Filling America’s Fiber Intake Gap: Summary of a Roundtable to Probe Realistic Solutions with a Focus on Grain-Based Foods$^{1,2}$

Roger Clemens, Sibylle Kranz, Amy R. Mobley, Theresa A. Nicklas, Mary Pat Raimondi, Judith C. Rodriguez, Joanne L. Slavin, and Hope Warshaw

Abstract

Current fiber intakes are alarmingly low, with long-term implications for public health related to risk of coronary heart disease, stroke, hypertension, certain gastrointestinal disorders, obesity, and the continuum of metabolic dysfunctions including prediabetes and type 2 diabetes. Eating patterns high in certain fibers are known to lower LDL cholesterol and blood pressure, lower blood glucose, and decrease insulin resistance in people with prediabetes and type 2 diabetes; help with both weight loss and maintenance; and improve bowel regularity and gastrointestinal health. With >90% of adults and children who fall short of meeting their daily fiber recommendations, the 2010 Dietary Guidelines for Americans once again classified fiber as a nutrient of concern. Despite efforts over the past decade to promote adequate fiber through fruit, vegetable, and whole-grain intakes, fiber consumption has remained flat at approximately half the daily recommended amount. The public health implications of inadequate fiber intake prompted the roundtable session “Filling America’s Fiber Gap: Probing Realistic Solutions,” which assembled nutrition researchers, educators, and communicators to identify challenges, opportunities, and realistic solutions to help fill the current fiber gap. The roundtable discussions highlighted the need for both consumer and professional education to improve acceptance for and inclusion of grain-based foods with added fiber as one strategy for increasing fiber intakes within daily energy goals. J. Nutr. 142: 1390S–1401S, 2012.

Introduction

Inadequate fiber intake is widespread, with <3% of all Americans meeting recommended intakes (1). It is recognized that the development of many risk factors associated with highly prevalent chronic diseases could be reduced by increasing consumption of fiber (2). Evidence suggests that fiber plays a critical role in reducing the risk of cardiovascular disease, obesity, and prediabetes and type 2 diabetes and is essential for optimal digestive health. Fiber was identified as an “under-nutrient of public health concern” by the 2010 Dietary Guidelines Advisory Committee (2). This statement was based on mean intakes well below Adequate Intake (AI)$^{11}$ levels, coupled with fiber’s established role in risk reduction of coronary heart disease and its emerging role in contributing to satiety and weight control (2).

With support from unrestricted educational funding from the Kellogg Company, a group of leading nutrition researchers, educators, and communicators, with expertise in fiber research, food technology, and consumer and professional education, convened on October 27, 2011, for a roundtable discussion entitled “Filling America’s Fiber Gap: Probing Realistic Solutions.” Objectives of the roundtable included identifying chal-

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Today’s Inadequate Fiber Intake: “A Public Health Concern for All Americans”

Fiber was first identified as a “nutrient of concern” for Americans in the 2005 DGA, and this categorization was reaffirmed in 2010 (3,12). Mean intakes of fiber range from 10 to 18 g/d for individuals aged 2 y (Fig. 1), indicating that most Americans need to double their consumption to meet the IOM fiber recommendation of 19–38 g/d (7,13). This translates to ≥90% of adults and children with fiber intakes below the daily recommended amount (14).

The AI for fiber is 14 g/1000 kcal, an amount associated with reducing the risk of cardiovascular disease (7). The AI is based on total daily fiber intake and does not differentiate between the IOM designations of “dietary” (intrinsic, or naturally occurring) and “functional” (added, or isolated) fiber (7). Other beneficial physiologic effects of sufficient intake of differing types of fiber include healthy laxation, normalization of total and LDL cholesterol, reduction in blood glucose and insulin levels, and protection against weight gain through its effects on satiety (6,15,16). In children, increased fiber intake has been found to be associated with better diet quality, which in turn is associated with lower risk for overweight or obesity (17,18).

At a time when two-thirds of American adults and 1 in 3 children are overweight or obese (19,20), and many are also undernourished despite excess energy intake, energy balance is a critical consideration (3). Current dietary guidance directs consumers to increase intakes of nutrient-dense and fiber-containing foods, yet emphasizes maintaining energy balance over time to achieve and sustain a healthy weight (3). This poses a key challenge in modifying current eating patterns to meet overall nutrient needs without exceeding energy goals. To meet daily fiber needs, the 2010 DGA recommended increased consumption of cooked dry beans and peas, other vegetables, fruit, whole grains, and other foods with naturally occurring fiber (3). On the basis of USDA nutrient profiles for food groups (Table 3), recommended intakes of vegetables and fruit will provide ~63% of the daily fiber goal for a 2000-kcal intake, whereas recommended intakes of grains will provide ~36% of daily fiber, with whole-grain choices accounting for the majority of the grain group’s fiber at ~28% of the daily fiber goal (21).

Fruit and vegetable intakes. Current consumption of fruit and vegetables is well below recommended intakes. According to the CDC, 40% of people nationwide consume fruit and vegetables ≤2 times/d (22). The typical American meets only 42% and 59% of his or her fruit and vegetable goals (3), respectively, and the vast majority of Americans aged ≥2 y have usual intakes below recommended amounts of fruit (80%) and vegetables (89%) (23).

