

Developing a Standard Definition of Whole-Grain Foods for Dietary Recommendations: Summary Report of a Multidisciplinary Expert Roundtable Discussion^{1,2}

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ABSTRACT

Although the term “whole grain” is well defined, there has been no universal standard of what constitutes a “whole-grain food,” creating challenges for researchers, the food industry, regulatory authorities, and consumers around the world. As part of the 2010 Dietary Guidelines for Americans, the U.S. Dietary Guidelines Technical Advisory Committee issued a call to action to develop definitions for whole-grain foods that could be universally accepted and applied to dietary recommendations and planning. The Committee’s call to action, and the lack of a global whole-grain food definition, was the impetus for the Whole Grain Roundtable held 3–5 December 2012 in Chicago, Illinois. The objective was to develop a whole-grain food definition that is consistent with the quartet of needs of science, food product formulation, consumer behavior, and label education. The roundtable’s expert panel represented a broad range of expertise from the United States and Europe, including epidemiology and dietary intervention researchers, consumer educators, government policy makers, and food and nutrition scientists from academia and the grain food industry. Taking into account the totality, quality, and consistency of available scientific evidence, the expert panel recommended that 8 g of whole grain/30 g serving (27 g/100 g), without a fiber requirement, be considered a minimum content of whole grains that is nutritionally meaningful and that a food providing at least 8 g of whole grains/30-g serving be defined as a whole-grain food. Having an established whole-grain food definition will encourage manufacturers to produce foods with meaningful amounts of whole grain, allow consistent product labeling and messaging, and empower consumers to readily identify whole-grain foods and achieve whole-grain dietary recommendations. *Adv. Nutr.* 5: 164–176, 2014.

Introduction

Definition of a whole-grain food is lacking

Although a working definition exists for what constitutes a whole grain (1), no standard definition for what constitutes

a whole-grain food was in place at the time of the roundtable, creating challenges for researchers, industry, regulatory authorities, and consumers alike. Developing a definition for a whole-grain food will be a critical first step to help consumers meet their whole-grain dietary intake recommendations and ultimately contribute to the improvement of their health.

The need for a standard definition for whole-grain foods is evidenced by the fact that:

- whole-grain foods are not consistently defined,
- whole-grain qualification standards, where they exist, vary among countries, government and regulatory agencies, and private bodies,
- whole-grain foods and package labeling lack standardization,

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- due to myriad labeling inconsistencies, consumers are often confused when shopping for whole-grain foods, and,
- whole-grain and fiber contents of foods are often incorrectly used interchangeably.

The roundtable experts agreed to assess 4 criteria for the establishment of a whole-grain food definition: scientific basis (rationale), food formulation (feasibility), consumer acceptance, and ease of label education (application). Standardizing a definition for whole-grain foods would encourage manufacturers and governmental and regulatory authorities to develop and label foods with meaningful amounts of whole grain, provide researchers with a consistent approach to quantify whole-grain intake, and help advance science related to the effects of whole grain on health outcomes.

The current lack of a clear definition for whole-grain foods may be contributing to the widespread failure of consumers to meet current whole-grain dietary recommendations.

A call to action to develop a definition for whole-grain foods that could be universally accepted and applied to dietary recommendations and planning was issued by the U.S. Dietary Guidelines Technical Advisory Committee (DGTAC)¹⁶ as part of the 2010 Dietary Guidelines for Americans (DGA). The committee stated, “Without clear definitions, it is difficult to compare studies examining the effectiveness of various whole grains on biomarkers of interest in disease. Clear definitions would also help consumers identify foods that can help them meet the Dietary Guidelines recommendation (2).”

The ongoing lack of a globally accepted whole-grain food definition, along with the DGTAC call to action, was the impetus to organize the “Whole Grain Roundtable” held 3–5 December 2012, in Chicago, Illinois. The purpose of the meeting was to discuss and agree upon a definition for a whole-grain food that could be used both in the United States and internationally. The roundtable, jointly sponsored by the General Mills Bell Institute of Health and Nutrition (United States) and Cereal Partners Worldwide (Switzerland), hosted experts from the United States and Europe in multiple disciplines, including epidemiology, public health nutrition, dietetics, clinical medicine, consumer education, policy and law, food science, and technology, including grain food processing. The panel of experts recognized that establishing a whole-grain food definition is critical to move the field forward, not only to improve dietary guidance but to provide a standard for the food industry to translate dietary recommendations for consumers. The primary objectives of the Whole Grain Roundtable were to: 1) present and discuss relevant scientific evidence to confirm that the benefits of whole grain are attributable to many of its components; and 2) review relevant evidence and develop a standard definition for whole-grain foods.

Health benefits of whole grains: A brief summary of the evidence

Although this is not a comprehensive review of the whole-grain science literature, the expert panel at the roundtable engaged in a review of the evidence relevant to the objectives. The evidence linking whole-grain intake to reduced risk of cardiovascular disease (CVD), diabetes, and excess weight is briefly summarized in **Table 1**. Consumption of whole grains also has been associated with greater nutrient intakes and enhanced diet quality (3–6).

