salad, potato salad and sushi rice. It's also found in packaged foods, via a natural ingredient called Hi-maize® natural resistant starch.

Luckily, many foods contain all three kinds of fiber, so your best plan is to eat the widest variety possible of fruits, vegetables and grains.

Q How much fiber should I eat every day?

A In 2002 the US government[5] set the daily recommended intake (DRI) for fiber at 38g per day for men under age 50, and 30g per day for older men. For women, the DRI is 25g per day under age 50 and 21g per day over 50.

Men and women, young and old require about the same proportion of fiber in their diets; the actual fiber amounts vary only because these different groups eat different levels of calories.

Q That doesn't sound like much. I probably get that much already.

A Probably not. The average American gets only about 13 grams (women) to 17 grams (men) of fiber per day, much less than recommended. Europeans on average eat more fiber, but still fall short of recommended levels.

Q Then what are the best ways for me to get more fiber?

A Below is a table[6] that shows some common foods and their fiber content.

Food	Serving size	Total fiber	Soluble	Insoluble
All-bran cereal	1/3 cup	8.43g	.59g	7.84g
Oatmeal, regular	1 cup	4.45g	1.64g	2.81g
Shredded wheat	2/3 cup	3.16g	.31g	2.86g
Apple with skin	1 medium	2.76g	.28g	2.48g
Strawberries	1 cup	2.68g	.60g	2.09g
Prunes	1/2 cup	6.00g	3.60g	2.40g
Kidney beans	1/2 cup	6.66g	1.41g	5.25g
Broccoli, raw	1/2 cup	2.57g	.23g	2.34g
Potato, with skin	1 medium	5.05g	1.21g	3.84g
Carrots, raw	1 medium	1.80g	.14g	1.66g
Peas, green	1/2 cup	2.80g	.24g	2.56g
Bread, whole wheat	1 slice	2.59 g	.57g	2.02g
Bread, white	1 slice	.65g	.15g	.50g

Eating foods with added resistant starch is another good way to get more fiber. Resistant starch added during processing often increases the fiber in foods by up to 200%.

Q You've convinced me. I'll eat much more fiber, starting today.

A Take it slowly. If you increase some kinds of fiber in your diet too quickly, you may suffer from constipation and gas while your body adjusts. Ramp up gradually, over about three weeks, and make sure to drink plenty of liquids (6-8 glasses a day) to balance a higher-fiber diet.

References

1 Chandalia M et al. Beneficial effects of high dietary fiber intake in patients with type 2 diabetes mellitus. *N Engl J Med*. 2000; 342:1392-1398.

2 Brown L, Rosner B, Willett WW, Sacks FM. Cholesterol-lowering effects of dietary fiber: a meta-analysis. *Am J Clin Nutr*. 1999 Jan;69(1):30-42

3 Bingham SA et al. Dietary fiber in food and protection against colorectal cancer in the European Prospective Investigation into Cancer and Nutrition (EPIC); an observational study. *The Lancet*, 361: 9368, May 3, 2003.

4 Liu S, Willett WC, Manson JE, et al. Relation between changes in intakes of dietary fiber and grain products and changes in weight and development of obesity among middle-aged women. *Am J Clin Nutr* 2003;78:920–7

5 National Academy of Science Institute of Medicine, *Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein and Amino Acids*. September 5, 2002.

6 Adapted from Marlett, JA. Content and Composition of dietary fiber in 117 frequently consumed foods. *J Am Diet Assoc* 92:175-186, 1992. As reprinted by the University of Nebraska Cooperative Extension.

How Much Fiber is Enough?

As the evidence of health benefits from fiber grows stronger and stronger, government agencies around the world have recommended that adults increase their fiber intake. For the most balanced diets, it is important to get a variety of different fibers, each with its own beneficial qualities.

In the U.S., the National Academy of Sciences in 2003 published new Dietary Reference Intakes for Energy, Carbohydrates, Fiber, Fat, Protein and Amino Acids, setting the new American recommendation for fiber at 14g per 1000 calories consumed, per day. The 2005 Dietary Guidelines follow the NAS recommendations.

Daily Fiber for Adults		Year	Recommending Agency
12-16g	5.8-8g/1000 kcal	1985	Health & Welfare, Canada
30g		1986	British National Advisory
20-35g	10-13g/1000 kcal	1987	Fed. Am. Soc. of Experimental Biol.
20-30g		1988	National Cancer Institute
20-35g		1988	American Dietetic Association
30g	12.5g/1000 kcal	1989	Dutch RDA (Voedingsraad)
30g	12.5g/1000 kcal	1991	German RDA
25g		1993	USDA & USFDA NLEA regulations
30g	12.5g/1000 kcal	1996	Nordic Committee on Food
25-38g	14g/1000 kcal	2003	US National Academy of Sciences
25-38g	14g/1000 kcal	2005	US Dietary Guidelines
28-38g		2006	Australian NHMRC Suggest Dietary Targets

Source: Comprehensive Reviews in Food Science and Food Safety, Vol. 3, 2002, p. 78 for all valgues through 2003. 2005 and 2006 from original source documents.

