

NUTRITIONAL IMPACT OF WHOLE GRAIN INGREDIENTS ON THE COMPOSITION OF READY-TO-EAT BREAKFAST CEREALS AND BAKED PRODUCTS

L. LEMAR AND G. HOLCOMB

Nutrient Data Laboratory, USDA, ARS, Beltsville Human Nutrition Research Center, Beltsville, MD 20705

Introduction

Publication of the *Dietary Guidelines for Americans* 2005 enhanced public awareness of the probable health benefits associated with increased whole grain consumption. The Dietary Guidelines Advisory Committee Report stated that "Consuming at least 3 servings (equivalent to 3 ounces) of whole grains per day can reduce the risk of diabetes and coronary heart disease (CHD) and helps with weight maintenance. Thus, daily intake of 3 ounces of whole grains per day is recommended, preferably by substituting whole grains for refined grains." ¹ The Dietary Guidelines Advisory Committee referenced the AACC definition for whole-grain. An illustration of a whole grain kernel, and identification of some of the primary nutrients found in each component, is given in Figure 1. However, it is not always possible from ingredient statements to determine whether the listed flour is whole grain or partially milled.

The objectives of this study were to use analytical data available from nationwide and local sampling of selected grain-based products and breakfast cereals to:

- Investigate the ability of modifications to the Nutrient Data Laboratory (NDL) formulation program for estimating the percentage of whole grain in a product.
- Investigate the relationship between estimated whole grain percentage and the analyzed level of nutrients generally acknowledged to be high in whole grain products.

Materials and Methods

Baked Products

- Nationally representative samples for taco shells, whole wheat breads and crackers were picked up from retail grocery stores in 12 locations using the USDA National Food and Nutrient Analysis Program (NFNAP) protocol. ² White breads were sampled from 24 nationwide locations.
- Taco shells, whole wheat and white bread brands for sampling were chosen based on A.C. Nielsen sales figures.
- Multi-grain breads were local samples obtained from 4 retail grocery stores in Blacksburg, VA.

RTE Breakfast Cereals

- 12 cereals were purchased nationwide as part of a larger study on vitamin D.
- A single composite of Uncle Sam cereal was available from an earlier study.
- Analyses on proximate nutrients were done on 4 randomized composites. For 6 of the nationally sampled cereals, vitamin and mineral analyses were done for homogenates from all 12 locations; for the other 6, the 4 randomized locations were analyzed.

All sample units were shipped and prepared at Virginia Polytechnic Institute and State University (VPI). VPI homogenized samples according to established protocol and shipped samples to designated laboratories for analyses. All samples except folate were analyzed at commercial laboratories, using standard AOAC methods and rigorous quality control measures including certified reference materials and/or in-house quality control measures. Folate was analyzed at the University of Georgia (baked products) or VPI (breakfast cereals) using tri-enzyme extraction.

Analytical Data Evaluation

- Accuracy and precision of the data were evaluated using the results for quality control materials. ³
- Data were compared to previous or similar food items in the NDBS.
- Data were also compared to current food labels and expectations based on listed ingredients

Databank Process

- Acceptable data were migrated into the NDBS.
- Data for similar products were aggregated and the final profile was disseminated in SR.
- Final analytical data were also used in the NDLS formulation program to estimate whole grain percentages.

Steps in the Formulation Program

- Grains classified as whole grains in the NDBS are treated as whole grain in the formulation program (see Table 1 for list).
- Ingredient statements for products were entered into the NDLS label program and accessed through the formulation program (Fig. 2).
- Nutrients were selected for best fit matching of calculated values to analytical values using linear techniques (Fig. 3). The best fit formulation minimizes the total model error.
- The formulation program arrives at an estimated formulation. The percentage of whole grain in a product is the sum of the whole grain ingredient percentages (Fig. 4).

Figure 1. Definition of Whole Grain

- Whole grain classification: Grains classified as whole grain in the National Nutrient Databank System meet the criteria for whole grain as adopted by the Food and Drug Administration based on the final definition developed by AACC International (formerly the American Association of Cereal Chemists).
- AACC International definition of whole grain: Whole grains shall consist of the intact, ground, cracked or flaked caryopsis, whose principal anatomical components – the starchy endosperm, germ and bran – are present in the same relative proportions as they exist in the intact caryopsis. ⁴
- Unlike other food components, there is no chemical method to determine the whole grain composition of foods.

