

Gradual Incorporation of Whole-Grain Flour into Grain-Based Products

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ABSTRACT

Industry, academia, and government agencies are exploring methods to increase whole-grain intake in the American diet. The gradual inclusion of whole-grain flour in a wide variety of grain-based foods in a way that maintains taste, convenience, and palatability could be a first transition step toward increasing whole-grain consumption while maintaining a product that is acceptable to consumers. This modeling study assesses the impact of incorporating various amounts of whole-grain flour by modifying formulations for 30 individual grain foods within 10 larger categories. Intake distribution was based on responses to questions concerning grain-containing foods given in a 1986 food frequency questionnaire as part of the Iowa Women's Health Study. In formulating products with whole grains, assumptions were made about serving size (grams), the proportion of flour in the existing product, and the proportion of that flour that is whole grain. If intake is unchanged by formulation modifications, adding whole-grain flour to existing formulations in amounts that we believe would have imperceptible effects on taste and texture would increase the number of 16-g whole-grain servings per day for these Iowa women from 2.0 to 3.3. For those who currently consume more refined-grain foods, the effect of adding small amounts of whole-grain flour would be even larger on a percentage basis. Gradual incorporation of whole-grain flour into a variety of grain-based foods may provide a vehicle for increasing whole-grain intake in the U.S. population, with the possible added benefit of familiarizing consumers with whole-grain products.

Whole cereal grains, those grass seeds that include bran, germ, and endosperm in their naturally occurring proportions, are lacking in the American diet. Commonly consumed cereal grains include wheat, rice, and corn and, less frequently, oats, barley, and rye. Using 16 g of flour or intact kernels as a serving, adults are estimated to consume 6.7–10 servings of any grain per day (3,9,35). Major grain-based foods include snacks (43%), breakfast cereals (31%), and yeast breads and rolls (14%) (10). Only one of these servings is whole grain, however. Eight percent of the U.S. population 2 years of age or older is estimated to consume at least 3 servings of whole grain per day (9,23).

Scientific evidence (8,16–21,24,27–29,32,34), policy statements (12,13,25,36), and regulatory guidelines (14,15,31) all support increasing whole-grain intake to reduce risk for chronic diseases. Recent government guidelines (13,36) recommend consumption of at least three whole-grain products daily for most age groups. Conse-

quently, various sectors, including industry, academia, and government agencies, are exploring methods to increase whole-grain intake. All parties involved in the effort to promote greater consumption must take into consideration that taste, convenience, and palatability are all essential aspects of widespread acceptance of any food.

Unfortunately, there is a lack of knowledge and considerable confusion about whole grains among the general population (1,2,6), as well as foodservice personnel (37), health educators (5), and professionals affiliated with the baking and cereal industries (7). From a consumer perspective, the most frequently cited barriers to whole-grain consumption include difficulty in identifying whole-grain versus dark breads (6); limited availability of whole-grain foods in grocery stores and restaurants; higher costs (22,23); and dislike of taste, color, and texture of whole-grain food products and lack of experience in preparing and incorporating whole-grain foods into daily dietary patterns (11). Studies indicate that foodservice personnel lack the knowledge to identify whole-grain foods (37), while health professionals lack general knowledge about whole grains and sufficient resources to deliver a compelling message to consumers (5). In addition, the food industry faces research and development, quality, and cost issues in the production of consumer-friendly whole-grain foods (7,11,30,33).

These findings indicate there is a need to clearly elucidate the health benefits of whole grains for consumers and provide a practical means for them to successfully identify and purchase whole-grain foods. Given the considerable barriers encountered in delivery and dietary intake of whole-grain foods, the gradual inclusion of whole-grain flour in a wide variety of grain foods to create products acceptable to consumers is one possible approach to increasing dietary intake. Recent whole-grain product innovations from major manufacturers have included breads, cereals, wraps, and snacks with some level of whole-grain flour incorporated into the product.