Whole-grain intakes. Among the plant-based foods recommended to increase fiber intake, whole grains are recognized and promoted in the 2010 DGA as a food to increase as part of a dietary pattern that meets daily fiber goals. In addition to contributing to fiber intake, whole-grain consumption is associated with improved diet quality and nutrient intake in both children and adults (24,25). The typical American eating pattern meets only 15% of the whole-grain goal, or <28 g (1 oz) of the recommended 85 g (3-oz equivalents)/d (3). More than 99% of Americans (aged 2 y) are not consuming recommended amounts of whole grains, yet nearly two-thirds meet daily intake goals for total amount of grains, including refined grains (23). In fact, mean daily intakes of total grains of 181 g (6.4 oz) are slightly above the recommended amount of 170 g (6 oz)/d for a 2000-kcal diet, whereas whole-grain intakes are 17 g (0.6 oz)/d compared with the recommended amount of ≥85 g (3 oz)/d, or one-half of total grain intake (5).

A focus on grain-based foods. The amounts of fiber in grains, fruit, and vegetables recommended by the 2010 DGA to close the fiber intake gap vary considerably, and many choices within these food groups are not considered a “good” source of fiber, defined as equivalent to 10–19% of the Daily Value, or 2.5–4.9 g per reference serving, nor an “excellent” source of fiber, defined...
as equivalent to ≥20% of the Daily Value or ≥5 g per reference serving, as defined by the FDA (26). Americans attempting to achieve increased intakes of fruit and vegetables would require a considerable change in behavior, because higher fiber fruits and vegetables currently are not widely consumed and efforts to change this have not resulted in measurable improvements (27).

### TABLE 1  Current definitions of fiber

<table>
<thead>
<tr>
<th>Organization (reference)</th>
<th>Definition</th>
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<tr>
<td>Institute of Medicine (7)</td>
<td>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 physiologic effects in humans. Total fiber is the sum of dietary fiber and functional fiber.</td>
</tr>
<tr>
<td>American Association of Cereal Chemists (8)</td>
<td>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 physiologic effects including laxation, and/or blood cholesterol attenuation, and/or blood glucose attenuation.</td>
</tr>
<tr>
<td>Codex Alimentarius Commission (9)</td>
<td>Dietary fiber means carbohydrate polymers,$^{1}$ with ≥10 monomeric units,$^{2}$ which are not hydrolyzed by the endogenous enzymes in the small intestine of humans and belong to the following categories: * Edible carbohydrate polymers naturally occurring in the food as consumed * Carbohydrate polymers that have been obtained from food raw material by physical, enzymatic, or chemical means and which have been shown to have a physiologic effect of benefit to health as demonstrated by generally accepted scientific evidence to competent authorities * Synthetic carbohydrate polymers that have been shown to have a physiologic effect of benefit to health as demonstrated by generally accepted scientific evidence to competent authorities</td>
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</table>

1 When derived from a plant origin, dietary fiber may include fractions of lignin and/or other compounds associated with polysaccharides in the plant cell walls. These compounds also may be measured by certain analytic methods (1) for dietary fiber. However, such compounds are not included in the definition of dietary fiber if extracted and reintroduced into a food.

2 The decision on whether to include carbohydrates of 3 to 9 monomeric units should be left up to national authorities.

### TABLE 2  Glossary of terms

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition (reference)</th>
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<tbody>
<tr>
<td>Energy balance</td>
<td>The balance between energy (kcal) consumed through eating and drinking and energy expended through physical activity and metabolic processes (3).</td>
</tr>
<tr>
<td>Added fiber (also known as functional, isolated, or novel fiber)</td>
<td>Isolated or synthesized nondigestible carbohydrates that have beneficial physiologic effects in humans. May be extracted from the original food source that it is being added back to, such as bran added to grain-based foods, or from fruit, vegetables, legumes, nuts, and seeds; modified forms of traditional fibers (e.g., fructooligosaccharides, or FOS, from inulin); or manufactured from other ingredients such as corn or wheat (7).</td>
</tr>
<tr>
<td>Functional foods</td>
<td>Whole foods and fortified, enriched, or enhanced foods that have a potentially beneficial effect on health when consumed as part of a varied diet on a regular basis at effective levels (10).</td>
</tr>
<tr>
<td>Nutrient dense</td>
<td>A way to describe foods or beverages that provide vitamins, minerals, and other substances that may have positive health effects, with relatively low energy contribution. Nutrient-dense foods and beverages are low in solid fats and minimize or exclude added solid fats, sugars, starches, and sodium (3).</td>
</tr>
<tr>
<td>Whole grain</td>
<td>The intact, ground, cracked, or flaked grain whose principal components—the starchy endosperm, germ, and bran—are present in the same relative proportions as they exist in the intact grain (11).</td>
</tr>
</tbody>
</table>
supplements or medications. Mean fiber intakes for individuals aged ≥2 y do not include breast-fed children. Data are from (7,13).

However, modifying grain-based food choices may be a more reasonable small step toward higher fiber consumption without increased energy intakes (4). Most Americans are already meeting (or exceeding) daily total grain recommendations (5); thus, a shift from low-fiber to higher fiber grain-based foods may be an achievable public health goal. This recognition was the focus of the remaining roundtable discussions and recommendations around grain-based foods.