USDA diagram

Table 1. Grains Classified as Whole Grains in the Nutrient Data Laboratory Formulation Program

- Amaranth
- Barley, hulled
- Buckwheat flour
- Buckwheat groats
- Bulgur
- Corn flour, whole grain
- Cormeal, whole grain
- Macaroni, whole wheat
- Millet
- Oats, rolled
- Quinoa
- Rice, flour
- Rice, brown
- Rye
- Rye flour, dark
- Sorghum
- Spaghetti, whole wheat
- Triticale flour, whole grain
- Wheat flour, whole grain
- Wheat, durum
- Wheat, hard red spring
- Wheat, hard red winter
- Wheat, hard white
- Wheat, soft winter
- Wheat, soft winter
- Wild rice

Results

Figure 2. NDLS Ingredients Matched to Label Ingredients



Figure 3. Comparison of Calculated Values to Analytical Values

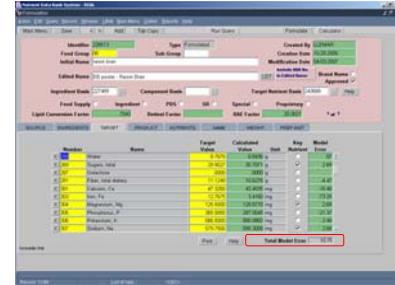
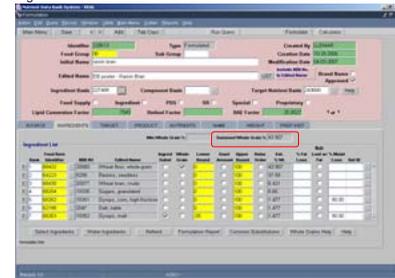


Figure 4. Percent Whole Grain Estimation



Results (continued)

Table 2. Nutrient Levels and Whole Grain Estimates Per 100g for Ready-to-Eat Cereals*

	Estimated % Whole Grain	0% Whole Grain				
		TDF (g)	Magnesium (mg)	Manganese (mg)	Pantothenic acid (mg)	Selenium (mcg)
Apple Jacks	0	1.69	21.90	0.54	0.35	6.00
Froot Loops	0	2.00	23.00	0.56	0.35	6.00
Frosted Flakes	0	1.80	7.00	0.04	0.22	4.00
Kix	0	2.60	46.00	0.65	0.32	27.00
Rice Krispies	0	0.80	26.00	1.38	0.60	18.00
Mean	0	1.76	24.60	0.68	0.37	12.00

	Estimated % Whole Grain	20% - 30% Whole Grain				
		TDF (g)	Magnesium (mg)	Manganese (mg)	Pantothenic acid (mg)	Selenium (mcg)
Honey Bunches Oats	22.00	4.50	47.50	1.03	0.61	6.00
Lucky Charms	22.70	4.70	55.00	1.87	0.66	16.00
Cinnamon Toast Crunch	24.00	3.80	42.00	1.48	0.53	7.00
Kix	34.30	8.10	51.00	1.13	0.52	6.00
Mean	28.75	5.35	49.75	1.38	0.58	10.00

	Estimated % Whole Grain	40% + Whole Grain				
		TDF (g)	Magnesium (mg)	Manganese (mg)	Pantothenic acid (mg)	Selenium (mcg)
Raisin Bran	43.90	11.10	126.00	2.84	0.92	4.00
Grape-Nuts	69.20	8.80	103.00	3.24	0.87	9.00
Uncle Sam	72.40	20.30	208.00	3.61	0.62	68.00
Cheerios	88.70	10.10	113.00	3.39	1.07	38.50
Mean	68.55	12.58	137.00	3.27	0.87	32.58

* Nutrient data are analytical
† Total dietary fiber

Figure 5. Estimated Whole-Grain Percent in Relation to Nutrient Content in RTE Cereals