The 2005 Dietary Guidelines for Americans

"The recommended dietary fiber intake is 14 grams per 1,000 calories consumed. Initially, some Americans will find it challenging to achieve this level of intake. However, making fiber-rich food choices more often will move people toward this goal and is likely to confer significant health benefits." *page 36, 2005 Dietary Guidelines*

Dietary Guideline Recommendations for Daily Fiber, in grams

Recommendations vary by age and activity level. Generally, these ranges are summarized by suggesting around 25g of fiber for most women and 38g for most men.

	Female		Male	
	Sedentary	Active	Sedentary	Active
Age 2-3	14g	20g	14g	20g
Age 4-8	17g	25g	20g	28g
Age 9-13	22g	31g	25g	36g
Age 14-18	25g	34g	31g	45g
Age 19-30	28g	34g	34g	42g
Age 31-50	25g	31g	31g	42g
Age 51+	22g	31g	28g	39g

In each range, the lower number is for sedentary people and the higher number is for active people whose physical activity is equivalent to brisk walking of 3 miles or more per day.

Note: Nutrition Facts Panels on foods continue to use slightly lower, outdated Daily Values of 25g for a 2000 calorie diet and 30g for a 2500 calorie diet.

The Fiber Gap – and How to Close It

There is a large difference between the quantities of fiber our bodies need and the amount we get, at all age levels. As a very conservative estimate, each of us needs about 15g of *additional* fiber per day – as much as 20g additional for most adult males.

Females	We Need	We Get	The Gap
Age 2-3	17g	10g	**7g**
Age 4-8	21g	12g	**9g**
Age 9-13	27g	13g	**14g**
Age 14-18	30g	13g	**17g**
Age 19-30	31g	13g	**18g**
Age 31-50	28g	14g	**14g**
Age 51+	27g	14g	**13g**

Males	We Need	We Get	The Gap
Age 2-3	17g	10g	**7g**
Age 4-8	24g	12g	**12g**
Age 9-13	31g	15g	**16g**
Age 14-18	38g	18g	**20g**
Age 19-30	38g	19g	**19g**
Age 31-50	37g	19g	**18g**
Age 51+	34g	19g	**15g**

Options for Filling the Fiber Gap

1. Capsules
   Swallow 30 Metamucil capsules ....+15g fiber
2. Dietary changes with existing food choices
   Breakfast: oatmeal instead of puffed rice cereal............................+4g fiber
   Lunch: 1 cup lentil soup instead of 1 cup tomato soup ....+7g fiber
   Snack: large apple instead of chocolate bar.................................+4g fiber
   Total additions through dietary changes..................+15g fiber
3. Eat foods made with extra natural fiber from resistant starch. Natural resistant starch adds roughly 2-3g of fiber per serving of most foods, along with unique health benefits. If all 6 of your daily grain servings include resistant starch, your fiber gap disappears.

Europeans have a slightly smaller fiber gap

An EPIC (European Prospective Investigation into Cancer and Nutrition) study followed 519,978 men and women aged 25-70 from 10 countries (Denmark, France, Germany, Greece, Italy, the Netherlands, Norway, Spain, Sweden, and UK) from 1992 to 1998. Fiber intake measured: 12.64g to 31.91g for women
12.77g to 35.61g for men

Sources

1. *"We Need" – Amount of fiber needed is the mean for different activity levels for each age group, as recommended by the IOM and the 2005 Dietary Guidelines.*
2. *"We Get" – Intakes are Mean Daily Intake of Dietary Fiber, in grams, for the United States from CSFII (1994-1996, 1998) as reported in* Dietary Reference Intakes for Energy, *Carbohydrates, Fiber, Fat Protein and Amino Acids (NAS, 2002, Appendix Table E-4)*
3. *Europeans – EPIC study published in The Lancet, 2003; 361:1496-1501, as reported by the Arizona Cancer Center at www.azcc.arizona.edu.*

What is Fiber? New Definitions

There are two main ways that scientists define fiber, *analytically* and *physiologically*. *Analytical* methods dissect foods, to arrive at "fiber content" for labeling purposes; they define "fiber" as any food component that reacts a certain way during the dissection process in a chemical lab. *Physiological* methods define fiber as any food component that reacts a certain way during the digestive process in our bodies.

Some food components test positive as fiber through both these methods, while others with proven beneficial digestive and physiological effects aren't measurable through traditional analytical methods. This dichotomy has led to efforts to create new, more comprehensive analysis procedures – and new definitions of fiber.

