CFW REVIEW

Grain-Based Foods and Health

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The the U.S. Department of Agriculture (USDA) *Dietary Guidelines for Americans 2005* (10) recommends that the average, sedentary American adult should consume at least 6 ounce-equivalent servings of grain products per day, including at least 3 servings of whole grains (Table I). However, most Americans fail to eat even a single serving of whole grains per day. Many consumers are confused about the health benefits of carbohydrate foods such as breads, and even more are unfamiliar with the potential health-promoting properties of whole-grain foods.

There is substantial evidence supporting the grain-consumption recommendations made in the 2005 dietary guidelines (10) and the latest revision of the food guidance system provided by the USDA (www.MyPyramid.gov) (50). Studies show that whole-grain foods may help reduce overall mortality. They contain not only health-promoting B vitamins and dietary fiber, but other potentially beneficial components as well, e.g., resistant starch, inulin, and other fermentable carbohydrates; beneficial and unusual fatty acids; and a variety of phytochemicals, including antioxidants and lignans (phytosterols). Refined grains typically are enriched with B vitamins but lack many of these additional grain components. It has been suggested that one or more whole-grain components may decrease the risk of diseases such as coronary heart disease (CHD), ischemic stroke, type II diabetes, birth defects, and some cancers.

Whole grains, as defined by AACC in 1999 and the U.S. Food and Drug Administration (FDA) in 2006, comprise the intact, ground, cracked, or flaked caryopsis, in which the starchy endosperm, germ, and bran (the main components) are found in the same relative proportions as in the intact caryopsis. The endosperm comprises approximately 80% of the whole grain, whereas the percentage of bran and germ components varies among different grain types. Whole grains contain no cholesterol; are low in fat and high in dietary fiber, starch, protein, antioxidants, vitamins, minerals, and phytochemicals; and are a rich source of fermentable carbohydrates. The nutrients and phytochemicals in whole grains are concentrated heavily in the outer portion of the grain (46).

In industrialized countries, most grains undergo processing or refining, such as milling, cooking, parboiling, or heat extraction. Modern milling separates the starchy endosperm from the bran and germ and grinds it into flour; these parts are then recombined to make whole-grain flours. For refined-grain products much of the bran and germ is removed, causing fiber, vitamins, minerals, and phytochemicals to be lost. Most refined grains in the United States are enriched (Table II) (51).

The most common cereal grains in North America are wheat, rice, and corn. Less common grains include rye, oats, barley, sorghum, triticale, and millet (46). These grains may be eaten in whole or refined form. Breads, pastas, crackers, and other flour-based products made with nutritionally important quantities of whole grains are thought to offer many of the health benefits of whole grains (the sidebar lists common whole-grain ingredients and pseudocereals).

This article reviews published scientific research relating to the health benefits and disease-prevention potential of grain-based foods. The article focuses particularly on whole grains and their components, which have specific health benefits both alone and in combination with other whole-grain components (Table III) (46).

Epidemiological Evidence for the Benefits of Grain-Based Foods

During the early 20th century, grains comprised nearly 40% of food-energy intake in the United States. By the 1970s, U.S. grain intake had decreased to ≈18–20% (26). Today, less than 1 serving of whole-grain foods is consumed per day as part of the American diet, and some segments of the population eat them rarely or never. This low intake of whole grains could have adverse effects on the health of Americans.

During the 1970s, Burkitt, Painter, and Trowell, British physicians who formulated what came to be known as the dietary fiber hypothesis, observed that populations in Africa who consumed large quantities of whole, plant-based foods were generally free of many Western diseases, including ischemic heart disease and colon cancer (48,49). Over the 30 years since the inception of this theory, some of the associations they reported have been the subject of controversy, whereas others have been supported by numerous studies (3).

A wide range of epidemiological studies on a variety of populations show the health benefits of whole-grain intake. Although the weight of evidence points to the benefits of whole grains, it must be noted that all of these epidemiological studies suffer from confounding. Those who eat whole grains also tend to have healthy lifestyles: they eat more fruits and vegetables and less red meat and saturated fat, and they exercise more and smoke less. Although most studies adjust for many of these factors, it is possible that findings attributed to the eating of whole grains may simply document that the ingestion of whole grain is a marker of a healthy lifestyle. It is encouraging, however, that intervention studies, although few to date, also support the health benefits of whole grains. Prospective studies on CHD and insulin resistance have shown that consuming whole grains does indeed have positive effects.