Findings from large, population-based, prospective, observational studies have consistently observed a dose-response relation between whole-grain intake and disease risk, with health benefits proportional to the amount of whole grain consumed (7–17). Consumption of 2–3 servings/d (~48 g) of whole grains, an amount that is readily achievable, may reduce risk of CVD, type 2 diabetes mellitus (T2DM), and overweight and obesity. Generally, the current evidence shows that consuming between 3 and 5 servings of whole grains per day reduce not only the risk of ischemic heart disease and CVD events but also risk factors associated with CVD (15, 18–20). Evidence also suggests that those who consume an average of 3–5 daily servings of whole grains have a 21–30% reduction in risk of T2DM compared with those who rarely or never consume whole grains (14,16,17,21,22). Potential mechanisms for whole grain health benefits include aiding in the maintenance of glucose and insulin homeostasis, lowering of serum cholesterol and LDL-cholesterol concentrations, and reducing inflammation and oxidative stress (7).

These observational data have been supported to some extent by small-scale intervention studies of at-risk populations, i.e., participants with T2DM, hypertension, and/or high cholesterol, but findings have not always been consistent (23–27).

In addition, there may be as-yet-unidentified genetic and other lifestyle influences that interact with the inclusion of whole grains in the diet as well as inherent metabolic differences among populations and between men and women that affect study outcomes. Proving a cause and effect relation with one aspect of the diet, even in intervention trials, can be challenging because of the inherent complexity of the food/dietary matrix and the general lack of large changes in targeted biomarkers in apparently healthy populations as a result of short-term dietary interventions.

Another factor contributing to inconsistent findings is that the diets of free-living populations typically contain a variety of grains, with different phytonutrients (e.g., phenolic acids, polyphenols, inositol, alkylresorcinol, phytosterols), fibers (e.g., β -glucans in oats and barley, arabinoxylans in wheat and rye), micronutrients, and macronutrients that may play important roles in whole-grain health benefits. Interactions among these whole grain co-passengers may contribute to the observed differences in health benefits, but because they exist together as part of the whole-grain package, delineating which compound(s) is (are) responsible for observed health benefits or whether specific synergies exist remains a challenge not yet addressed (28–30).

¹⁶ Abbreviations used: AACCI, American Association of Cereal Chemists International; CVD, cardiovascular disease; DGA, Dietary Guidelines for Americans; DGTAC, U.S. Dietary Guidelines Technical Advisory Committee; T2DM, type 2 diabetes.

TABLE 1 Summary of the potential whole-grain health benefits evidence^{1,2}

Outcome	Benefits	USDA evidence analysis conclusion (6)
CVD	Associated with ~21% lower risk of CVD	A moderate body of evidence from large prospective cohort studies shows that whole-grain intake, which includes cereal fiber, protects against CVD.
T2DM	Associated with ~26% lower risk of T2DM	Limited evidence shows that consumption of whole grains is associated with a reduced incidence of T2DM in large prospective cohort studies.
Weight management	Associated with lower BMI, less weight gain during 8–13 y (1.27 kg), and lower central adiposity	Moderate evidence shows that intake of whole grains and grain fiber is associated with lower body weight.

¹ Conclusions are drawn from a series of meta-analyses and critical systematic reviews of whole grains in relation to health outcomes. Compared with never/rare consumers of whole grains, those consuming 2–3 servings/d of whole grains have lower risk of CVD, T2DM, and weight gain. CVD, cardiovascular disease; T2DM, type 2 diabetes.

² The most up-to-date systematic review and meta-analysis assessing the role of whole-grain intake in developing health outcomes of interest indicate that compared with never/rare consumers of whole grains, those consuming ≥ 48 g/d of whole grains have a lower risk of CVD, T2DM, and body weight gain.

Although the understanding of the mechanisms behind whole-grain health benefits is limited, relying on randomized controlled trials that focus on intermediate outcomes alone may not be the best approach for setting dietary recommendations. In evaluating studies for the 2010 Dietary Guidelines, the DGTAC gave more weight to experimental studies than to observational studies, more weight to meta-analysis of randomized controlled trials than to individual randomized controlled trials, and more weight to cohort studies than to case-control studies (6). Overall, the panel supported the view that the totality of the evidence for health benefits of whole-grain consumption is convincing and serves as the basis of dietary recommendations globally to include and/or choose whole grains more frequently in the diet (31–48) (Table 2).

Recommendations to increase consumption of whole grains are global

Worldwide, dietary recommendations for consuming whole grains range from the generic, e.g., eat more fruits, vegetables, and whole-grain products (49), and intermediate, e.g., eat at least 30 g of dietary fiber daily, especially from whole-grain products (50), to the more specific, e.g. consume at least one-half of all grains as whole grains and increase whole-grain intake by replacing refined grains with whole grains (2).

Several countries recommend consumption of whole grains, including Australia, Canada, Chile, China, Colombia, Denmark, France, Germany, Greece, Iceland, India, Latvia, Mexico, Oman, Singapore, Switzerland, the United Kingdom, and the United States. Table 2 provides a summary of some existing global dietary whole-grain guidelines. However, the specific quantities of whole grains recommended to be consumed per day vary considerably. The first specific advice in the United States to include whole-grain servings was a part of the 2005 DGA (51). This change from a more general grain recommendation to a specific whole-grain recommendation was developed from and supported by a body of epidemiological (52) and mechanistic experimental (53) studies linking whole-grain intake to an array of beneficial outcomes. The 2010 DGA recommends 6–11 servings/d of grains based on an individual's energy needs, with at least one-half of those servings (at least 3 servings) as whole grains. In these guidelines, foods with at least 51% of the total weight as whole-grain ingredients or at least 8 g of whole

grains/ounce-equivalent (~30 g) were identified as foods that provided a substantial amount of whole grains (47).