Since 1953, when nutritionist EH Hipley first coined the term "dietary fiber," the scientific community has struggled to define the meaning of this phrase. Most recently, in 2000, the American Association of Cereal Chemists (AACC) proposed a physiological definition that would include many components not traditionally considered fiber according to analytical methods. Two years later, the National Academy of Sciences built on the work of the AACC and many other sources to create its own updated definition.

Definition of Fiber
American Association of Cereal Chemists (2000)
Dietary fiber is the edible parts of plants or analogous carbohydrates that are resistant to digestion and absorption in the human small intestine with complete or partial fermentation in the large intestine. Dietary fiber includes polysaccharides, oligosaccharides, lignin, and associated plant substances. Dietary fibers promote beneficial physiological effects including laxation, and/or blood cholesterol attenuation, and/or blood glucose attenuation.

Definition of Fiber
National Academy of Sciences (2002)
Dietary Fiber consists of nondigestible carbohydrates and lignin that are intrinsic and intact in plants.
Functional Fiber consists of isolated, nondigestible carbohydrates that have beneficial physiological effects in humans.
Total Fiber is the sum of Dietary Fiber and Functional Fiber.

The NAS definition recognizes the many natural sources of fiber as Dietary Fiber, and classifies most manufactured fibers as Functional Fiber. Naturally occurring resistant starch (such as found in whole grains, legumes, cooked and chilled pasta, potatoes and rice, unripe bananas) is considered Dietary Fiber under the NAS definition; Resistant starches added to foods for health benefits are classified as Functional Fiber.

Recommendations for the Intake of Fiber

2005 Report of the Dietary Guidelines Advisory Committee

Fibers are different from sugars and starches in that they are not digested and absorbed in the small intestine and converted to glucose. Humans do not have the necessary enzymes to break down fibers into their constituent parts so that they can be absorbed into the body. Therefore, fibers pass from the small intestine into the large intestine relatively intact. There they can be fermented by the colonic microflora to gases such as hydrogen (H2) and carbon dioxide (CO2) and to short chain fatty acids. Although fibers are not converted to glucose as are sugars and starches, some of these short chain fatty acids are absorbed and can be used for energy in the body. However, determining the amount of calories supplied by fiber is complex since it depends on such factors as the fermentability of the fiber, the individual's colonic microflora, how long fiber stays in the colon, etc.

The IOM has set an Adequate Intake (AI) value for fiber of 14g of fiber per 1,000 kcal. This AI is based on the totality of the evidence for fiber decreasing the risk of chronic disease and other health-related conditions, but the actual numbers for the AI were derived from the data supporting a decreased risk for the development of coronary heart disease (CHD). The major food sources of fiber are fruits, vegetables (particularly legumes), and grains. Milk does not contain fiber although certain milk-containing products may.

WHAT ARE THE MAJOR HEALTH BENEFITS OF FIBER-CONTAINING FOODS?

Conclusion

Diets rich in dietary fiber have a number of important health benefits including helping to promote healthy laxation, reducing the risk of type 2 diabetes, and decreasing the risk of coronary heart disease (CHD). Prospective cohort studies suggest that decreased risk of heart disease is associated with the intake of 14 g of dietary fiber per 1,000 calories.

Rationale

Overview. The conclusion regarding the recommended intake of dietary fiber is consistent with the IOM's AI value of 14 g of fiber per 1000 kcals (IOM, 2002). This AI for fiber intake was based on the totality of the evidence for certain health benefits of dietary fiber, placing emphasis on fiber's protective role against CHD but also including its effect on laxation (Burkitt 1972; Cummings, 1992; Kelsay et al., 1978) and diabetes (Colditz et al., 1992; Salmeron et al., 1997a). The Committee evaluated the potential effects of fiber on laxation and diabetes and focused on the effects of fiber on CHD, since that was the basis of setting a value for fiber intake. Particular attention was paid to studies published since the IOM report. Studies on the association between fiber and diabetes are discussed under Question 2 in this section: How important is the glycemic response to carbohydrates to human health? Summaries of the studies on the relationship of fiber to healthy laxation and to risk of CHD are shown below.

Review of the Evidence

Fiber and Laxation. Chronic constipation is one of the most common disorders in Western countries (Roma et al., 1999). Although there is no one accepted definition of what constitutes normal laxation, constipation has been defined as difficulty in passing stools or an incomplete or infrequent passage of hard stools (Anderson, 2003). Epidemiological studies have reported a negative correlation between per capita fiber consumption and the incidence of chronic constipation (Graham et al., 1982). Dietary fibers from whole grains, fruits, and vegetables (including legumes) increase stool weight, which promotes normal laxation in children and adults. In general, the greater the weight of the stool, the more rapid the rate of passage through the colon (Birkett et al., 1997) the better the laxative effect. The water holding capacity and bulking ability that result in increased laxation are thought to reduce intracolonic pressure and lower the risk for diverticular disease as well (Bodribb et al., 1976).