Barriers to Meeting Fiber Recommendations

Limited understanding and recognition of fiber’s role in health

The roundtable experts recognized that the fiber deficit has long-term health implications for Americans, potentially contributing to increased risk of chronic diseases and obesity (15,16,28,29), yet agreed that understanding and recognition of this fiber deficit as a public health concern and priority are often overlooked. Whereas science continues to point to fiber’s role in promoting health and reducing the risk of developing some noncommunicable diseases, these benefits are primarily longer term, making fiber intake less of an immediate concern to consumers and health professionals. Unlike many other nutrient inadequacies, the clinical signs or symptoms of low fiber intakes are not directly evident. However, there are some immediate benefits of adequate intakes of fiber, such as promoting healthy laxation in addition to contributing to satiety, which have short- and long-term implications related to weight management and reducing the risk of obesity, prediabetes, and type 2 diabetes (30). Data on the effect of fiber intake on children’s health are limited (31).

The lack of new clinical research on fiber benefits combined with poor understanding of the effects of low fiber intake have given fiber less prominence as a nutrient of concern by health professionals. Recommendations for fiber intake in the 2010 DGA are based primarily on achieving nutrient density, rather than physiologic benefits. Although much of what we know about fiber’s effects on health is based on observational data, most of the clinical studies of fiber’s physiologic benefits have been conducted using isolated forms of fiber rather than whole, fiber-containing foods (7,15). Current dietary guidance, which emphasizes foods that contain naturally occurring fiber, disregards clinical research outcomes that use isolated fibers to demonstrate health benefits, which are the same fibers used when adding fiber back to grain foods. Yet, intact fiber in foods is typically perceived as healthier and accepted as providing health benefits without undergoing the same clinical scrutiny to demonstrate these effects. The 2010 DGA call attention to dietary fiber that occurs naturally in foods as helping to reduce the risk of heart disease, obesity, and type 2 diabetes and as essential for optimal digestive health. In its advice to consume foods naturally high in dietary fiber, however, the DGA overestimate the ability of these foods to meet fiber needs in typical diets, and undervalue the potential role and contribution of foods that contain added fiber.

Whole grains, fiber, and health. The health-protective mechanisms of whole grains are complex and are likely due to the interaction between fiber, minerals, antioxidants, and bioactive compounds (32). Epidemiologic studies have suggested an association between higher intakes of whole grain and reduced risk of heart disease, certain types of cancer, type 2 diabetes, and obesity (33). However, recent research suggests that not all whole grains exert the same effects (34,35). A review examining the association between whole grains, based on the FDA definition, and reduction in risk for cardiovascular disease found an association, but only when the definition of whole grains was broadened to include studies using fiber-rich bran and germ (36), which suggests that the fiber components of whole grains deliver the key benefits. Although whole grains are believed to play an important role in the diet beyond fiber (33),

### TABLE 3

<table>
<thead>
<tr>
<th>Food group</th>
<th>Serving</th>
<th>Mean fiber (g/serving)</th>
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<tbody>
<tr>
<td>Fruit</td>
<td>0.5 cup</td>
<td>1.1</td>
</tr>
<tr>
<td>Dark-green vegetables</td>
<td>0.5 cup</td>
<td>2.1</td>
</tr>
<tr>
<td>Orange vegetables</td>
<td>0.5 cup</td>
<td>2.1</td>
</tr>
<tr>
<td>Cooked dry beans (legumes)</td>
<td>0.5 cup</td>
<td>6.0</td>
</tr>
<tr>
<td>Starchy vegetables</td>
<td>0.5 cup</td>
<td>1.7</td>
</tr>
<tr>
<td>Other vegetables</td>
<td>0.5 cup</td>
<td>1.1</td>
</tr>
<tr>
<td>Whole grains</td>
<td>28 g (1 oz)</td>
<td>2.4</td>
</tr>
<tr>
<td>Refined grains</td>
<td>28 g (1 oz)</td>
<td>0.7</td>
</tr>
<tr>
<td>Meat</td>
<td>28 g (1 oz)</td>
<td>0.1</td>
</tr>
</tbody>
</table>

1 From (21). Mean fiber reflects fiber amounts of the food group or subgroup composite, a representation of the foods contained in the group in amounts that correspond to relative consumption. Fiber data derived from USDA National Nutrient Database for Standard Reference, Release 17.
this point is often overlooked in dietary guidance that emphasizes consumption of whole grains as a primary way to increase fiber intake. To help differentiate and reduce confusion, there is a need in future research and education to clearly delineate between “whole grains” and “fiber” to avoid the interchange of the food (whole grains) with the nutrient (fiber) and to provide clearer direction for choosing grain foods that provide at least a good source of fiber, an idea yet to be embraced by policymakers. For example, the recently released Nutrition Standards in the National School Lunch and School Breakfast Programs include new directives that all grains must be “whole-grain rich” within 2y after implementation (37), yet do not address a fiber requirement for defining a food that is “whole-grain rich.” By not using fiber as a marker of whole-grain quality, the roundtable experts considered this to be a missed opportunity for clarifying the role of fiber in providing key health benefits in whole grains.

Confusion about “good sources” of fiber

The roundtable experts discussed how current fiber and whole-grain recommendations may have unintended consequences of making it more challenging to achieve adequate fiber intakes. For example, dietary guidance emphasizes eating more of specific foods to achieve fiber recommendations, including fruit, vegetables, legumes, and whole grains, yet many of the foods in these categories are not considered a “good” or “excellent” source of fiber based on FDA labeling definitions. Some naturally occurring fiber-containing foods are also higher in moisture, including many fruit and vegetables, and contain only 1–3 g of fiber per serving. This is illustrated in the mean fiber content per serving for food groups/subgroups on the basis of typical consumption, which is used to assess adequacy of the USDA’s food intake patterns (Table 3).