Whole-grain recommendations in some countries have recently become more specific. In Mexico, e.g., the recommendation from the Official Mexican Norm of Nutrition/Food Education was recently altered from “Wholegrains should be recommended...” to “Include wholegrain cereals in each meal...” (41). Many recommendations stress the importance of the co-passengers in whole grain, including fiber and phytochemicals, but without specifying quantities or defining what constitutes a whole-grain food.

Historically, increasing whole-grain intake was recommended primarily because it increased fiber intake, as whole-grain foods make an important contribution to dietary fiber intake. Choosing whole grains that are higher in fiber has additional health benefits; however, high fiber does not always equate with whole grain, just as whole grain does not always equate with high fiber (2,54) (Table 3). Dietary recommendations in some countries have slowly shifted over time from being nutrient based to being food based (55–59). Importantly, although countries may vary in their food vs. nutrient approaches to dietary guidelines, many include a recommendation to increase consumption of whole grains (60,61).

Whole grains are defined but whole-grain foods are not

In 1999, a whole-grain ingredient definition was developed by the Whole Grains Working Group of the American Association of Cereal Chemists International (AACCI) (1). The AACCI established this working group as a source of accurate scientific information on whole grains and charged the group with discussing and establishing criteria to define a whole grain. The AACCI definition states that whole grains are “intact, ground, cracked or flaked fruit of the grain whose principal components, the starchy endosperm, germ and bran, are present in the same relative proportions as they exist in the intact grain” (1). This definition was adopted and issued by the U.S. FDA in its Draft Whole Grain Label Guidance in 2006 (62,63). Some countries use an adapted AACCI/FDA whole-grain definition and/or DGA whole-grain dietary recommendation (1). The European HEALTHGRAIN Forum, a European Union consortium of scientists, industry representatives, and policy makers advocating for whole grains and grain-based foods also agreed and published a whole-grain

TABLE 2 Global dietary whole-grain guidelines¹

Country/organization	Specific recommendation	Reference
Australia	The Australian Dietary Guidelines and Guide to Healthy Eating recommend 3–8 1/2 servings (dependent upon age, sex, or caloric requirements) of grain (cereal) foods, mostly whole grain, such as breads, cereals, rice, pasta, noodles, polenta, couscous, oats, quinoa, and barley.	31
Austria	The Austrian Food Pyramid (Die österreichische Ernährungspyramide) recommends consuming 4 servings/d of cereals, bread, pasta, rice, or potatoes (5 servings for active adults and children), preferably whole grain.	32
Canada	The Canadian Food Guide recommends 3–8 servings/d (age and sex dependent) of grain products and advises making at least one-half of the grain product choices whole grain each day. Further recommendations state to eat a variety of whole grains such as barley, brown rice, oats, quinoa, and wild rice.	33
Chile	Group of pediatricians in Chile from Chilean Pediatric Society recommends that one-half of grains should be whole grain to reach recommended amount of fiber.	34
China	The Chinese Dietary Guidelines and the Diet Pagoda recommend adults consume 300–500 g/d (dependent upon energy requirements) of total grains, cereals, and legumes, among them, at least 50 g/d of coarse grains, including whole grains.	35
Denmark	Denmark's Food Administration uses the Diet Compass (Kostkompasset) and the Dietary 8 (8 kostråd) to recommend consuming 75 g/d whole grains (for energy requirements of 10 MJ/d). Bread, grains, rice, and pasta should be an essential part of the diet and for older children and adults, 500 g/d is recommended.	36
France	France's Guide of the National Health and Nutrition Program (Guides alimentaires du programme national nutrition-santé) recommends consumption of breads, cereals, and starchy foods at each meal, especially whole-grain foods that provide considerable amounts of fiber.	37
Greece	The Dietary Guidelines for adults in Greece suggest consuming 8 servings of nonrefined cereals and products, preferably whole-grain varieties (whole-grain bread, whole-grain pasta, brown rice, etc).	38
India	The Dietary Guidelines for Indians recommends increasing consumption of whole grains, legumes, and nuts to maintain body weight and body composition.	39
Latvia	The Latvian Health Ministry recommends consumption of 4–6 servings/d of cereals, especially whole grains such as fiber-rich whole-grain products (bread, pasta, oatmeal porridge) to reduce the risk of diseases.	40
Mexico	Mexico's Department of Nutrition and Health Promotion recommends consumption of cereals should be recommended, preferably whole grains without added sugar. Their fiber and nutrients should be highlighted. Whole grains should be eaten with every meal, with legume seeds.	41
Norway	The Health Directorate of Norway's Key Advice for a Healthy Diet (Nøkkelråd for et sunt kosthold) suggests increasing intake of whole-grain products and cereals each day. The whole-grain products should together provide 70–90 g/d of whole-meal flour or whole grain.	42
Oman	The Omani Guide to Healthy Eating recommends choosing whole grains and cereals and consuming potatoes, with their skin. For an average diet of 2000 kcal, 2–3 servings/d of whole grains is advised.	43
Singapore	The Dietary Guidelines for Adult Singaporeans and Healthy Diet Pyramid recommend eating sufficient amounts of grains especially whole grains. Out of the 5–7 servings of rice and alternatives, adults should consume 2–3 servings/d of whole-grain food.	44
Switzerland	The Swiss Society for Nutrition recommends that each main meal should be served with 1 starch-rich side dish (i.e., 3 portions/d, 1 portion = 75–125 g of bread or 60–100 g of pulses (raw weight)); for instance, lentils/chick peas or 180–300 g of potatoes or 45–75 g of pasta/rice/flakes/corn/other grains (raw weight), including at least 2 portions of whole-grain products.	45
United Kingdom	The National Health Service's Eatwell Plate recommends eating plenty of bread, rice, potatoes, pasta, and other starchy foods (shown as one-third of a plate) and choosing whole-grain varieties whenever possible.	46
United States	The 2010 DGA suggests consuming 3 or more ounce-equivalents of whole-grain products per day, with the rest of the recommended grains coming from enriched or whole-grain products (at the 2000 kcal intake level). Consume at least one-half of all grains as whole grains. Increase whole-grain intake by replacing refined grains with whole grains.	47
WHO	The WHO and the FAO of the United Nations recommend increasing consumption of whole grains as a strategy to prevent diet-related chronic diseases. The WHO/FAO rate the strength of evidence for whole-grain consumption and decreased risk of CVD and diabetes as probable.	48