Several factors affect stool weight, including the fermentability of the fiber (the less fermentable, the greater the fecal bulk) the water holding capacity of the fiber, and the contribution of the fiber to microbial mass, which also contributes to fecal bulk (Bach Knudsen et al., 1997; Blackwood et al., 2000 Chen et al., 1998). In addition, certain fibers may contain unfermented gel, which acts as an emollient and a lubricant (Marlett et al., 2000). Cummings reviewed over 100 studies of the effect of fiber intake on stool weight and calculated the increase in weight of the stool as a function of fiber intake (Cummings et al., 1992). There was a wide range of the contribution of dietary fiber to fecal weight (e.g. an increase of 5.7 g fecal bulk per gram of wheat bran fed compared to an increase of 1.3 g per gram of pectin in the diet). A meta-analysis of 11 studies in which daily fecal weight was measured accurately in 26 groups of people ($n = 206$) on controlled diets of known non-starch polysaccharide content shows a significant correlation between fiber intake and mean daily stool weight ($r = 0.84$) (Cummings et al., 1992). Although stool weight continues to increase as fiber intake increases (Burkitt et al., 1972; Wrick et al., 1983), there is a plateau effect for both intestinal transit time and fecal frequency. In general, most studies show that once intestinal transit time was less than 1 day and fecal frequency reached two to three per day the only effect of extra fiber in the diet was increased stool weight (Haack et al., 1998). The fecal weight required to achieve normalcy is variable, but the effect on decreasing transit time appears to plateau at fecal outputs >160 to 180 g per day (Burkitt et al., 1972). Many fiber experts have interpreted this as fiber having a "normalizing" effect on laxation: once normal laxation has been achieved, additional fiber may contribute to other health benefits but not to laxation.

A number of recent feeding studies of healthy individuals provide further evidence to support the role of a fiber-rich diet in normal laxation and other purported benefits to colonic health (Bach Knudsen et al., 1997; Blackwood et al., 2000; Chen et al., 1998 Haack et al., 1998). There are a large number of recent publications on the use of pre- and pro-biotics to alter the colonic microflora. Although a change in the microflora has been documented in several studies, functional endpoints are lacking at this time. (Cummings et al., 2002). Certain clinical studies have reported successful management of chronic constipation with fiber supplementation (Cummings, 1984; Hein et al., 1978; LoeningBaucke, 1994; Shafik et al., 1993).

Children. Consumption of adequate dietary fiber is associated with important health benefits throughout the lifecycle, but certain populations may require specific comment. For example, since the new AI for fiber is based on a decreased risk for CHD, some may assume that meeting the AI for fiber is less important for children than for adults. However, chronic constipation is one of the most common causes of morbidity in childhood (Bakwin, 1971; Leung, 1996; Loening-Baucke, 1995). Some studies have shown that up to 10 percent of children have chronic constipation (Bakwin, 1971; Leung, 1996; Loening-Baucke, 1995), which accounts for 25 percent of visits to pediatric gastroenterology clinics (Loening-Baucke, 1994). Several cross-sectional surveys on U.S. children and adolescents found inadequate dietary fiber intakes (Champagne et al., 2004; Cavadini et al., 2000). A randomized study of Greek children (291 with constipation and 1,602 controls) age 2 to 14 found that constipated children had lower caloric and nutrient intakes ($P < 0.001$), lower body weight/height ($P < 0.001$), and reported a higher prevalence of anorexia ($P < 0.001$). Despite the age of onset of constipation, dietary fiber alone was inversely correlated with chronic constipation ($P < 0.001$) (Roma et al., 1999). Another study found that children with constipation consumed approximately half as much fiber as a control group that was not constipated (McClung, et al., 1995). Similarly, Morais et al. (1999) reported that children with chronic constipation ate less fiber than their age-matched counterparts.

Elderly. There are a number of issues regarding healthy laxation and the elderly, some of which are summarized in Imershein et al. (2000). Some of these issues involve varied definitions of what constitutes normal laxation. However, there are also very real issues of drug interactions with laxation and lack of appropriate hydration due to concerns about urinary incontinence. Diuretics (often prescribed for hypertension) may result in hard stools, which are difficult to pass. Limitations on mobility also contribute to constipation. Not only is the prevalence of constipation higher in the elderly than in the general population (Grant, 1999), but the impact on quality of life appears to be greater (Pettigrew et al., 1997). Constipation may affect up to 20 percent of people over 65 years of age (Rouse et al., 1991).