Most whole-grain bread products, particularly yeast breads, are made with red wheat. These products are generally dark in color and have a bitter taste and tough texture compared with refined-grain foods. These attributes are less well liked than those of refined-grain foods. Whole white wheat flour used in whole-grain yeast bread products tends to have a milder flavor, lighter color, and more appealing texture. Similar to hard red winter wheat, hard white wheat has a high protein content, strong gluten, and high water absorption that make it a good choice for breads and related products. The incorporation of whole white wheat flour into a variety of grain-based foods may serve as a tool to develop products that meet consumer taste preferences and provide a meaningful (significant) level of whole grain in the U.S. diet. This gradual approach may allow consumers to continue to eat products they are accustomed to and, at the same time, both improve their health and increase their acceptance of products that contain larger amounts of whole grain. For example, as consumers become accustomed to a fuller taste in their grain products, colonic bacteria may adapt to accommodate increased levels of dietary fiber.

This article describes a model to determine the potential impact of incorporating whole-grain flour into commonly consumed grain

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foods at levels acceptable to consumers. The intent of this modeling exercise is to explore potential avenues to increase whole-grain intake in the U.S. population. The model is based on the daily grain intake self-reported on a food frequency questionnaire (FFQ) in 1986 by women aged 55–69 years who participated in the Iowa Women's Health Study (IWHHS).

Survey Data and Projected Whole-Grain Intake

Whole-grain intake was examined for 30 individual grain foods within 10 larger categories. The specific food items and their groupings are listed in Table I. Intake data were self-reported as part of the IWHHS. A FFQ was filled out in January 1986 by 38,734 women aged 55–69 years, randomly sampled from the Iowa driver's license list (42% response rate). The mean servings of grain-containing foods consumed per week were computed. Assumptions were made for each food about the proportion of flour in the existing product, serving size (grams), and proportion of flour that is whole grain

(Table I, column D). To predict the effect of adding small amounts of whole grain to foods, we made further assumptions about the proportion of refined flour that could be replaced by whole-grain flour without causing substantial alterations in taste and other sensory attributes (Table I, column E). We also assumed that the grain-food consumption pattern would not be altered after the addition of whole-grain flour, so the enhanced amount of whole grain consumed is the product of the mean number of servings per week × serving size × proportion of flour × proportion of flour that is whole grain. The primary outcome of this model was a comparison of the originally reported and the enhanced 16-g servings of whole-grain flour (Table I, columns F and G).

Grain product categories included breads and muffins, breakfast cereals, desserts, entrées, hot cereals, miscellaneous products, pancakes, pasta, rice, and snacks. Table II provides typical formulations for several of these products, including total amount of flour, which is the base for substitution of whole- for refined-grain flour.

Table I. A model to examine whole-grain intake with inclusion of whole-grain flour (WGF) in common grain foods (based on postmenopausal women in the Iowa Women's Health Study)

Food Category (serving size)	Observed Servings/Day (mean)	% Flour in Existing Formulation	Flour Servings in Existing Formulation ^a	WGF in Existing Formulation ^b (%)	Feasible % of WGF in Formulation ^c	Total WGF Servings in Existing Product ^d	Total WGF Servings in Product with Added WG ^e
	A	B	C	D	E	F	G
Bread/Muffin							
Dark bread (32 g)	0.915	51	0.93	50	0	0.47	0.47
English muffin/bagel (57 g)	0.102	50	0.18	0	25	0.00	0.05
Muffin/biscuit (53.5 g)	0.070	25/52	0.06/0.12	0	50/15	0.00	0.03/0.02
White bread (28 g)	0.641	51	0.57	0	25	0.00	0.14
Cereal							
Bran (40 g)	0.127	70	0.22	100	0	0.22	0.22
Refined (40 g)	0.084	70	0.15	0	50	0.00	0.07
Variety (40 g)	0.009	70	0.02	0	75	0.00	0.01
Whole grain, not bran (40 g)	0.139	70	0.24	75	0	0.18	0.18
Dessert							
Brownie (28 g)	0.042	20	0.01	0	100	0.00	0.01
Cake, home baked (64 g)	0.074	24	0.07	0	25	0.00	0.02
Cake, ready made (64 g)	0.014	24	0.01	0	25	0.00	0.00
Cookie, home baked (30 g)	0.355	20	0.13	0	50	0.00	0.07
Cookie, ready made (30 g)	0.196	20	0.07	0	50	0.00	0.04
Doughnut (47 g)	0.062	52	0.10	0	25	0.00	0.02
Pastry, home baked (71 g)	0.074	60	0.20	0	25	0.00	0.05
Pastry, ready made (71 g)	0.077	60	0.20	0	25	0.00	0.05
Pie, home made (30 g)	0.060	63	0.05	0	25	0.00	0.01
Pie, ready made (30 g)	0.015	63	0.01	0	25	0.00	0.00
Entrée							
Pizza (140 g), crust (55 g)	0.054	23	0.11	0	30	0.00	0.03
Hot cereal							
Other cooked breakfast (180 g)	0.059	60	0.51	0	50	0.00	0.26
Cooked oatmeal (180 g)	0.103	60	0.89	100	0	0.89	0.89
Miscellaneous							
Bran, added to food (7 g)	0.081	100	0.04	100	0	0.04	0.04
Other grains (140 g)	0.005	40	0.02	75	0	0.01	0.01
Wheat germ (7 g)	0.023	100	0.01	100	0	0.01	0.01
Pancake							
Pancake/waffle (70 g)	0.057	50	0.12	0	50	0.00	0.06
Pasta (cooked)							
Pasta (140 g)	0.107	40	0.37	0	25	0.00	0.09
Rice (cooked)							
Brown (140 g)	0.020	40	0.07	100	0	0.07	0.07
White (140 g)	0.073	40	0.25	0	25	0.00	0.06
Snack							
Cracker (14 g)	0.490	85	0.36	0	50	0.00	0.18
Popcorn (30 g)	0.203	100	0.14	100	0	0.14	0.14
Total servings/day						2.03	3.29/3.27