¹ CVD, cardiovascular disease; DGA, Dietary Guidelines for Americans.

TABLE 3 Fiber content of a variety of grains¹

Grain	Fiber content	
	g/8 g grain	g/100 g grain
Brown rice	0.3	3.5
Wild rice	0.5	6.2
Corn, yellow	0.6	7.3
Oats	0.9	10.6
Wheat	1.0	12.2
Amaranth	1.2	15.0
Rye	1.2	15.1
Barley	1.4	17.3

¹ Data from reference 54.

definition. This defines whole grains as “consisting of the intact, ground, cracked or flaked kernel after the removal of inedible parts such as the hull and husk. The principle anatomical components—the endosperm, germ and bran—are to be present in the same relative proportions as they exist in the intact kernel. Small losses of components, i.e., <2% of the germ or <10% of the bran, which may occur through processing methods consistent with safety and quality, are allowed” (64). The definition differs from that of the AACCI in that it allows for small losses during initial processing/cleaning of the grain. It has been suggested that the effects of further processing (baking, malting, and fermentation) should be determined before a whole-grain food definition is developed (65). However, available research suggests that the frequency of consumption and amount of whole grain eaten, rather than the type of processing, are the most important considerations when selecting a healthful diet (66). As new scientific evidence emerges, dietary recommendations and guidelines should be reexamined and further consideration of defining whole-grain foods may be warranted.

Although definitions exist for whole grains and relevant whole-grain ingredients, a consistent definition for what constitutes a whole-grain food has not been developed and adopted for use by the FDA, the USDA, or the European Commission. Researchers have defined criteria for quantifying whole-grain foods based on the available information and marketplace of whole-grain products, but in the absence of an accepted definition of a whole-grain food, an array of packaged food products provides diverse amounts of whole grain per serving. Given the different regulatory standards and requirements across the globe, for the purpose of this roundtable meeting and discussions, the United States was considered as the starting point for defining whole-grain foods. In the United States, a standard grain food serving size is estimated to be 1 ounce-equivalent by the USDA (39) or ~30 g by the FDA (67), a definition for whole-grain foods that incorporates a specific amount of whole grains per 30-g serving is needed.

Multiple whole grain policies and regulations

Though no universally accepted definition has existed for whole-grain foods, several government agencies in the United States and elsewhere have established whole-grain food definitions for a wide range of purposes (31,35,41,47,48,62,63, 65, 68–72), which has added to the confusion (Table 4).

Some have argued for quantifying whole-grain content of foods based on fiber content, e.g., as a compliance marker for the FDA whole-grain health claim. However, fiber content of whole grains varies widely (Table 3), considerably limiting its reliability as a whole-grain indicator for all whole-grain foods. Furthermore, the content and type of fiber in a whole-grain food depends not only on the grain but also on the density of the product, moisture content, amount of bran, and other ingredients. For example, a grain food made with 100% whole-grain corn will naturally contain ~1 g fiber/30-g serving but still provide all of the beneficial compounds found in that whole grain. An internationally accepted definition for whole-grain foods could help in the development of clear regulatory standards and food package labeling, differentiate between whole grains and fiber, promote easier identification of whole-grain foods by consumers, and contribute to improved quantification of whole-grain intake.

The 2010 DGA recommends that consumers make one-half of their grains whole, which approximates to a minimum of 48 g/d whole grains (47). If whole-grain foods are defined as providing 8 g whole grains/30 g (27 g/100 g), then consumers could meet the whole-grain recommendation of 48 g/d with six 30-g servings of such foods, the current minimum amount of grain foods the DGA recommend to include in the diet each day (2). For foods with 100% whole-grain content, the target could be met with 3 servings (each of 16 g whole grains).

Whole-grain food definition would support whole-grain research efforts

Whole-grain information in nutrient databases varies.

Whole-grain research, both observational and intervention trials, largely relies upon the completeness and accuracy of nutrient databases to capture whole-grain intakes of study participants. A substantial increase in the availability of whole-grain products during the past decade has made accurate assessment of whole-grain intake increasingly challenging. Dietary intakes in most observational studies reflect intakes before the introduction of a wider variety of whole-grain foods, with whole-grain intakes being represented mainly by whole-grain breads and whole-grain ready-to-eat breakfast cereals. Existing whole-grain food composition data are limited, as are the number of whole-grain food items listed on some FFQs. Up-to-date nutrient databases are needed to better assess whole-grain intake and capture the changing whole-grain food supply.