Fiber and CHD. Evidence from a large number of epidemiological studies supports a protective role for dietary fiber against CHD (Fraser et al., 1992; Humble et al., 1993; Kromhout et al., 1982; Kushi et al., 1985; Khaw and Barrett-Connor et al., 1987; Morris,1977; Liu et al., 1999; Pietinen et al., 1996; Rimm et al., 1996; Wolk et al., 1999). The actual numbers used to set the AI were from three well-designed, adequately powered prospective epidemiological studies that measured the intake of fiber in healthy people and related the intake to later development of CHD (Pietinen et al., 1996; Rimm et al., 1996; Wolk et al., 1999) (see Table D5-1). Specifically, in the Health Professionals Follow-up Study, in which 43,757 men were followed, the relative risk for CHD for men in the highest quintile of fiber intake was 0.59 compared to 1.0 for the men in the lowest quintile of fiber intake ($p<0.001$). In the Nurses' Health Study, involving 68,782 U.S. women, the relative risk for the highest quintile of fiber intake was 0.77 compared to 1.0 for the lowest (Wolk et al., 1999). In the Finnish Men's Study, involving 21,930 men, the relative risk for CHD for men in the highest quintile of fiber intake was 0.45 compared to the lowest quintile ($P <0.001$) (Pietinen et al., 1996). As can be determined from data rows one through three of Table 5-1, the AI of 14 g of fiber per1,000 kcal was calculated using the average intake of fiber in the "protected group" in each of the studies (i.e., the highest quintile of fiber intake) and dividing that intake by the average energy intake for that quintile to obtain grams of fiber per calorie. Fiber intake then was expressed as grams per 1,000 calories to provide a more useable number. In brief, to be in the group with the lowest risk for CHD, an average intake of 14 g of fiber per 1,000 kcal would need to be consumed.

Two more recent prospective cohort studies (Bazzano et al., 2003; Liu et al., 2002) provide further evidence that supports the AI of 14 g of fiber per 1000 kcal (Table D5-1). Liu et al. used prospective data from the Women's Health Study over a 6-year period to assess the relationship between total dietary fiber, soluble and insoluble fiber, and fiber sources on the risk of cardiovascular disease or myocardial infarction. A significantly smaller number of cardiovascular disease cases occurred in the highest quintile of intake than in the lowest quintile of intake (99 cases vs. 140 cases). The age and randomized treatment-adjusted relative risk (RR) of cardiovascular disease was 0.65 (P for the linear trend = 0.001) comparing the highest and lowest quintiles (Liu et al., 2002). Liu et al. also reported a pooled analysis of nine published dietary fiber and CHD epidemiological studies. This pooled analysis shows an RR of 0.83 associated with 10 g increases in dietary fiber intake (Liu et al., 2002). Bazzano et al. (2003) examined the relationship between total and soluble dietary fiber intake and the risk of CHD and cardiovascular disease in 9,776 adults who participated in the National Health and Nutrition Examination Survey 1 Epidemiologic Follow-up Study. They report that individuals in the highest quartile for dietary fiber intake (20.7 g per day) had an RR of 0.88 for CHD events compared to those in the lowest quartile (5.9 g per day).

A meta-analysis by Pereira et al. (2004) compared intakes of dietary fiber and its subtypes (cereal, fruit, and vegetable fibers) and risk of CHD. This pooled analysis of 10 large prospective studies reported that each 10 g per day increment of dietary fiber was associated with a 14 percent decreased risk of coronary death. Fiber from cereals and fruits also had a strong, inverse association with CHD risk (RR 0.75 and 0.70, respectively). This association was not found for vegetable fiber (RR 1.00).

When setting the AI for fiber, the IOM also took into consideration small-scale clinical intervention trials and potential mechanisms for this observed protective effect against CHD. As reviewed by Fernandez (2001), a large number of relatively small-scale clinical intervention trials have shown that viscous fibers can lower serum cholesterol. It is generally accepted that a decrease in serum cholesterol is protective against CHD (see Part D, Section 4, for further information). Notably, in the studies in the Types and Sources of Dietary Fiber Summary Tables, Appendix G-3, total dietary fiber from foods was shown to be protective against CHD, not just those fibers that lower cholesterol. Whole grains, fruits, and vegetables are the food sources of fiber. Other possible mechanisms for the protective effect of high-fiber diets include the delayed absorption of macronutrients; a decrease in serum triglyceride levels; and a lowering of blood pressure.

Also, whole grains, fruits and vegetables contain substances, such as phytochemicals, that may contribute to their beneficial effect in protecting against CHD.

SUMMARY Carbohydrates—the sugars, starches, and fibers found in grains, fruits, vegetables, and milk products—are an important part of a nutritious, healthy diet. … To reduce the risk of CHD disease and promote healthful laxation, the Committee recommends the intake of 14 g of dietary fiber per 1,000 calories.

REFERENCES

Anderson KN. (ed). Mosby's Medical, Nursing, & Allied Health Dictionary. 6th Edition. Mosby Publishing Company, Inc., 2003.