Whole Grains and All-Cause Mortality. In the Iowa Women's Health Study (24), a prospective cohort study, 41,836 postmenopausal women aged 55–69 years completed a standardized food-frequency survey. After excluding numerous incomplete or erroneous surveys, 11,040 women were followed for more than 10 years.

The data showed that those who ate an average of 4.7 g of whole-grain fiber and 1.9 g of refined-grain fiber per 2,000 kcal had a 17% lower mortality rate versus those who ate mostly refined-grain fiber (4.5 g of refined-grain fiber and 1.3 g of whole-grain fiber per 2,000 kcal). The lower mortality rate included reductions in deaths from CHD, cardiovascular disease (CVD), and cancer.

Similarly, Steffen and coworkers (47) found that whole-grain, fruit, and vegetable consumption had a beneficial effect on the risk of total mortality and incidence of coronary artery disease (CAD) in the Atherosclerosis Risk in Communities Study. This multicenter, prospective, mixed-

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race study followed 11,940 adults aged 45–64 years at baseline for 11 years. Of the participants who were CAD- and stroke-free at baseline, 867 died; of those, 535 had fatal or nonfatal CAD, and 270 had fatal or nonfatal stroke (214 of those strokes were ischemic). Whole-grain food consumption was inversely associated with total mortality ($P \leq 0.02$) and CAD ($P \leq 0.05$); fruit and vegetable consumption was inversely associated only with total mortality ($P \leq 0.02$). Ischemic stroke was not related to consumption of plant-based or whole-grain foods.

Cardiovascular Disease. A large meta-analysis (3) showed that regular intake of whole-grain foods is associated with a lower risk of CHD. Individuals in the highest quintile of whole-grain intake had an adjusted CHD risk of ≈0.74 compared with individuals in the lowest quintile. Intake of whole grains had a stronger association with protection against CHD than intake of cereal fiber, fruits, or vegetables. The authors concluded that 3 ounce-equivalent servings per day of whole grains may have a cardioprotective effect. Anderson and Hanna (2) have postulated that protection against CHD may be due to a variety of effects from whole-grain intake, including lipid lowering, antioxidant activity, antithrombotic effects, inhibition of platelet aggregation, and beneficial effects on vascular reactivity.

The Nurses' Health Study began in 1976 and included 121,700 female registered nurses who answered a questionnaire on medical history and lifestyle. This study group has been followed every two years since. Liu and coworkers (34) examined the relationship between grain consumption and heart disease among 75,521 members of the cohort. None had a previous history of CVD or type II diabetes. During the 10 years of follow-up, there were 761 cases of CHD: 208 fatal cases and 553 cases of nonfatal myocardial infarction (MI).

The relative risks of CHD from the lowest to the highest quintile of whole-grain intake were 0.86, 0.82, 0.72, and 0.67 ($P < 0.001$ for trend). Age-adjusted relative risk for women in the highest versus the lowest quartile was 0.51. The inverse relationship between whole-grain consumption and CHD risk was strongest for women who had never smoked. The authors noted that the decreased CHD risk with consumption of whole grains could not be fully explained by the effects of dietary fiber, folate, vitamin B_6, and vitamin E. Multivariate adjustment for body mass, alcohol intake, medical history, lifestyle, and other factors reduced the robustness of the findings, but the risk reduction remained significant ($P = 0.01$).

Mozaffarian and coworkers (41) conducted a prospective study of 3,588 men and women without known CVD aged 65 years and older. During the ≈8.6 years they

Table I. Sample USDA food guide for a 2,000-cal diet[a]