Results from an analysis of consumers’ fiber sources found that adults’ mean intake of 13.8 g fiber/d comes from ~25 different food items in a single day, including a variety of foods such as vegetables, sandwichs, fruit, ready-to-eat cereals, and potatoes (38). Although white flour and white potatoes provide the most fiber in the U.S. food supply, these are not concentrated fiber sources but instead are widely consumed foods (16,39). Foods that provide at least a “good” or “excellent” source of fiber include most legumes, foods that contain additional bran, or foods that include other added-fiber ingredients. By emphasizing whole, plant-based foods in dietary guidance, consumers have the perception that they can achieve recommended fiber intakes by choosing a variety of fruit, vegetables, and whole grains. In reality, meeting recommended fiber intakes requires a careful selection of foods within food groups, which includes the challenge of first meeting recommended daily servings and then choosing foods that provide fiber in the upper range for that food group.

Moreover, any increase or addition of fiber-containing foods must be paired with other dietary trade-offs to avoid exceeding energy needs, a critical consideration in today’s nutrition environment. A modeling study examined the effects on fiber intake and calories when currently consumed fiber-containing foods (grains, vegetables, fruit) increased by 10, 25, 50, or 100% (4). Although fiber intakes increased from 16.9 to 29.5 g/d, there was a concurrent energy increase ranging from 104–1042 kcal/d. This illustrates the concern with simply advising increases in fiber intake and calories when currently consumed fiber-containing foods over the past 5 y (42).

Whole-grain labeling and content do not guarantee fiber

The roundtable experts agreed that whole-grain labeling of foods may be a source of consumer confusion regarding fiber content. There has been a proliferation of packaged foods that boast their “whole grain” content, estimated by the Whole Grain Council as a 20-fold increase in the number of new whole-grain product launches from 2000 (164 new products) to 2010 (3272 new products) (43). However, this has not translated to increased whole-grain and fiber intakes, despite a recommendation, beginning with the 2005 DGA, that all age groups should consume at least half of their grain servings as whole grains to help increase fiber intakes. At the same time, it has become increasingly clear that labeling claims for “fiber” and “whole grain” may be synonymous in the minds of consumers (38). Yet, all whole-grain foods do not qualify as a “good” source of fiber. A web-based study in 1000 adults was conducted to measure perceptions and understanding of the relationship between whole grains, fiber, and potential health benefits. This research found that 85% of respondents believed that if a product indicates it is made with whole grains, then it also contains at least a good source of fiber (38).

There is also contradiction in consumers’ perceptions of whole-grain products and the actual amounts of fiber delivered by products that contain whole grains. A marketplace audit was conducted of nationally distributed ready-to-eat cereals with whole-grain claims, such as “made with whole grains,” “rich in whole grains,” and “whole grain guaranteed” during a 3-y period from 2005 to 2008 (38). The fiber content in the 72 cereals analyzed ranged from 0 to 11 g/serving, with nearly half of the cereals containing less than the minimum amount of fiber to be labeled as a “good” source of fiber. Approximately 60% of these cereals with whole-grain claims that provided less than a “good” source of fiber contained ≤1 g of fiber. With evidence that consumers are seeking out more whole-grain products with an expectation of obtaining fiber, this scenario has the potential to create the unintended consequence of increased energy intake without a substantial increase in fiber intake.

The misunderstanding of whole grains and fiber is likely due in part to a lack of clear and consistent labeling of whole-grain containing products. The FDA issued “draft guidance” for whole-grain label statements in 2006, but these are yet to be finalized (44). Although this guidance allows manufacturers to make factual statements about the amount of whole grain, content claims (e.g., good or excellent source of whole grains) are not approved, with the rationale that source claims for whole-grain content are considered to be implied claims about fiber content and may be misleading. Despite the lack of labeling guidelines for whole grains, the FDA approved a health claim linking diets rich in whole-grain foods and other plant foods with reduced risk of heart disease and certain cancers (45).
Foods that bear the whole-grain health claim are required to contain ≥51% whole-grain ingredients by weight per reference amount and to meet criteria for fat and cholesterol, but there is not a minimum requirement for fiber content. Likewise, the “Whole Grain Stamp,” a popular icon developed by the Whole Grains Council, allows a food that contains ≥8 g (0.5 serving) of whole grains to qualify for using the basic stamp or that contains a minimum of 16 g of whole grain per serving to qualify for the almost identical stamp, “100% Whole Grain” (46). However, the product’s fiber content is not part of these requirements.

Sensory, attitudinal, and economic factors
In the roundtable discussions, it became clear that multiple levels of influence affect behaviors that determine fiber intake. The International Food Information Council’s 2011 Food and Health Survey indicated that taste and price are the primary factors influencing purchasing decisions for foods and beverages overall (47). Healthfulness was the third most important factor, with convenience following closely behind. When asked about barriers to consuming functional foods, consumers identified expense, taste, and availability/convenience as the top 3 barriers (47). Sensory barriers to increasing fiber intake, particularly from whole-grain foods, include taste, texture, color, and moisture content in addition to the perception that cost is greater (48). Consumers and marketers tend to have a negative perception of the taste and texture of fiber, with marketing that often focuses on how specific fiber-containing foods do not taste like “cardboard” and actually taste good.