Bach Knudsen KE, Johansen HN, Glitsø V. Rye dietary fiber and fermentation in the colon. Cereal Foods World 72:690-694, 1997.

Bakwin H, Davison M. Constipation in twins. American Journal of Diseases of Children 121:179-181, 1971.

Bazzano, LA, He J, Ogden LG, Loria CM and Whelton PK. Dietary fiber intake and reduced risk of coronary heart disease in U.S. men and women. The National Health and Nutrition Examination Survey I Epidemiologic Follow-up Study. Archives of Internal Medicine 163:1897-1904, 2003.

Birkett AM, Jones GP, de Silva AM, Young GP, Muir JG. Dietary intake and faecal excretion of carbohydrate by Australians: importance of achieving stool weights greater than 150 g to improve faecal markers relevant to colon cancer risk. European Journal of Clinical Nutrition 51:625-632, 1997.

Blackwood AD., Salter J, Dettmar PW, Chaplin MF. Dietary fibre, physicochemical properties and their relationship to health. Journal Review of Sociological Health 120(4):242-7, 2000.

Brodribb, AJM, Humphreys DM. Diverticular disease: Three studies. Part II - Treatment with bran. British Medical Journal 1:425-428,1976.

Burkitt, DP, Walker ARP, Painter NS. Effect of dietary fibre on stools and transit-times, and its role in the causation of disease. Lancet 1408-1412, 1972.

Cavadini C, Siega-Riz AM, Popkin BM.. U.S. adolescent food intake trends from 1965 to 1996. Archives of Diseases of Children 83(1):18-24, 2000.

Champagne C M, Bogle ML, McGee BB, Yadrick K, Allen HR, Kramer TR, Simpson P, Gossett J, Weber J. Dietary intake in the lower Mississippi delta region: results from the Foods of our Delta Study. Journal of the American Dietetic Association; 104(2):199-207, 2004.

Chen HL, Haack VS, Janecky CW, Vollendorf NW, Marlett JA. Mechanisms by which wheat bran and oat bran increase stool weight in humans. American Journal of Clinical Nutrition Sep;68(3):711-719, 1998.

Colditz GA, Manson JE, Stampfer MJ, Rosner B, Willett WC, Speizer FE. Diet and risk of clinical diabetes in women. American Journal of Clinical Nutrition 55:1018-1023, 1992.

Cummings JH, Bingham SA, Heaton KW, Eastwood MA. Fecal weight, colon cancer risk and dietary intake of non-starch polysaccharides (dietary fiber). Gastroenterology 103:1783-1789, 1992.

Cummings JH. The effect of dietary fiber on fecal weight and composition. In: Spiller, G.A. (ed.), CRC Handbook of Dietary Fibre in Human Nutrition. Ann Arbor: CRC Press pp. 263-349, 1992.

Cummings JH. Constipation, dietary fiber and the control of large bowel function. Postgraduate Medical Journal 60:811-819, 1984.

Fernandez ML. Soluble fiber and nondigestible carbohydrate effects on plasma lipids and cardiovascular risk. Current Opinion in Lipidology 12:35-40, 2001.

Fraser, GE, Sabate J, Beeson WL and Strahan TM. A possible protective effect of nut consumption on risk of coronary heart disease: the Adventist Health Study. Archives of Internal Medicine 152:1416-1424, 1992.

Graham YD, Moser ES, Estes KM. The effect of bran on bowel function in constipation. American Journal of Gastroenterology 77:599-603, 1982.

Grant E. An audit of laxative use and fibre/fluid intakes in a care of ther elderly rehabilitation ward. Journal of Human Nutrition and Dietetics 12:409-413, 1999.

Haack V S, Chesters JG, Vollendorf NW, Story JA, Marlett JA. Increasing amounts of dietary fiber provided by foods normalizes physiologic response of the large bowel without altering calcium balance or fecal steroid excretion. American Journal of Clinical Nutrition 68(3):615-22, 1998.

Hein, AB, Beerends JJ. A successful pediatric program based on dietary control bowel training and family counseling. Clinics in Pediatrics 17:67-70, 1978.

Humble CG, Malarcher AM, Tyroler HA. Dietary fiber and coronary heart disease in middle-aged hypercholesterolemic men. Am J Prev Med 9:197-202, 1993.

Imershein N, Linnehan E. Constipation: a common problem of the elderly. Journal of Nutrition for the Elderly 19:49-54, 2000.

Kelsay, JL, Behall KM, Prather ES. Effect of fiber from fruits and vegetables on metabolic responses of human subjects. American Journal of Clinical Nutrition 31:11491153, 1978.

Khaw K, Barrett-Connor E. Dietary fiber and reduced ischemic heart disease mortality rates in men and women: a 12-year prospective study. American Journal of Epidemiology 126:1093-1102, 1987.