Lack of a whole-grain food definition slows research progress.

The significant heterogeneity among studies is in part the result of differing whole-grain classifications (73) used such as: 1) foods that list a whole grain as the first ingredient on the food label (13); 2) fiber-rich, whole-grain cereals providing specific amounts of total, insoluble, and soluble fiber per serving (74); 3) whole-grain items with added bran, germ, and fiber (9); 4) products with 25% or more of whole-grain or bran weight (9); 5) whole grain

TABLE 4 Multiple whole-grain dietary guidance, policies, and regulations in the United States and internationally¹

Agency/organization (reference)	Definition/classification
United States 2010 DGA (47)	Make one-half of your grains whole grains. Eat at least 3-oz equivalents of whole grains daily (1 ounce equivalent is about 1 slice bread; 1 oz ready-to-eat cereal; or 1/2 cup cooked rice, pasta, or cereal; 1 ounce equivalent ~30 g). 51% whole grain is a significant amount. Foods with at least 8 g whole grains per ounce-equivalent. Whole grains provide benefits beyond fiber.
FDA Whole Grain Health Claim (1999, 2003, 2008) (62)	Foods must be $\geq 51\%$ whole grain by weight per RACC. Dietary fiber used as marker for compliance. Exceptions include single ingredient whole-grain food, i.e., first grain ingredient and no fiber marker.
FDA Draft Guidance on Whole Grain Label Statement (2006) (63)	Allows factual statements about whole-grain content of products, e.g., 100% whole grains, 10 g of whole grains, 1/2 oz whole grains. Restates the FDA whole-grain health claim as a permitted statement: product must meet the requirements outlined in the health claim. Does not characterize a significant amount of whole grain (no minimal standard). No final guidance.
USDA School Meals Regulations (2012) (68)	Whole grain rich defined as $\geq 50\%$ whole grain by weight or first ingredient is whole grain or ≥ 8 g whole grain/serving.
USDA WIC Food Package Regulations (2013) (69)	Bread: Standard of identity for whole-grain bread and contain a minimum of 51% whole grain by weight (using dietary fiber as the indicator) and first ingredient whole grain and meet FDA labeling requirement for making a whole-grain health claim and meet regulatory definitions for "low saturated fat" and "low cholesterol" and bear quantitative <i>trans</i> fat labeling and contain ≤ 6.5 g total fat/RACC and ≤ 0.5 g <i>trans</i> fat/RACC. Cereal: Same requirements as whole-grain bread plus no more than 21 g sugars/100 g.
USDA Food Safety and Inspection Service Statement of Interim Policy Guidance (2005) (70)	Only applicable to products containing meat or poultry. Foods can be considered whole grain that meet 51% of the grain as whole grain or 51% of the product by weight or contain at least 1/2-oz equivalent or 8 g dry whole-grain ingredient. Products that meet FDA standards of identity or that contain at least 1/2-oz equivalent or 8 g whole grain can be described as "made with whole grains."
Whole Grain Council Stamp (71)	100% Stamp: all grain ingredients are whole grains. Minimum requirement of 16 g of whole grain per labeled serving. Basic Stamp: contains at least 8 g of whole grain. Even if a product contains large amounts of whole grain (23 g, 37 g, 41 g, etc.), it will use the Basic Stamp if it also contains extra bran, germ, or refined flour.
Other countries/organizations	
Australia (31)	Whole-grain food must provide a minimum of 8 g/serving. The Chinese Dietary Guidelines and the Diet Pagoda recommend adults consume 300–500 g/d (dependent upon energy requirements) of total grains, cereal, and legumes, among them, at least 50 g/d of coarse grains, including whole grains.
China (35)	
Germany (72)	Whole-grain bread must be 90% whole grain.
Mexico (41)	Mexico's Department of Nutrition and Health Promotion recommends consumption of cereals, preferably whole grains without added sugar. Their fiber and nutrients should be highlighted. Whole grains should be eaten with every meal, with legume seeds.
Sweden Code of Practice (65)	Conditions for the use of the whole-grain claim according to the Code are that flours, grains, and flakes must be 100% whole grain and other products, including breakfast cereals and bread, must have at least 50% whole grain based on the dry matter. Dietary fiber content must be at least 4.5 g/1000 kJ and conditions regarding fat, sugar, and salt content for the keyhole must be fulfilled.
WHO (48)	The WHO and FAO of the United Nation recommend increasing consumption of whole grains as a strategy to prevent diet-related chronic diseases.

¹This is not a comprehensive list of all relevant guidance, regulations, or policies. DGA, Dietary Guidelines for Americans; RACC, Reference Amount Customarily Consumed.

from “dark” breads (9); and 6) products with $\geq 51\%$ of whole grain by weight (9–11). Products made with whole grains that fail to meet a study’s unique criteria for what constitutes a whole-grain food may still contribute to an individual’s whole-grain intake. Failure to account for these foods may lead to substantial misclassification of whole-grain intake and have an impact on study outcomes.

Previous epidemiological studies have categorized whole-grain intakes into discrete groups ($>50\%$, 25–50%, or $< 25\%$ whole grain by weight) or “servings,” in order to rank intakes and compare them with health outcomes of interest. However, such a ranking strategy cannot completely quantify the content of whole grains within foods, making the comparison of findings across studies difficult, particularly among diverse populations.