For consumers who may choose to reduce or control their intake of carbohydrates, such as individuals with diabetes or those attempting to manage their weight, fiber intake may be compromised based on the false assumption that carbohydrate-containing foods are unhealthy and should be limited. In fact, research supports the use of lower energy/fat diets with ≥25 g fiber/d over low-carbohydrate diets for people with diabetes and for weight loss (49). With regard to blood glucose control in people with diabetes, it is generally believed that an increased fiber intake helps to modulate blood glucose (2), but this effect is generally not seen with typical fiber intakes of <24 g/d (50).

In an effort to change attitudes and behaviors, educators and communicators often take a binary approach, suggesting the same solutions to ongoing problems, such as the general advice to “choose more fruit, vegetables, and whole grains to improve fiber intakes.” Although this not only limits innovation, it also narrows the scope of the problem and prevents new solutions from being considered, such as the use and acceptance of added fiber in foods that Americans already consume. In the case of fiber, improving outcomes must go beyond approaches that simply focus on increasing knowledge. Consumers need to value fiber and have reasons to care about eating more fiber. They also need skills for how to select and prepare good-tasting foods with more fiber.

Agricultural and economic challenges are important considerations in meeting recommendations for increasing intakes of fruit, vegetables, and whole grains. To support the production of crops needed to supply adequate amounts of produce and grains, millions of additional acres of cropland would be required (51), making it unlikely that current production of whole grains could supply the quantities needed to meet recommended intakes.

Opportunities to Fill the Fiber Intake Gap
After discussing the obstacles consumers encounter in meeting current fiber recommendations, the roundtable experts focused on identifying opportunities to improve intakes of fiber to help close the gap between current and recommended fiber consumption. The discussions centered around understanding and addressing consumer attitudes and behaviors, whole-grain labeling reform, focusing on all types of fiber, optimizing eating occasions, and education and resources for health professionals.

Meet consumers where they are to overcome barriers
The roundtable experts emphasized the importance of taking consumers’ current understanding and dietary behaviors into account to help them overcome the barriers they face in increasing their fiber intake. This requires segmenting the target audience and providing small-step guidance that is realistic and addresses their unique concerns. Recognizing that consumers already meet recommendations for total grains makes this an important area of focus. Simple swaps from low-fiber grain choices to whole grain or fiber-added enriched grains with at least a “good” source of fiber offer a way to boost fiber intake without affecting energy intake and do not require a considerable behavior change. Breaking down the barriers of taste, texture, cost, and convenience may prove that fiber-containing foods can be accessible, tasty, and affordable. Sampling, demonstrations to show how to increase fiber in food preparation, and use of coupons are ways to expose consumers to less familiar fiber-containing foods. Incentives for increasing fiber were discussed, with agreement that fiber for weight management and health benefits for children and families were strategies that would be most likely to motivate consumers.

Fiber for weight management
The 2010 DGA were released at a time of rising concern about the health of Americans, with recognition that nutrient-poor intakes and physical inactivity have contributed to the obesity epidemic in American adults and children. The DGA clearly point out the need to focus on maintaining energy balance while consuming more nutrient-dense foods and beverages. This dichotomy of getting more nutrients for fewer kilocalories is a concept that consumers need to understand and implement. Unlike several other nutrients of concern—calcium, potassium, and vitamin D—fiber is unique in that different types of fiber are associated with varying health benefits, and adequate intakes of this nutrient also play a role in weight management (16,30).

A recent study evaluating the effect of consumption of total fiber and types of fiber on the prevalence of overweight and obesity found that total fiber intake is inversely related to BMI, waist circumference, and percentage of obesity (29). The inverse relationship between fiber intake and body weight was more pronounced for cereal fiber compared with fruit and vegetable fiber, which may be a factor in the low consumption of fruit and vegetables and the inconsistent association between fruit and vegetable intake and adiposity (27,52). Fiber is believed to play a role in weight management by slowing digestion, contributing to satiety, and subsequent reduced energy intake (30). In addition, higher fiber intakes may delay digestion of other macronutrients in the small intestine, and reduce postprandial blood glucose, which improves insulin sensitivity and favors fat oxidation (30,53).

In children, a lower risk of overweight and obesity with increased fiber intake has been observed (54). This investigation using national intake data found that children who consume high amounts of fiber consume large amounts of lower-fiber foods, such as French fries and pizza. Thus, establishing the evidence for a beneficial effect of fiber intake on children’s health is confounded by the fact that children who meet the intake recommendations are likely overweight and are therefore
overweight or obese. In communications to improve fiber intakes, a focus on the benefit of managing weight is a strategy for getting the attention of consumers, including parents of overweight children, who have concerns about weight.

**Health benefits for children and families.** Fiber recommendations for children vary, whether based on energy needs, age, or weight, due to the fact that effects of fiber on child health have not been studied closely. However, evidence suggests that reducing constipation, obesity, and type 2 diabetes could be achieved in children with increased intakes of fiber (31). Because children’s dietary intake patterns are likely to track into adulthood, increasing fiber intakes during the earlier years of life presents an opportunity to improve children’s health and potentially influence their health as adults in a positive way.

Fiber is consistently consumed at inadequate levels by most preschool-aged children, yet in a study in which children were provided with higher-fiber snacks and lunch items in a day care setting, they were found to try and like these foods, with the result of higher daily intakes of fiber (55,56). Interestingly, parents and child care providers may make the assumption that their children will not like certain fiber-containing foods, with the unintended consequence of limiting their fiber intakes along with other nutrients of concern. Although it has been shown that children prefer familiarity and consistency in their diets, and may be reluctant to try new foods, exposing children to a variety of fiber sources beginning in the first years of life makes them more accepting of novel foods (31,57,58). Other options for parents are to add fiber to foods that children like, such as using whole-wheat flour in baked goods or substituting whole-grain versions of crackers, chips, and pizza crust in place of lower-fiber products.