Food Group Subgroups	Recommended Amount	Equivalent Amount
Fruits	2 cups (4 servings) per day	0.5 cup-equivalent servings 0.5 cups of fresh, frozen, or canned fruit 1 medium fruit 0.25 cups of dried fruit 0.5 cups of fruit juice
Vegetables	2.5 cups (5 servings) per day	0.5 cup-equivalent servings
Dark green	3 cups/week	0.5 cups of cut-up raw or cooked vegetables
Orange	2 cups/week	1 cup of raw leafy vegetables
Dry beans (legumes)	3 cups/week	0.5 cups of vegetable juice
Starchy vegetables	3 cups/week	
Others	6.5 cups/week	
Grains	6 ounce-equivalent servings	1 ounce-equivalent serving
Whole grains	3 ounce-equivalent servings	1 slice of bread
Other grains	3 ounce-equivalent servings	1 cup of dry cereal 0.5 cups of cooked rice, pasta, or cereal
Meats and beans	5.5 ounce-equivalent servings	1 ounce-equivalent serving 1 oz of cooked lean meat, poultry, or fish 1 egg 0.25 cups of cooked dry beans or tofu 1 tbsp of peanut butter 0.5 oz of nuts or seeds
Milk	3 cups	1 cup-equivalent serving 1 cup of low-fat or fat-free milk or yogurt 1.5 oz of low-fat or fat-free natural cheese 2 oz of low-fat or fat-free processed cheese
Oils	6 tsp (24 g)	1 tsp-equivalent serving 1 tsp of vegetable oil 1 tbsp of low-fat mayonnaise 1 tbsp of light salad dressing

[a] Data from *Dietary Guidelines for Americans 2005* (10).

Whole-Grain Ingredients and Pseudocereals

Whole-Grain Ingredients

- Whole-wheat flour and berries, farro, cracked wheat, and bulgur
- Whole-rye flour (also called pumpernickel flour) and berries and flaked or rolled whole rye
- Barley and whole-barley flour
- Whole-grain corn meal (not degermed) and grits and popcorn
- Oat groats (berries) and whole-grain oat flour
- Oatmeal (all forms), including old-fashioned, quick, rolled, steel-cut, Irish, and Scottish
- Brown rice and other whole-grain rices, such as red and black (*wehini*)
- Quinoa
- Millet and sorghum
- Teff
- Ancient wheat parents—whole-grain spelt, emmer, kamut, and eikorn

Pseudocereals

- Amaranth
- Buckwheat or kasha
- Wild rice

Table II. Nutrient content of whole-grain and enriched wheat flours[a]

Nutrient	Whole-Grain Flour (120 g)	Enriched Flour (125 g)
Protein (g)	16.44	12.91
Fat (g)	2.24	1.23
Dietary fiber (g)	14.6	3.4
Sugars (g)	0.49	0.33
Minerals		
Iron (mg)	4.66	5.80
Zinc (mg)	3.52	0.88
Copper (mg)	0.458	0.180
Manganese (mg)	4.559	0.853
Selenium (mg)	84.8	42.4
Vitamins		
Thiamin (mg)	0.536	0.981
Riboflavin (mg)	0.258	0.618
Niacin (mg)	7.638	7.380
Vitamin B_6 (mg)	0.409	0.055
Folate/folic acid, total (μg)	53	229
Vitamin E (mg)	0.98	0.28

[a] Data from USDA National Nutrient Database for Standard Reference (51).

were studied, 811 CVD events occurred. The investigators found that cereal-fiber intake was inversely associated with incident CVD. Participants in the highest intake quintile had a 21% lower risk than those in the lowest intake quintile (hazard ratio = 0.79; 95% confidence interval [CI] = 0.62–0.99). In contrast, neither fruit- nor vegetable-fiber intake was associated with incident CVD in this population. Higher cereal-fiber intake also was associated with lower risk of total and ischemic stroke.

A recent study of 229 postmenopausal women with existing CAD supports the reported cardiovascular health benefits of whole grains. In this study, Erkkilä and coworkers (11) administered a food-frequency questionnaire and conducted coronary angiography at baseline. After ≈3 years, they found that whole-grain intake of >6 servings/week was significantly associated with better maintenance of coronary artery diameter compared with lower whole-grain intakes (0.06 mm diameter reduction versus 0.10 mm, respectively; $P = 0.04$). They concluded that high intakes of whole grain and cereal fiber are associated with less progression of atherosclerosis in postmenopausal women with existing CAD.

Ischemic Stroke. In a prospective study, Liu and coworkers (33) studied the association between whole-grain intake and risk of ischemic stroke in U.S. women aged 38–63 years who participated in the Nurses' Health Study, observing patients over 12 years of follow-up. At baseline participants had no history of type II diabetes, stroke, or CVD. There was no association between total grain intake and stroke but a strong inverse association between consumption of whole-grain products and risk of ischemic stroke.