^a Flour servings (16 g)/day = (serving size/16) × A × B.

^b Percentage of flour in existing formulation that is whole grain.

^c Feasible percentage of flour in a formulation that could be whole grain with minimal perceptual change.

^d Total whole-grain flour servings (16 g)/day in the existing product = C × D/100.

^e Total whole-grain flour servings (16 g)/day in product with added whole grain = C(D + E)/100.

Based on experience with these products, we assumed that whole-grain flour could be substituted for 25–30% of the refined-grain flour in most of the foods (Table I, column E); some were amenable to greater additions (e.g., crackers, brownies, cookies, pancakes, breakfast cereals). Assuming no change in consumption of modified foods, adding small amounts of whole-grain flour to existing formulations would increase the total number of 16-g servings of whole-grain flour per day in these Iowa women from 2.0 (Table I, column F) to 3.3 (Table I, column G).

Model Limitations, Challenges to Increasing Whole-Grain Intake, and Future Directions

The model used in this article, demonstrates how modest changes in food product composition could result in a 70% increase in the whole-grain intake reported by Iowa women in 1986. Basing the model on IWHS findings was convenient because the FFQ created simple food groups, and the data are fairly reliable. Although the food data are 20 years old, whole-grain consumption today is similar to 1986 levels. One limitation of the findings is that the mostly postmenopausal IWHS women consumed more whole grains than has been reported in the general U.S. population. However, for those who currently eat more refined-grain foods, the effect of adding small amounts of whole-grain flour would be even larger on a percentage basis, because it would be distributed over more refined-grain foods, whereas whole-grain consumption for such people would still be lower than the 3.3 servings/day level we predicted for the postmenopausal women.

One weakness of the model is that the FFQ lacks detail about specific food products, and as a result, assumptions about the amount of whole grain that can be added to a food without perceptible change in its sensory attributes may not apply equally to every food in a grouping. In this way the model is approximate. The greater limitation, however, may be our assumption that consumption patterns would not change due to addition of small amounts of whole grain; results could change significantly if consumption were to decline or increase as a result of changes in whole-grain flour content. Nevertheless, our model does illustrate that whole grain added to existing foods in imperceptible amounts would substantially alter the amount of whole grain consumed.

This observation should encourage greater collaboration among various sectors (government, industry, academia) and disciplines (farmer, manufacturer, health and medical professionals) within the grain supply chain to move the U.S. population toward eating more whole-grain foods. The specific proposal here is that gradual incorporation of whole-grain flour into existing products would be an initial step in this process.

Increasing whole-grain consumption will likely proceed through gradual adaptation from whole-grain items that possess the attributes of refined grains on one end of the continuum and slowly move toward whole-grain products with traditional whole-grain characteristics. This is not surprising given the long tradition of consumption of refined-grain foods, as well as the considerable hurdles faced by the industry and consumers. Gradual incorporation of whole-

grain flour into current refined-grain products would proceed in parallel with the existing movement in the market to add new whole-grain products and to clarify the amount of whole grain in both existing and new whole-grain foods.