Comparisons of study findings are also hampered by the diversity and characteristics within whole grains (oats vs. rye vs. wheat). For example, according to the USDA database, which bases the serving size recommendations on the DGA and FDA guidelines (54) and many FFQs, 1/2 cup (97 g) of cooked brown rice and 1/2 cup (117 g) cooked oatmeal are both considered a single serving of a whole-grain food, yet the actual amount of whole grain they provide differs significantly; brown rice provides 26 g of whole grain per serving, whereas oatmeal provides 17 g, because of the different dry matter content of each food. They also differ substantially in the amounts and spectrum of the bioactive components (such as dietary fiber, micronutrients, and phytochemicals) each serving provides due to differences in composition of the 2 cereal grains. The lack of a standard measurement for a whole-grain food could also affect the observed association between biomarkers and health outcomes. Unless a whole-grain food definition is developed that allows researchers to capture the whole-grain contribution of lower fiber whole grains as well as products with different whole-grain content, determining health effects will continue to be challenging, particularly if whole grains are consumed in combination with refined grains.

Whole-grains research needs for the future. There is a clear need for large, controlled, dietary intervention studies in diverse ethnic populations that examine the potential health effects of specific and well-characterized whole grains alone and in combination, as a prerequisite to demonstrating sustained health effects over time. Overall, observational research suggests that health benefits are dose dependent, i.e., the more whole grains that are consumed, the greater the likelihood of a protective effect (14,75–81). However, intervention studies are needed to better identify the amount of whole grains likely to confer the most health benefits.

In tandem, standardized methods for identifying and classifying whole grains and their biomarkers are needed to help distinguish whole-grain intake from fiber intake and intact grains from processed flours, and to accurately identify and precisely quantify whole-grain foods. Gaining consensus on a definition of what constitutes a whole-grain food can help overcome current challenges in determining

whole-grain intakes in populations and ultimately in evaluating the strength of the evidence for issuing population-specific dietary guidance internationally.

Educating consumers on how to incorporate whole grains into their diets

A clear definition for whole-grain foods would help health professionals and consumers to accurately identify foods that provide a meaningful amount of whole grains. For example, although continued public education efforts in the United States encourage the consumption of one-half of the recommended 6 servings of grain-based foods per day as whole grains (48 g/d), the median intake of U.S. adults based on current classifications is about one-half serving or 8 g/d (2). Less than 1% of the U.S. population consumes the recommended intake and 20% of individuals report consuming no whole-grain products (3). A USDA analysis found that Americans choose refined grains over whole grains by a ratio of 5:1 (80). In the UK, the average daily whole grain intake is 14–16 g, with one-third of the adult population never eating whole grains (81). The average whole-grain consumption in France is only 7.3 g/d. In contrast, adult populations in Sweden and Denmark consume much higher amounts, a mean of 42 g/d whole grains in Sweden and 36 g/d in Denmark (82–84).

Motivators and barriers to increasing consumption of whole-grain foods are sometimes similar, depending on consumer perceptions of taste; familiarity with whole-grain foods, especially for children; cost; identification skills; and knowledge of the associated health benefits (85,86). The following are strategies found to be effective in increasing whole-grain consumption (87,88):

- Direct substitution (i.e., brown rice for white rice)
- Replacement of refined-grain foods with whole-grain foods, where the 2 foods differ (i.e., whole-grain pretzels instead of refined-grain crackers)
- Adding new whole-grain foods in the diet (i.e., whole-grain cereals or whole wheat pasta that were not previously consumed)
- Structural changes in meal patterns (i.e., eating breakfast that contains whole grains when breakfast was not previously consumed)
- Stealth approach (i.e., whole-grain ingredients are gradually substituted for refined grains)

Inconsistencies in labeling and wide variations in the amounts of whole grain found in foods labeled as whole grain make it difficult for educators to provide advice to consumers on what to look for in a whole-grain food product. Because whole grain is an ingredient, and not a nutrient, it does not appear on the Nutrition Facts Panel, the very place where consumers are instructed to look for important nutrition information. Consumers often equate fiber, which is available on the Nutrition Facts Panels of food products, with whole grain (89), mistakenly believing that a food must be high in fiber to provide whole grains. In the United States, many health professionals, in fact, instruct their clients to look for fiber as a proxy for whole grains and recommendations exist to choose whole-grain foods that provide

at least 3 g fiber/serving (90). However, most nutrient-rich whole grains provide fewer than 3 g fiber/16 g whole grain, including amaranth, barley, brown rice, oats, wheat, wild rice, and quinoa (91) (Table 3).

Barriers to increasing the consumption of whole grains should be addressed in part by focusing on identification skills (86,90,91). Unlike fruits and vegetables, which are available in distinct, recognizable units, making it easy for consumers to know if they are meeting recommendations, whole grains are often consumed as an ingredient in a packaged food and are not easily identified. A standard whole-grain food definition would identify whole-grain foods for consumers. Multicomponent educational strategies in schools, including classroom curricula, family newsletters, and supermarket and bakery tours coupled with daily exposure in school cafeterias, have increased the knowledge and whole-grain product identification skills of children, parents, and school food service personnel and increased intake among children (85,92).