An added outcome associated with consuming higher fiber foods is greater intake of other nutrients and the improvement of diet quality (17), which in turn may potentially affect weight and health. Furthermore, if children accept and like a new food, it often leads to children requesting the new foods at home; thus, parents may change their dietary habits to match their children’s likes. Home availability and accessibility of foods such as fruit, vegetables, and whole grains can be an important factor in improving consumption (59). This underscores the importance of helping parents learn how to select whole-grain foods that provide a good source of fiber (60).

**Call for clear and consistent labeling of fiber in whole-grain foods**

A critical need identified by the roundtable experts to help improve fiber intakes from grain foods is to develop clearer, universal messaging that also focuses on the fiber content in whole-grain products. This could help address the confusion around fiber and whole grains and may help promote greater fiber intakes from all grain products, including whole grains and enriched grains with added fiber. The 2010 Dietary Guidelines Advisory Committee acknowledged that there is no consistent way that whole-grain foods are defined and determined, and identified developing a universally accepted definition and criteria for “whole-grain foods” as an area for future research (2). Defining what constitutes a whole-grain food would allow consumers to better identify foods that can help them meet recommendations for whole grain and fiber, and it would allow comparison of research studies examining the effectiveness of whole grains, independent of fiber content, on biomarkers and health conditions, such as cardiovascular disease, diabetes, and obesity (2).

Currently, the FDA’s draft guidance allows food manufacturers to include factual statements about whole grains on package labels, such as “8 grams of whole grains” or “100% whole grains” (44), which consumers tend to equate with claims about fiber content. This lack of clarity in whole-grain labeling may be feeding the confusion around fiber and whole grains, with the unintended consequence of exacerbating the fiber deficit. Eligibility criteria for whole-grain claims based on the amount of fiber per serving is a logical approach that would help to inform and reinforce the expectation that whole-grain products can deliver a good source of fiber.

Label statements on whole-grain products that include a qualifying statement to highlight total fiber could bring greater prominence to the fiber content while reinforcing whole grains as a source of varying amounts of fiber. The use of food labels to make purchasing decisions is linked to healthier eating, with higher fiber intakes among food label users (61). In recognition that every gram of fiber counts toward reaching daily fiber goals, teaching consumers to check for fiber on a product’s Nutrition Facts label is a simple action to help determine fiber content, especially for products that note their whole-grain content. This encourages consumers to pay closer attention to fiber amounts in their typical food choices and promotes selection of whole-grain-containing foods with greater amounts of fiber per serving.

**Focus on all forms and sources of fiber**

The roundtable experts agreed that more emphasis needs to be placed on consuming adequate fiber, whether intrinsic or added. Regardless of whether fiber occurs naturally in food or is added, both forms become part of the total fiber content of the food, referred to as Total Fiber by the IOM, and the amount reflected on the Nutrition Facts label (7). Similarly, DRI recommendations and fiber definitions from the American Association of Cereal Chemists and Codex address dietary fiber without differentiation of amounts of naturally occurring and added fibers. Thus, it is logical that recommendations for obtaining fiber from food should be inclusive of all types of fibers (intrinsic and added).

Adding nutrients to foods to promote positive health benefits is a practice that is well accepted and has been successful in reducing nutrient deficits. With folic acid, for example, fortification of widely consumed grains has raised intake of this nutrient to more desirable levels, with subsequent reduction in rates of neural tube birth defects (62). A recent analysis of usual intakes of micronutrients in individuals aged 2 y found that many Americans would not achieve the recommended micronutrient intake levels set forth in the DRI recommendations without enrichment, fortification, or supplementation (63). Compared with intakes from naturally occurring nutrients, enrichment and/or fortification dramatically improved intakes of several key nutrients, including folate, thiamine, iron, and vitamins A and D. The 2010 DGA acknowledge that “fortified foods and supplements may be useful in providing one or more nutrients that otherwise might be consumed in less than recommended amounts” (3). Although extensive fiber fortification of food was not considered a solution, roundtable participants agreed that adding fiber lost in processing back to enriched grains or adding to the fiber that is naturally present in whole-grain foods are realistic and potentially impactful solutions. As a nutrient of concern, total fiber content could be used to establish the quality of a grain food.

The IOM acknowledges that consuming fiber from a variety of sources with the objective of increasing total fiber intake offers varying health benefits specific to the fiber source (Table
Certain sources of fiber deliver more than physiologic benefits and also offer functional and/or nutritional properties. Growing recognition of the positive benefits of different types of fibers, both intrinsic and added, has contributed to a greater use of isolated fibers as food ingredients, particularly in grain foods.

**Achieve energy balance with added fiber in grain-based foods.** In its recommendations for grain foods, the 2010 DGA advise that at least half of total grain intake should be from whole grains, with the remaining from enriched grains. Whole grains are recognized in the DGA as a source of nutrients such as iron, magnesium, selenium, B vitamins, and fiber, with the caveat that whole grains vary in their fiber content. The DGA acknowledge that whole grains higher in fiber have additional health benefits but offer little advice on strategies to consume foods with added fiber despite mounting evidence and recognition that isolated fibers also exert important physiologic health benefits (6). This signifies the need for additional research and education to create greater awareness of the benefits and importance of added fiber as a strategy for filling the fiber intake gap.