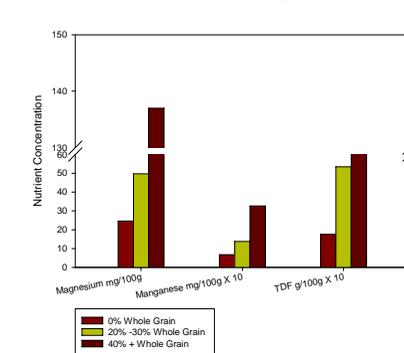


Table 3. Selenium in Rice Krispies by Store Pick-up Location

Selenium (mcg/100g)	Store location
<3.00	NY
<3.00	CT
<3.00	OK
<3.00	AL
<3.00	IN
23.00	FL
23.50	MO
23.80	CA (Fremont)
26.00	NC
27.80	CA (Paradise)
30.50	CO
36.00	MI

- It appears that rice from this study came from at least 2 distinct regions – a low soil/water selenium region, resulting in breakfast cereal with a selenium level below the level of quantitation of 3 mcg/100g, and a higher selenium region yielding product levels of at least 23-36 mcg/100.
- 2/3 of the US medium grain crop is grown in the Sacramento Valley of California. The rest is grown in the South (AK, MO, MS, LA, TX). ⁵
- The manufacturer confirmed that rice for Rice Krispies could come from any of the rice-producing areas of the US.
- When large price differentials occur, industrial users of medium grain rice switch from California rice to rice from the South.

Figure 6. Comparison of Vitamin and Mineral Levels in Retail Whole Wheat Flour and Industrial Refined Flour (enriched)

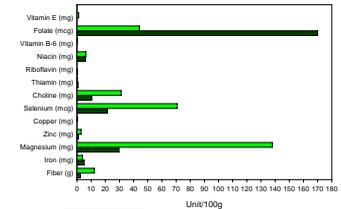


Table 4. Nutrient and Whole Grain Estimated Per 100g in Baked Products*

Baked Items	Estimated % Whole-Grain	B-Vitamins			Minerals		
		Thiamin (mg)	Riboflavin (mcg)	Folate (mcg)	Potassium (mg)	Magnesium (mg)	Selenium (mcg)
Whole-wheat crackers	83	0.212	0.253	297	110	10	
Taco Shell	81	0.216	0.08	69	223	85	5
Whole-wheat bread	38	0.353	0.216	50	248	82	40
Multi-grain bread	31	0.195	0.131	230	78	33	
White bread, enriched	0	0.455	0.331	111	100	23	17

* Nutrient data are analytical

Discussion

Formulation Program Modifications

- Ingredients coded as whole grain were identified in the formulation program ingredient listing with a whole grain checkmark (Fig. 2)
- In the Raisin Bran formulation, nutrients selected for best-match targeting (see key nutrient checkmark) closely approximated the known analytical values (Fig. 3). Those individual nutrient model errors were less than 3%. Iron's extremely high model error is of no practical importance because the analytical value reflects fortification levels.
- The formulation program summed all whole grain ingredients to give an estimated whole grain percentage (Fig. 4).

RTE Cereals

- As cereals progress from 0% to over 40% whole grain, mean values for TDF, magnesium, manganese, and pantothenic acid increase (Table 2 and Fig. 5).
- Looking at oat cereals, Cheerios (primarily whole grain) has a considerably higher content of those food components expected to be high in whole grain than does 22% whole grain Lucky Charms (Table 2).

Baked Products

- With the exception of folate, refined flours do not contain as much of the nutrients as whole wheat flours (Fig. 6).
- Table 4 shows baked products with higher estimates of whole grain ingredients are also higher in magnesium and potassium.
- The amount of selenium does not appear to be directly affected by the percentage of whole grain (Table 4).

Conclusion

- Modifications made to the formulation program functioned well. Good compatibility was found between analytical and calculated values for nutrients known to be high in whole grains. This gives confidence in the whole grain estimations.
- It was not possible to investigate the whole grain effect on many minerals and vitamins in cereals due to common fortification practices that add at least 10 vitamins and minerals in addition to 2-3 minerals added as functional ingredients.
- The Nutrient Data Lab does not plan to disseminate whole grain estimates in their databases.
- Nutrient Data estimates are designed to assist researchers in other ARS units in breaking down grain-based foods into whole grain and non-whole grain components through the Pyramids Serving Database.

Future Research

If further research were conducted on the effect of whole grain content on nutrient concentrations, multiple brands containing the same type of grain (e.g., wheat, rice, corn or oats) would need to be sampled. However, the products available through the NFNAP sampling program have been very useful in testing the feasibility of making whole grain estimates and in demonstrating a positive effect of whole grain on many components with known health benefits.

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