Kromhout D, Bosschieter EB, de Lezenne Coulander C. Dietary fibre and 10-year mortality from coronary heart disease, cancer and all causes. The Zutphen Study. Lancet 2:518-522, 1982.

Kushi LH, Lew RA, Stare FJ. Diet and 20-year mortality from coronary heart disease: the Ireland-Boston Diet-Heat Study. New England Journal of Medicine 312:811-818, 1985.

Leung AK, Chan PY, Cho HY. Constipation in children. American Family Physician 54:611-627, 1996.

Liu S, Buring JE, Sesso HD, Rimm EB, Willett WC, Manson JE. A prospective study of dietary fiber intake and risk of cardiovascular disease among women. Journal of the American College of Cardiology 39:49-56, 2002.

Liu SM, Stampfer MJ, Hu FB, Giovannucci E, Rimm E, Manson JE, Hennekens CH, Willett WC. Whole-grain consumption and risk of coronary heart disease: results from the Nurses' Health Study. American Journal of Clinical Nutrition 70:412-419, 1999.

Loening-Baucke V. Functional constipation. Seminars in Pediatric Surgery 4:2634,1995.

Loening-Baucke V. Assessment, diagnosis and treatment of constipation in childhood. Journal of Wound, Ostomy and Continence Nursing 21:49-58, 1994.

Marlett JA, Kajs TM, Fischer MH. An unfermented gel component of psyllium seed husk promotes laxation as a lubricant in humans. American Journal of Clinical Nutrition 72:784-789, 2000.

McClung HJ, Boyne L, Heittlinger L. Constipation and dietary fiber intake in children. Pediatrics 96:999-1001, 1995.

Morais MB, Vitolo MR, Aguirre ANC, Fagundes-Neto UF. Measurement of low dietary fiber intake as a risk factor for chronic constipation in children. Journal of Pediatric Gastroenterology and Nutrition 29:132-135, 1999.

Morris JN, Marr JW, Clayton DG. Diet and heart: a postscript. British Medical Journal 2:1307-1314, 1977.

Pettigrew M, Watt I, Sheldon T. Systematic review of the effectiveness of laxatives in the elderly. Health Technology Assessment 1:13, 1997.

Pereira MA, O'Reilly E, Augustsson K, Fraser GE, Goldbourt U, Heitmann BL, Hallmans G, Knekt P, Liu S, Pietinen P, Spiegelman D, Stevens J, Virtamo J, Willett WC, and Ascherio A. Dietary fiber and risk of coronary heart disease: a pooled analysis of cohort studies. Archives of Internal Medicine 164(4):370-376, 2004.

Pietinen, P, Rimm EB, and Korhonen P. Intake of dietary fiber and risk of coronary heart disease in a cohort of Finnish men: the alpha-tocopherol, beta-carotene cancer prevention study. Circulation 94:2720-2727, 1996.

Rimm, EB, Ascherio A, Giovannucci E, Spiegelman D, Stampfer MJ, Willett WC. Vegetable, fruit, and cereal fiber intake and risk of coronary heart disease among men. Journal of the American Medical Association 275:447-451, 1996.

Roma E, Adamidis D, Nikolara R, Constantopoulos A, Messaritakis J. Diet and chronic constipation in children: the role of fiber. Journal of Pediatric Gastroenterology and Nutrition 28(2):169-174, 1999.

Rouse M, Mahapatra M. An open randomised parallel group study of lactulose versus ispaghula ni the treatment of chronic constipation in adults. British Journal of Clinical Practice 45:28, 1991.

Salmeron J, Ascherio A, Rimm EB, Colditz GA, Spiegelman D, Jenkins DJ, Stampfer MJ, Wing AL, Willett WC. Dietary fiber, glycemic load, and risk of NIDDM in men. Diabetes Care 20:545-550, 1997.

Shafik A. Constipation. Pathogenesis and management. Drugs 45:528-540, 1993.

Wolk, A, Manson JE, Stampfer MJ, Colditz GA, Hu FB, Speizer FE, Hennekens CH, Willett WC. Long-term intake of dietary fiber and decreased risk of coronary heart disease among women. JAMA 281:1998-2004, 1999.

Wrick, KL, Robertson JB, Van Soest PJ, Lewis BA, Rivers JM, Roe DA, Hackler LR. The influence of dietary fiber source on human intestinal transit and stool output. Journal of Nutrition 113(8):1464-1479, 1983.

FDA Approved Fiber Claims

The FDA has approved three different health claims relating to fiber content in foods. Qualified foods containing resistant starch would be eligible to use the first and second claims (101.76 and 101.77). On labels, the resistant starch would appear as “cornstarch.”