Those in the highest quintile of whole-grain consumption ate just over 3 ounce-equivalent servings of whole-grain products per day. Approximately 30–40% lower stroke risk was associated with consuming 1.3 servings a day. The authors concluded that replacing even 1 serving of refined grains with whole grains may significantly reduce ischemic stroke risk.

Metabolic Syndrome. Metabolic syndrome is characterized by abdominal obesity, atherogenic dyslipidemia, elevated blood pressure, insulin resistance, and prothrombotic and proinflammatory states (43) and is a modifiable risk factor for both type II diabetes and CVD (37).

The Framingham Offspring Study is a CVD-focused study of offspring of the original Framingham Heart Study Cohort and their spouses ($N = 2,834$). McKeown and coworkers (37) analyzed data from the study to determine whether increasing carbohydrate intake adversely affects insulin resistance and predisposes some patients to metabolic syndrome. They found an inverse association between whole grains and insulin resistance. Prevalence of metabolic syndrome was significantly lower in the highest quintiles of cereal-fiber intake (odds ratio = 0.62; 95% CI = 0.45–0.86) and whole-grain intake (odds ratio = 0.67; 95% CI = 0.48–0.91) compared with the lowest quintile. After correction for confounding factors, the prevalence of metabolic syndrome was 38 and 33% less in the highest versus the lowest categories of intake for cereal fiber and whole grains. These findings are consistent with a population-based, cross-sectional study of 827 adult men and women, indicating that diets rich in whole grains are associated with a reduced risk of metabolic syndrome (12).

Type II Diabetes and Insulin Resistance. Many dietary components and lifestyle factors are thought to contribute to the increasing rates of diabetes found in the industrialized world, including carbohydrates and refined foods. Liu and coworkers (32) used multiple assessments of total, whole-, and refined-grain intake to determine whether high whole-grain intake is associated with reduced type II diabetes risk and whether high refined-grain intake is associated with increased risk. They analyzed prospective data from the Nurses' Health Study ($N = 75,521$ women). After 10 years there were 1,879 incident cases of type II diabetes. They found no association between total grain intake and risk of type II diabetes. However, whole-grain intake was inversely associated with type II diabetes risk, and refined-grain intake was positively associated with risk. These findings were independent of dietary and nondietary risk factors for type II diabetes, even though at baseline women with high intake of whole grains also smoked less, exercised more, weighed less, and were more likely to use vitamin supplements than women with lower whole-grain intakes. In addition, intake of calories, carbohydrates, protein, dietary fiber, and cereal fiber was higher, and intake of fats, cholesterol, and alcohol was lower. Family history of diabetes did not vary between groups.

Increased insulin sensitivity may also show a relationship between high whole-grain intake and reduced type II diabetes risk. Liese and coworkers (30) evaluated data from the Insulin Resistance Atherosclerosis Study (Exam I, 1992–1994) (52). Adults (N = 978) with normal (67%) or impaired (33%) glucose tolerance were evaluated. Intravenous glucose tolerance tests revealed that higher dietary intake of whole grains was associated with increased insulin sensitivity: increasing whole-grain intake from 0.8 to 1.0 servings per day was estimated to result in a 6.3% lower fasting insulin concentration. The authors concluded that increased insulin sensitivity or decreased insulin resistance may have led to the observed health benefits, including reduced risk of type II diabetes, of high whole-grain intake (30).

A crossover intervention study by Pereira and coworkers (44) demonstrated the effects of whole grains on insulin sensitivity in overweight and obese hyperinsulinemic adults aged 25–56 years. Subjects consumed a diet (55% carbohydrate and 30% fat) that was high in either refined or whole grains. Fasting insulin was 10% lower with consumption of whole grains versus refined grains. Other measures of glucose use also improved in the whole-grain diet group. The

Table III. Whole-grain components and postulated protective mechanisms[a]

	Protective Mechanism							
Component	**Antioxidant**	**Tumor Growth Suppressor**	**Enzyme Modulator**	**Binding Scavenger**	**Chemical Inactivator**	**Cholesterol Reducer**	**Gut Modifier**	**Hormonal Effects**
Dietary fiber			X			X	X	X
Oligosaccharides			X	X		X	X	
Flavonoids	X	X	X					
Inositols	X							
Lignin	X							
Omega-3 fatty acids		X				X		
Phenolics	X	X	X					
Phytates	X							
Phytoestrogens	X	X						X
Protease inhibitors		X						
Saponins		X						
Selenium	X	X						
Tocopherols	X		X					
Zinc	X				X			

[a] Data from Slavin and coworkers (46).

authors concluded that improved insulin sensitivity may be an important mechanism whereby whole-grain foods reduce the risk of type II diabetes and heart disease (44).