More broadly, there are several different approaches that could be used to introduce acceptable, palatable whole-grain foods into the marketplace: 1) gradually incorporate whole grains into existing products (slowly adding more whole grain into the product formulation while maintaining a palatable product); 2) use whole white wheat and other whole grains instead of whole red wheat (because the color change is less distinct and apparently less perceptible); 3) use fine particle size flour, both red and white (minimize changes in texture and appearance); 4) vary the grains in the formulation (white versus red wheat and mixtures of grains with various flavor characteristics, such as oats and barley); 5) provide and make available more 100% whole-grain breads, breakfast cereals, and other products; and 6) develop innovative products containing whole grains. A number of these approaches have been used by manufacturers to introduce products with some level of whole grain.

Issues that need to be addressed from an environmental perspective include the availability of whole-grain foods in retail stores and restaurants. In 2001 only 5–10% of retail grain food products contained whole grain (23). According to CSFII data from 1994 to 1996, two-thirds of total grain servings were from “at-home” sources, and fewer than 15% of whole-grain servings were from “away-from-home” food sources (26). Recent surveys suggest that 100% whole-wheat bread and grain products are less likely to be available in low-income neighborhood grocery stores ($N = 13$ stores) (7). In addition, 100% whole-wheat bread is less likely to be available at the end of the month at small independent grocery stores. Discount 100% whole-wheat breads had 2 g of fiber per serving, whereas brand name 100% whole-wheat breads contained higher levels of fiber per serving. If all grocery stores offered 100% whole-wheat bread and larger package sizes for healthier substitutes, the costs could be halved (22).

Yeast breads and grain-based snacks make up a large portion of grain food sources compared with other grain items, such as pastas, rice, cakes, cookies, pies, and others (9). As a result, a simple substitution of whole-grain bread for refined-grain bread can result in a significant increase in whole-grain consumption. One manufacturer recently released a new “transition” whole white wheat bread that is a whole-grain bread with characteristics similar to white pan bread, while another traditional white pan bread manufacturer has introduced a 100% whole-grain bread. These breads are promoted as having the “taste, texture, appearance and economy of white bread” but are considered a source of whole grain. Consumption of these whole-grain foods may increase whole-grain intake among refined-grain bread consumers.

Pizza is another popular food item that readily allows substitution of whole red or white wheat flour for refined-grain flour. The toppings (cheese and sauce) tend to neutralize or blend with any strong flavors associated with whole-grain flour. A pizza consisting of a 50/50 blend of whole and refined white wheat flours consumed by elementary school children had an acceptance level the same as that for pizza made with refined-wheat flour. Products such as bread sticks, sandwich buns, and dinner rolls with the same 50/50 blend of whole and refined white wheat flours have been consumed at levels similar to their refined-grain counterparts (4). Partial whole-grain lemon and apple pastries were developed and well accepted, with little if any whole-grain flavor detected. Very similar to the refined-grain version, a 50/50 blend muffin was also well received (Great Northern Bakeries, Minneapolis, MN, unpublished data).

Studies using government dietary databases are needed to further examine models for predicting the potential role of gradually increasing whole-grain intake in the American diet. More data would more accurately reflect the specific impact that adjustments in the composition of grain-based foods might have on individual and group intakes of whole-grain foods. In addition, consideration should

Table II. Flour content of common grain-based products

Product	Flour Content (%)	Serving (g)	Total Flour (g)
Brownie	20	28	5.6
Cake	22–27	64	14.1
Cookie, chocolate chip	22	30	6.0
Cracker	84–86	14	11.9
Doughnut, yeast	51–54	47	23.5
Muffin, apple cinnamon	29	53.5	15.5
Muffin, blueberry	25	53.5	13.4
English muffin	50	57	28.5
Pasta	40	140	56
Puff pastry	60	71	42.6
Pie crust	63	20	12.6
Pizza	23	140	32.2
White bread	51	28	14

be given to a surveillance mechanism to document current whole-grain intake and to more closely monitor dietary intake patterns over time.

Conclusions

Government and industry are already directly involved in encouraging whole-grain consumption through science, education, policy, and regulatory guidelines. Increased intake of whole-grain foods will likely occur at a gradual pace and involve a variety of approaches. We need to further assess what level of whole grain might be added to specific foods to increase whole-grain intake in the general population—a level that would elicit a measurable increase in intake of whole-grain servings, yet remain almost undetectable by consumers.

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