Current recommendations to increase fiber intake pose a challenge to consumers who also need to manage energy intake while maximizing nutrient intake. All grain-based foods, including whole- and enriched-grain products, are logical vehicles for added fibers because intakes of grain-based foods already meet daily recommendations. A modeling study using intake data obtained from NHANES 2003–2006 simulated various approaches to increasing fiber in Americans’ diets and measured the effect on total energy intake when whole-grain intake increased and when fiber was added to grain foods already being consumed (4). The addition of 2.5 or 5.0 g of fiber per serving to

| TABLE 4 Types, effects, and sources of fiber ingredients |
|---------------------------------|---------------------------------|---------------------------------|
| **Isolated, modified, or synthesized fibers added to foods** | **Main physiologic effects** | **Usually isolated or derived from** |
| β-Glucan and oat bran | Blood lipid lowering | Oats and barley |
| | Attenuates blood glucose response | |
| Cellulose | Laxation | Plant foods |
| Chitin/chitosan | Blood lipid lowering (as seen in animal studies) | Fungi or shellfish |
| Guar gum | Blood lipid lowering | Guar bean (legume) |
| | Attenuates blood glucose response | |
| Short-chain fructooligosaccharide, including inulin, oligofructose | Laxation | Chicory root |
| | Gut health | Jerusalem artichoke |
| | Microbiota modulation toward a more healthful community | Synthesized from sucrose |
| | Blood lipid lowering | |
| Galactooligosaccharide (64,65) | Gut health | Legume extract |
| | Microbiota modulation toward a more healthful community | Dairy products |
| | Immune system modulation | Human milk |
| Pectin | Blood lipid lowering | Plant foods |
| | Attenuates blood glucose response | |
| Polydextrose | Laxation | Synthesized from dextrose (glucose) |
| Psyllium | Laxation | Psyllium husk (plant) |
| | Blood lipid lowering | |
| | Attenuates blood glucose response | |
| Resistant dextrins | Blood lipid lowering | Corn and wheat |
| | Attenuates blood glucose response | |
| Resistant starch | Laxation | Plant foods |
| | Gut health | |
| | Attenuates blood glucose response when substituted for digestible carbohydrates | |
| Soluble corn fiber (66) | Attenuates blood glucose response | Corn |
| | Gut health | |
| Wheat bran | Laxation | Wheat |
grain foods low in fiber resulted in fiber intakes of 24.7 and 39.1 g/d, respectively, without an increase in energy intake. Increasing consumption of currently available whole-grain foods to the recommended levels increased fiber intake in all adults to 25.3 g/d, but with an additional increase in energy of 1266 kcal/d (4).

Optimize eating occasions with the greatest potential impact
National eating-occasion data (NHANES 2007–2008) shows that breakfast and snacks contribute 18% and 21%, respectively, to the total daily fiber intake of Americans, compared with lunch (25%) and dinner (36%) (67). These findings illustrate the potential for focusing on breakfast and snacking as eating occasions to help consumers increase fiber intake. Eating breakfast has been associated with managing body weight, higher-quality diets, and cognitive performance, especially in children (68–72). It also offers an opportunity to consume fiber and whole grains, which have the potential to enhance overall diet quality and offer satiety (24,30). These important benefits combined with the wide variety of breakfast foods available that provide fiber, such as whole-grain and fiber-added cereals and breads, give breakfast the potential for making a substantial impact on increasing fiber intakes in both children and adults. Additional choices for higher-fiber breakfast items “on the go” and tips for easy substitutions can help to increase the fiber contribution of the breakfast meal.

Snacks offer another opportunity for increasing fiber consumption, especially for children, with an array of snack-food choices, whole-grain and/or fiber-added crackers, chips, baked goods, and granola bars. As with any unfamiliar food, children are more likely to enjoy higher-fiber snack foods when they are exposed at an earlier age, and when influential adults such as parents, caregivers, teachers, and coaches model healthy higher-fiber snacking habits. Cultural food practices should also be considered in fiber education. For example, some Latinos use cereals as a snack food and add grains to beverages (e.g., batido de trigo and atole).

Health professional education and resources
The roundtable discussions underscored the importance of reaching consumers with accurate and practical information about fiber. To do this, health professionals must understand the significance and potential long-term consequences of the fiber deficit, and their pivotal role in helping consumers make necessary changes to increase fiber intakes through both naturally occurring and added fiber sources. As research continues to explore the mechanisms and benefits of fiber and whole grains, including sources of isolated/added fibers, health professionals will need resources to stay current in their knowledge of fiber as well as practical tools for working with consumers. An online survey (unpublished results, Kellogg Company, August 2010) of 150 registered dietitians (RD) in general or medical practice specialty groups revealed that fiber from natural, whole-food sources was preferred by RD participants for addressing the fiber deficit. There was general consensus among the RD participants that adding fiber to foods is also an acceptable option, particularly when fiber is added to traditional sources of fiber, including breads, ready-to-eat cereals, and cereal bars. Yet, RD participants expressed concern that some fiber-added foods may not offer the same benefits as natural fiber sources. With regard to whole grains, >90% of the RD participants surveyed expected that “whole-grain labeled products” will provide at least a good source of fiber (3 g/serving).