Mining Components of Whole Grains for Health

Numerous components in whole grains may act alone or in tandem to promote positive effects on health. Components found in the endosperm include carbohydrates and protein. The germ contains antioxidants, B vitamins, vitamin E, phytochemicals, and fatty acids and lipids, whereas the bran contains fiber, B vitamins, trace minerals, and antioxidants. These components and the mechanisms by which they exert their effects are discussed below.

Fermentable Carbohydrates. When undigested carbohydrates (dietary fiber, inulin, and resistant starch) from whole grains reach the colon, they can have many positive effects. Fibers bind bile acids, which inhibits the conversion of primary bile acids to secondary bile acids that can have adverse effects on the colon. The presence of fiber increases fecal bulk and water retention, both of which dilute bile acids. Microflora ferment fibers, yielding short-chain fatty acids (SCFAs) that lower colonic pH (46), which reduces the solubility and availability of free bile acids. This activity decreases the cocarcinogenic potential of free bile acids and may reduce cancer risk (7, 25). In addition, the SCFA butyrate is the preferred fuel of healthy colonic cells and has been shown to have antineoplastic activity (36,46).

The cholesterol-lowering effects of whole-grain foods are thought to be due to at least two grain properties. First, SCFAs from fermentation are absorbed and carried to the liver, where they inhibit the same cholesterol-synthesizing enzyme as statin drugs. Second, the binding and excretion of bile acids by fibers cause circulating cholesterol to be used to make the needed bile acids (1,21). Not all fibers from whole grains are equally effective in lowering serum cholesterol, however. Fibers such as the β-glucan found in oats and barley are particularly effective (5,27).

Fiber from whole grain also produces beneficial changes in the gut (19). Undigested carbohydrates increase fecal weight (both wet and dry) in two main ways—the increased biomass from bacterial growth and the ability of fibers to hold increased water, speeding intestinal transit (46). Faster transit time results in less time for fecal mutagens to interact with intestinal epithelia. A meta-analysis of 11 studies from around the world by Cummings and coworkers (9) showed a high correlation between fiber intake and mean daily fecal weight and a significant inverse relationship between fecal weight and colon cancer incidence. Fecal weight has been directly associated with the amount of dietary fiber consumed and the amount of whole grain in the diet (19).

Beneficial Fats and Fatty Acids. Whole grains are low in fat but do provide beneficial fatty acids—mainly oleic and linoleic acids (46). Studies have shown that some grain lipids (e.g., plant sterols from rye and oryzanol from brown rice) have cholesterol-lowering effects (6,35,39). Others, such as policosanol (a common name for a mixture of high molecular weight alcohols that are constituents of plant waxes), may be found in whole grains such as wheat (20,22). Wheat germ oil with its high policosanol content, specifically octacosanol, has been reported to improve physical fitness (22). Still other grain lipids and sterols have been shown in human and animal studies to reduce the incidence of colonic tumors and affect immune response (19,23).

Antioxidants and Phytochemicals. Whole grains are a good source of antioxidants, such as vitamin E and selenium, and trace minerals, such as copper, zinc, and manganese (46). Other phytochemicals found in whole grains, including phytates, phenolics, lignans, tocotrienols, and tocopherols, also have antioxidant activities (4,18, 46). Grain-specific phenolics, such as avenathramides from oats, offer antioxidant and antiatherogenic potential (38).

Miller and coworkers (38) measured the in vitro antioxidant activity of whole-grain cereals, fruits, and vegetables. They found that the whole-grain breakfast cereals they analyzed contained high levels of antioxidants (2,200–3,500 TE/100 g). Fruits (excluding berries) ranged from 600 to 1,700 TE/100 g. Berries had the highest antioxidant contents at 3,700 TE/100 g.

Antimutagens and Immune Boosters. In addition to compounds with antioxidant activity, several whole-grain components are classified as antimutagens (28), including such compounds as flavonoids, phenolics, tocopherols, and dietary fiber. The ability of whole grains to affect the immune response also may play a role in reducing disease risk. Whole grains and their components, such as β-glucan, have been shown to improve the immune response in animals (8,29).