	Fiber & Cancer	**Fiber & Heart Disease**	**Produce & Cancer**
	21 CFR 101.76	21 CFR 101.77	21 CFR 101.78
Model Claim, statements	Low fat diets rich in fiber-containing grain products, fruits, and vegetables may reduce the risk of some types of cancer, a disease associated with many factors.	Diets low in saturated fat and cholesterol and rich in fruits, vegetables, and grain products that contain some types of dietary fiber, particularly soluble fiber, may reduce the risk of heart disease, a disease associated with many factors	Low fat diets rich in fruits and vegetables (foods that are low in fat and may contain dietary fiber, Vitamin A, or Vitamin C) may reduce the risk of some types of cancer, a disease associated with many factors. Broccoli is high in vitamin A and C, and it is a good source of dietary fiber.
Foods that qualify	Grain products, fruits and vegetables that • contain dietary fiber • are low fat • are a good source of dietary fiber (without fortification)	Grain products, fruits and vegetables • that contain fiber • low in saturated fat • low in cholesterol • low in fat • with at least 0.6g of soluble fiber per RACC (without fortification) • where soluble fiber content is on label	Fruits and vegetables that • are low fat • are a good source (without fortification) of Vitamin A OR Vitamin C OR dietary fiber
Required terms	• “Fiber,” “Dietary fiber,” or “Total dietary fiber” • “Some types of cancer” or “Some cancers”	• “Fiber,” “Dietary Fiber,” “Some types of dietary fiber,” “Some dietary fibers,” or “Some fibers” • “Saturated fat” and “Cholesterol” • “Heart disease” or “Coronary heart disease”	• “Fiber,” “Dietary fiber,” or “Total dietary fiber” • “Total fat” or “Fat” • “Some types of cancer” or “Some cancers”
Other		Must include physician statement ("Individuals with elevated blood total--or LDL--cholesterol should consult their physicians") if claim defines high or normal blood total--and LDL--cholesterol.	Must characterize fruits and vegetables as "Foods that are low in fat and may contain Vitamin A, Vitamin C, and dietary fiber." Must characterize specific food as a "Good source" of one or more of the following: Dietary fiber, Vitamin A, or Vitamin C.
Not allowed	Does not specify types of dietary fiber that may be related to risk of cancer		Does not specify types of fats or fatty acids or types of dietary fiber that may be related to risk of cancer.

Health claims must comply with the general requirements specified under 21 CFR 101.14.

FDA Definitions Used Above

Low fat .... 3g or less per serving
Low saturated fat .... 1g or less per serving
Good Source of dietary fiber .... 2.5g of fiber
Low in cholesterol .... 20 mg or less and 2 g or less of saturated fat per serving

Structure/Function Claims for Dietary Fiber

Structure/function claims, a separate regulatory claim category of labeling claims, are a growing area of opportunity for food manufacturers. The Dietary Supplement Health and Education Act (DSHEA) of 1994 initially created the regulatory framework for "structure/function" claims, which describe the ability of a product to maintain healthy structure or function of the body. While structure/function claims were initially applied to "dietary supplements," they also apply to foods.

Structure/function claims are relatively under-utilized in foods, but they expand a manufacturer's ability to describe the benefits of their food beyond the traditional "health claims" and "nutrient content" claims.

Three types of statements may qualify as structure/function claims. Under no circumstance can structure/function claims imply the diagnosis, treatment, prevention, mitigation or cure for a disease (other than a classical nutrient deficiency disease). The three types include:

1. A statement that claims a benefit related to a nutrient deficiency disease (like Vitamin C and scurvy), as long as the statement also tells how widespread such a disease is in the United States.
2. A statement whose claims describe the role of a nutrient or dietary ingredient intended to affect the structure or function in humans, for example, "dietary fiber promotes digestive health."
3. A statement that characterizes the means by which a nutrient or dietary ingredient acts to maintain such structure or function, for example, "fiber maintains bowel regularity" or "antioxidants maintain cell integrity" or they may describe the general well-being from consumption of a nutrient or dietary ingredient.

While health claims require approval, structure/function claims are not subject to FDA approval. Manufacturers are responsible for ensuring the accuracy and truthfulness of these claims. Manufacturers must have the substantiation for these claims before they make the claim. Upon challenge, this substantiation must be produced and may be critically reviewed to determine if it adequately substantiates the labeling claim.

There are numerous studies upon which to base structure/function claims for dietary fiber and for natural resistant starches. As different dietary fibers deliver different benefits, substantiation for structure/function claims must be based upon the fiber delivered in the food product.

Examples of Structure/Function Claims Related to Natural Resistant Starch

- Helps maintain healthy weight by reducing the caloric density of foods
- Helps maintain healthy blood sugar levels
- Helps to balance energy in the hours following a meal
- Promotes digestive health
- Helps to maintain regularity