Guidance for choosing whole-grain foods should be in the context of the overall healthful diet and include specific information on how to identify and limit whole-grain foods that are high in calories, sugar, sodium, saturated fats, or *trans* fats. In the United States, this would be in accordance with the FDA's definitions for acceptable levels of negative nutrients (93). The ongoing obesity and diabetes epidemics call for the grain community to provide leadership by making more nutrient-dense, lower energy, whole-grain options available. Additionally, to ensure nutrient adequacy, especially for folate, individuals, especially women of child-bearing age, who consume all of their grains as whole grains should include some enriched grains that have been fortified with folic acid (2). There must also be whole-grain educational efforts within the food industry itself. Currently, little effort focuses on industry-wide recommendations for food product formulation that would increase availability of more healthful whole-grain foods in the marketplace (94).

An environment in which supermarkets, restaurants, homes, and other venues support current dietary guidance on whole grains will require small and gradual modifications to grain food staples, combined with aggressive consumer education and awareness building. A universally accepted definition for whole-grain foods outlining a meaningful minimum amount of whole grains would ease the transition for the food industry as its members develop new whole-grain food products and for consumers as they learn to more easily identify and incorporate whole-grain foods into their daily dietary intake. Although such a whole-grain definition is important, the message to consumers should continue to be that "more is better," within the scope of calories and negative nutrients, and they should be encouraged to consume whole-grain-dense foods and make more healthful whole-grain food choices.

Challenges, considerations, and future opportunities for formulating whole-grain foods

To increase consumption in populations, whole-grain foods must be formulated to be practical, affordable, and desirable

for consumers. Consumer taste preferences often present the greatest challenge in the development of whole-grain food products. The variety of the grain, the cultivar, and the processing technique employed all affect flavor, appearance, texture, shelf life, and the final cost of a product. A variety of other factors affect the formulation and processing of whole-grain foods, including serving size; stability of the food matrix; moisture content; presence of other ingredients such as yeast, spices, sugar, fats, and oils; and total grain content. For example, a food with a larger portion size can accommodate more whole grains in its formulation without introducing considerable changes in taste, appearance, or texture, i.e., the amount of whole grains that can be incorporated into a food with a 15-g serving size without substantially affecting sensory characteristics would be less than the amount that can be incorporated into a food with a 30-g serving size. Eight grams of whole grain per 30-g serving (27 g/100 g) assures an achievable and meaningful minimum amount of whole grain relative to serving size and simplifies for consumers the identification of whole-grain foods. This would encourage manufacturers to promote whole-grain foods with smaller serving sizes and potentially increase whole-grain intake while gaining wider consumer acceptance.

Although new processing opportunities exist for the future, the industry is faced with processing challenges now. Most manufacturing facilities are designed to accommodate large volumes of refined grains, not whole grains. New cost-effective manufacturing lines and processes that can work with large volumes of whole grains would be able to accommodate any resulting increase in demand for whole-grain foods. A coordinated effort to implement comprehensive change across the entire food industry is needed, yet food companies may be hesitant to initiate such widespread formulation and processing changes without clear consumer demand and preferences for whole-grain foods. A consistent definition for whole-grains foods would not only enable clearer identification of whole-grain foods but can also increase their availability and consumer acceptance of whole-grain foods. In the United States, grains and grain-based foods constitute a considerable portion of the packaged foods consumed (66). New products can serve as the primary vehicles to carry beneficial whole grains while reducing fat, sugar, sodium, calories, and portion size, in keeping with dietary guidance. Packaged foods represent a unique opportunity to increase whole-grain consumption.

The limitations and gaps that currently exist in whole-grain research provide future research opportunities, including the identification of biomarkers for individual whole grains, the role that each of the components of whole grains plays in health and disease prevention, and the unique contributions of each whole grain to health.

Coordinated approach to increasing whole-grain intake

A clear whole-grain food definition, coupled with the cooperation of various sectors and disciplines, could provide an

organized process for gradually shifting the amount of whole grain incorporated into the food supply and increasing the availability of desirable, affordable, and healthful whole-grain foods for consumers. Partnerships of industry, government, academia, and food and nutrition organizations to develop a supply chain infrastructure and help support the gradual introduction of more whole-grain foods into the diet are needed. Such an effort has been underway in the United States with the recent stealth introduction of whole-grain foods into school meals. These interventions have been effective in increasing whole-grain intake among children in school cafeterias and afterschool programs, including substituting whole-grain foods for refined-grain menu items (95,96), reformulating products to gradually increase whole-grain content (88), and distributing novel whole-grain commodity food products (97). In a study of fifth and sixth grade students in a large suburban school district, whole-grain consumption was increased by nearly a full serving when white whole wheat flour was partially substituted for refined wheat flour in pizza crust (98). Findings were similar for 10 schools in Minnesota and 7 schools in Texas in which refined-grain pancakes and tortillas were replaced with whole-grain versions (99). Current supply chain technologies, processes, and infrastructure developed through the delivery of whole grains into school cafeterias can be effectively applied to restaurant and other food service settings as well.

Dietary modeling exercises of U.S. children ages 9–18 y indicate the feasibility of increasing intake via substitution of whole-grain ingredients in commonly consumed foods (99). Substituting whole-grain products for refined-grain products, particularly yeast breads, pizza, and grain-based desserts, which together account for almost one-half of the refined grains in the American diet (100), could be one effective strategy to increase whole-grain consumption.

To increase the availability of whole-grain foods in food-service as well as retail and home environments, dietary guidance should be aligned with food formulation and new product development.