Fortification of Refined Grains with Folic Acid and Other B Vitamins

Although many health benefits have been found with increased intake of whole grains, enriched refined grains also provide several important B vitamins, including folic acid. The importance of folic acid in the prevention of neural tube birth defects is well established (42). Since the mandatory folic acid fortification of enriched flour and grain products began in the United States, neural tube and other birth defects have declined

(53). According to the latest data from the U.S. Centers for Disease Control and Prevention, the prevalence of spina bifida has been reduced by 34% among non-Hispanic whites and 36% among Hispanics from 1995 through 2002 (54).

Folic acid may do more than reduce birth-defect risks, however. Studies indicate an association between folic acid intake and decreased risk of incident hypertension, CHD, and some cancers (16,17,40,45,55). Forman and coworkers (16) analyzed patient data from two prospective cohort studies: 93,803 women aged 27–44 years in the Nurses' Health Study II and 62,260 women aged 43–70 years in the Nurses' Health Study I. The objective was to determine whether increased folate intake might reduce the risk of incident hypertension. No patients in either group had a history of hypertension. In 8 years of follow-up, there were 7,373 cases of hypertension in the younger women and 12,347 cases in the older women. Women who consumed at least 1,000 µg of total folate per day (recommended upper level of intake, dietary and supplemental) had significantly less risk of incident hypertension than women who consumed ≤200 µg/day ($P \leq 0.05$). The positive association between folate intake and reduced risk of hypertension was strongest for younger women with high intakes, who had a 46% lower risk of incident hypertension than younger women with low intakes ($P < 0.001$).

Rimm and coworkers (45) conducted a prospective cohort study using data from 80,082 women in the Nurses' Health Study to examine the relation of folate and vitamin B_6 intake to incidence of nonfatal MI and fatal CHD. In this study, the primary sources of folate were vitamins (26%), cold cereal (8%), orange juice (8%), and lettuce (7.5%). Over 14 years of follow-up, there were 658 cases of nonfatal MI and 281 fatal cases of CHD. Lower CHD risk was seen with higher folate and vitamin B_6 intake. After age adjustment, the relative risk of CHD was 47% lower in women in the highest versus the lowest quintile of folate intake.

Zhang and coworkers (56) examined the relationship between folate and vitamin B_6 and colorectal cancer among women enrolled in a randomized trial study of the protective effects of aspirin and vitamin E. Nearly 38,000 women with no history of cancer or CVD provided dietary information at baseline. Average follow-up was 10 years, during which time 220 cases of colorectal cancer occurred. Interestingly, total folate (including intake from supplements) and vitamin B_6 intakes were not associated with cancer risk, but dietary folate intakes were significantly inversely associated with reduced risk. (These results were found only in women who did not take supplemental folate and vitamin B_6.) The relative risks for women with the highest versus lowest intake levels were 0.46 (95% CI = 0.26 and 0.81, respectively) for dietary folate and 0.69 (95% CI = 0.41 and 1.15, respectively) for dietary vitamin B_6. The authors concluded that higher dietary intakes of folate and vitamin B_6 may reduce colorectal cancer risk in women.

Conclusions

The history of enriched grains shows that dietary intervention may be of substantial benefit to public health. Per capita consumption of whole-grain foods in the United States and other industrialized nations falls well below the recommended 3 ounce-equivalent servings per day. The FDA has made it easier for consumers to identify whole-grain foods by authorizing a health claim that can appear on foods that contain at least 51% whole-grain ingredients by weight and are low in saturated fat and cholesterol (13–15):

> Diets rich in whole grain foods and other plant foods and low in total fat, saturated fat, and cholesterol may help reduce the risk of heart disease and certain cancers.

Based on the available evidence, grain foods, particularly whole grains, appear to offer a variety of potential health benefits, as is demonstrated by folic acid fortification and reductions in neural tube defects. Much research remains to be done regarding these beneficial effects and the specific grain components to which they may be attributed. A simple-to-remember goal is to consume half of your total grains as whole grains. For most consumers, 6 ounce-equivalent servings of grain-based foods are recommended daily, and 3 of these servings should be whole grains (10). For those with daily caloric requirements above 2,000, more grain-based foods can be consumed, keeping in mind the recommendation that half the grains be whole grains.

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