To help RD and other health professionals overcome these knowledge gaps and improve their communications with consumers, the roundtable experts recommended several key strategies:

- Develop continuing education modules to address the latest research on fiber, with emphasis on the importance of fiber variety and the physiologic value of all types of fiber, whether intact or added, in providing beneficial effects. Additional learning on the regulatory aspects of nutrient claims related to fiber, and how to use language consistent with approved regulatory guidance, particularly for whole grains, was also recommended.
- Debunk common myths about fiber, including the belief that whole grain is equivalent to fiber, and concerns about added-fiber sources, such as isolated and synthesized fibers. Help consumers understand that all types of fiber deliver important physiologic benefits, and become familiar with the types of ingredients that may be used to add fiber to grain-based foods.
- Acquire and use cultural competency skills to better understand how to address fiber in typical food choices, practices, and behaviors of ethnic groups and develop culturally appropriate programs and messages to optimize fiber intakes.
- Offer practical, “how to” guidance to show consumers how to select and serve foods that provide fiber. For example, sample menus can illustrate how small changes in food choices, including use of foods with added fiber, can add up to dramatic changes in daily fiber intakes while controlling energy intake (73).
- Address consumer concerns with taste, time, and cost, which may include showing how to prepare foods with more fiber through recipes and food demonstrations, food budgeting and shopping to address cost concerns of fiber sources, and meal planning using MyPlate resources (e.g., ChooseMyPlate.gov) to show how to incorporate a variety of fiber sources into daily meals. Recognize the importance of meeting consumers where they are with their dietary and lifestyle behaviors, and encourage them to make incremental small changes that can have a dramatic impact on improving diet quality, including increasing fiber intake, without consuming additional calories (74).
- Emphasize label reading as an essential skill for selecting grain foods, with fiber content recommended as a marker for comparing foods, with fiber content recommended as a marker for comparing and choosing grain foods, including whole grains. A simple criterion such as “choose grain foods with at least 3 g of fiber (or with ≥10% of the Daily Value per serving)” offers a straightforward strategy for consumers to make an informed decision about both whole-grain products and added-fiber foods.

Closing the fiber intake gap will require involvement by various sectors of influence, including educators, health and culinary professionals, policymakers, and the food industry. Continued discussion and exploration of the potential benefits of all fiber sources will help support development of clear and consistent messages to reinforce the importance of adequate fiber intakes. Additional resources, including review papers and position statements, can provide support for the variety of fiber sources and address needs for research and educational tools on all types of fiber, including naturally occurring and fibers added to foods. Industry can be leveraged as a resource to help support needs for research and education with objective, applicable, and practical information for students and practitioners. Industry can also play a role in increasing fiber intakes through product innovation with development of good-tasting and affordable foods that provide fiber, including adding fiber to lower-fiber, nutrient-dense grain-based foods.

Summary
Fiber’s essential role in optimal health creates an urgency to help Americans overcome the barriers that hinder adequate fiber
intakes. There was consensus among roundtable participants that grain foods offer a unique opportunity to help Americans increase their fiber intakes. With current grain intakes at or slightly above recommended amounts, making simple changes to choose grain foods with a good or excellent source of fiber may be the most realistic and impactful way to help Americans make immediate progress toward filling the fiber intake gap while staying within energy needs. The roundtable experts agreed that an energy-neutral strategy to increase fiber intakes is adding fiber back to selected enriched grain foods when it was lost in processing or adding more fiber to whole-grain products.

Roundtable participants acknowledged the importance of meeting daily recommendations for other fiber-containing foods such as fruit, vegetables, and legumes, yet recognized that increasing intakes of these foods to recommended amounts requires more complex behavior changes, including how to increase servings of these foods while reducing intakes of other foods to stay within daily energy goals.

The roundtable concluded with several key statements that frame the current fiber intake situation and that provide realistic solutions to close the fiber intake gap:

- Americans’ fiber intake is a public health concern for both adults and children, with potential consequences that may increase the risk of several chronic diseases and obesity. Although fiber is recognized by the 2010 DGA as a nutrient of concern, recommendations to improve fiber intakes focus on increased consumption of fruit, vegetables, and whole grains, with little recognition of the effect on total energy intake and the positive role of adding fibers to foods to help close the fiber intake gap. With increased emphasis on energy balance, added fiber in select grain-based foods is a practical and energy-neutral solution.
- All forms and sources of fiber, including intrinsic and added fiber, can play a role in closing the fiber intake gap. The 2009 Codex definition of fiber acknowledges dietary fiber as naturally occurring, isolated from food, or synthetically derived (9). This recognizes the contributions of both intrinsic and added fiber, thus giving value to all sources of fiber.
- Small changes in eating patterns—and to foods people already enjoy—can help to increase fiber intakes without increasing energy intake. Meal occasions with the most potential for increasing fiber intake are breakfast and snacks.
- Use of fiber as a marker for grain-based food quality offers a practical way to identify grain-based foods that provide a good source of fiber (3 g/serving), including whole grains and enriched grains with added fiber. Using “whole grain” to characterize only grain-based food quality does not tell the complete nutritional story because many whole-grain products are not good sources of fiber.
- Eligibility criteria for whole-grain labeling claims based on the amount of fiber per serving would help to inform and reinforce the expectation that whole-grain products vary in their fiber content and, with careful selection, they can deliver a good source of fiber.
- There are opportunities to educate health professionals and other advocates with proof that illustrates how all fiber sources have important health benefits and can contribute to filling Americans’ fiber intake gap.

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