Expert Panel Recommendation for Adopting a Standard Definition of a Whole-Grain Food

Benefits of whole-grain components. An accumulating body of evidence now shows that diets rich in whole grains impart health benefits (8–15). Dietary fiber greatly contributes to these benefits but does not explain them all. For example, some, but not all, studies suggest that consuming brown rice, which is a whole grain that is relatively low in fiber (3.5% by weight), can impart health benefits (101–103). In contrast, a recent meta-analysis by Hu et al. (104) indicated that higher consumption of white rice is associated with a significantly increased risk of 2TDM, especially in Asian (Chinese and Japanese) populations. Although fiber is the most extensively studied, it is only one of a complex array of beneficial bioactive components, including vitamins, minerals, dietary fiber, lignans, β -glucan, inulin, and phenolic and polyphenolic constituents, phyosterols, and sphingolipids

that are found in much greater amounts in whole grains than in their refined-grain counterparts (30). All of these components are present in different proportions in the bran, germ, and endosperm fractions of the whole grain and vary in concentration based on the type of whole grain. Whole grains contribute to a phytochemical-rich dietary pattern. However, research has been unable to identify how much of the reduced risk associated with consumption of whole grains is due to fiber alone or to the combination of the compounds found in whole grains. Whole-grain phytochemicals and macro- and micronutrients may work synergistically to contribute to the observed whole-grain health benefits (30). More research is needed to better understand the effects of these individual components on health outcomes.

Participants in the roundtable discussed whether the definition of a whole-grain food should include products with partially refined grain, or products which contain other grain components, like “added bran” and “added germ.” The AACCI and HEALTHGRAIN definitions of whole grain clearly state that a whole-grain flour must contain all the constituent parts of the grain and in the same proportions as the original grain. The 2010 U.S. DGA also specifically states that bran is not a whole grain (2). Thus, a food made from refined flour with bran or germ as an additional ingredient alone does not qualify as a whole-grain food and should not be described as such. Both observational and intervention studies that have examined the effects of the consumption of specific whole grains and whole-grain foods on biomarkers, surrogate endpoints, and incidence of disease have found that when intakes of added bran and germ were controlled for, the beneficial association with whole grain remained (14,15,105). Although the majority of phytochemicals in whole grains are indeed found in the bran and germ, in some cases, a substantial proportion can be found elsewhere: in whole wheat, the starchy endosperm contributes >50% of the β -cryptoxanthin, almost 50% of the lutein, 21% of the flavonoid content, and 17% of the total phenolic content (106). Furthermore, evidence for beneficial metabolic effects is stronger for consuming a variety of whole grains than for a single moiety in isolation (14).

In practice, recombining or reconstitution of whole-grain components is the most common way in which whole-grain flours are produced. The roller mill process involves dividing the germ, bran, and endosperm during processing of the grain and then recombining or reconstituting them back to their original proportions during processing. The majority of products found on retail store shelves would be considered recombined or reconstituted whole-grain products. Not only do recombined or reconstituted whole grains comprise most of the whole grains in the food supply, but most studies showing health benefits of whole grains have used recombined or reconstituted whole grains (107).

Whole-grain food definition. Dietary guidance from several countries currently recommends increased consumption of whole grains (Table 2). The observational research data published to date clearly demonstrate an association

between intake of whole grains and a reduced risk of disease. From a practical standpoint, many food products already on the market provide at least 8 g of whole grains per serving and can contribute to achieving the dietary recommendation of 48 g/d (1). Therefore, it is recommended that 8 g of whole grain per 30 g (27 g/100 g), without a fiber requirement, be considered a minimum content that is substantial and meaningful to aid consumers toward achieving their whole-grain dietary recommendation and that a food providing at least 8 g of whole grains per 30 g (27 g/100 g) be recognized as a whole-grain food. This aligns with both the 2010 DGA and the newly approved AACCI whole-grain characterization, which states that a whole-grain food product must contain at least 8 g whole grain/30 g of product. On 21 May 2013, the AACCI Board of Directors independently approved the Whole Grains Working Group's characterization (108) (the roundtable was held ~6 mo prior to AACCI's announcement of a characterization of what constitutes a whole-grain food). Provided that this requirement is fulfilled, the product can contain additional amounts of bran or germ and be deemed a "wholegrain food with added bran," for example.

When making whole-grain dietary recommendations, it should also be recognized that different whole-grain varieties provide different types and amounts of fiber as well as phytonutrients, micronutrients, and macronutrients. Based on the existing evidence, consensus was also achieved by the expert panel that fiber contributes to the health benefits of whole grains but does not explain them all. Therefore, to help consumers fill the current whole-grain consumption gap, a balanced diet should include a variety of whole grains and whole-grain foods that provide a minimum of 8 g whole grains/30-g serving (27 g/100 g) but do not contain excessive amounts of fat, sugar, sodium, or calories. This definition would apply to all foods, not just grain-based foods.

Although regulations will understandably vary across the globe to accommodate existing dietary intake patterns, dietary recommendations, and regulations within countries, the definition proposed here is the first phase in a process to engage an international community in the development of a universal definition for whole-grain foods within the context of cultural food intake patterns.

Developing a wider array of whole-grain foods in keeping with the proposed definition of 8 g whole grains/30-g serving (27 g/100 g) and with the ultimate goal of increasing whole-grain consumption of populations will require the involvement and the coordinated efforts of food science and nutrition science, as well as the food service and grain and food industries.

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