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White whole-wheat flour can be partially substituted for refined-wheat flour in pizza crust in school meals without affecting consumption

Hing Wan Chan, BS; Teri Burgess Champoux, PhD, RD, LD; Marla Reicks, PhD, RD; Zata Vickers, PhD; Len Marquart, PhD, RD

Please note that this study was published before the implementation of Healthy, Hunger-Free Kids Act of 2010, which went into effect during the 2012-13 school year, and its provision for Smart Snacks Nutrition Standards for Competitive Food in Schools, implemented during the 2014-15 school year. As such, certain research may not be relevant today.

ABSTRACT

Objectives
Recent dietary guidance recommends that children consume at least three servings of whole-grains daily. This study examined whether white whole-wheat (WWW) flour can be partially substituted for refined-wheat (RW) flour in pizza crust without affecting consumption by children in a school cafeteria.
Methods
Subjects included first to sixth graders from one elementary school in a large suburban school district, 324 boys and 314 girls. Pizza crust made with RW flour was served on two days; two weeks apart prior to serving the 50:50 blend pizza for four days at two week intervals. Liking rating forms were completed by 4th and 5th graders who had pizza on their trays. Plate waste was determined for each grade.
Results
There was no difference in consumption for the 50:50 blend or the RW pizza crusts. Children in lower grades ate significantly less pizza than children in the sixth grade. For liking, there was no difference for pizza crust made with RW flour compared to pizza crust made with the 50:50 blend.
Application to Child Nutrition Professionals
The pizza product made with a crust containing a 50:50 blend of WWW flour was as well accepted by children as pizza crust made entirely with RW flour. Substitution of WWW flour resulted in nearly a full serving of whole-grain in fifth and sixth grades.

INTRODUCTION

Prospective cohort studies indicate that consumption of whole-grains reduces risk for chronic disease (Jacobs, Marquart, Slavin, & Kushi, 1998; Jacobs, Meyer, Kushi, & Folsom, 1998; Liu et al., 2000). The 2005 Dietary Guidelines for Americans encourage daily consumption of three or more servings of whole-grain foods for children (U.S. Department of Agriculture and U.S. Department of Health and Human Services, 2005). Only 10% of children consume three servings of whole-grains daily as recommended by the Healthy People 2010 Objective (Kantor, Variyam, Allshouse, Putnam, & Biing-Hwan, 2001; U.S. Department of Health and Human Services, 2000). Taste and appearance may strongly affect children's preferences for breads, cereals, and other grain-based foods. Focus groups conducted with children indicate that familiarity, appearance and taste of whole-grain foods were important factors that influenced acceptability (Burgess-Champoux, Marquart, Vickers, & Reicks, 2006).

Most whole-grain bread products, particularly yeast breads are made with red whole-wheat flour (Atwell, 2001). These products are generally darker in color and have a stronger taste compared to refined-grain foods (Atwell, 2002). White whole-wheat (WWW) flour has been used in yeast bread products that tend to be less bitter, lighter in color, and softer in texture compared to products made with red whole-wheat (Lukow, Guinard, & Adams, 2004; Syms & Cogswell, 1991). Both types of whole-wheat flours have similar macronutrient and micronutrient content (Syms & Cogswell). A lack of darker pigment in the bran portion of WWW flour compared to red whole-wheat flour is primarily responsible for the lighter color of these grain products (Atwell, 2001). Similar to hard red winter wheat, hard white winter wheat contains a high protein content, strong gluten and high water absorption capacity that make it a good choice for breads and related products (Atwell, 2001).

A previous study showed that children preferred bread made with WWW flour over bread made with red whole-wheat flour (Lukow et al., 2004). However, no studies have examined children's acceptance of grain products made with WWW flour compared to products made with refined-wheat (RW) flour.

The strategy of substituting healthier ingredients for less healthy options has been advocated to effectively change dietary behavior (Kumanyika et al., 2000). Several studies have shown that lower fat, lower sodium foods can be substituted for less healthy foods in school cafeterias (Ellison, Capper, Goldberg, Witschi, & Stare, 1989; Snyder, Story, & Lytle, 1992) and that various ingredients (e.g. whole-grain flour) can be used to enhance the healthfulness of entrees, grains, and dairy foods for children (Endres, Barter, Theodora, & Welch, 2003) and adults (Adair, Knight, & Gates, 2001; Rankin & Bingham, 2000; Wu, Brochetti, & Duncan, 1998).

Pizza is a popular food for children, with nationally representative dietary intake data suggesting that children aged 2-18 increased intake of pizza from 1.4% of total energy to 3.4% over the past 20 years (Nielsen, Siega-Riz, & Popkin, 2002). Baseline data from a recent intervention showed that children were consuming a quantity of pizza that accounted for 6-10% of total energy intake, and together with snack foods and desserts, accounted for one-third of the daily energy intake (Van Horn, Obarzanek, Friedman, Gernhofer, & Barton, 2005). Modifications in pizza to incorporate WWW flour in the crust would improve the healthfulness.

Pizza crust is an excellent food for the incorporation of WWW flour because the whole-grain flavor and color might be masked by sauce and toppings. Marlette, Templeton, and Panemangalore (2005) indicated that pizza had the highest acceptance rate and the least plate waste among mixed dishes served to elementary school children. The inclusion of some whole-grain flour in pizza may be an effective approach to deliver whole-grains to children given their high acceptance level. The pizza sauce and crust provide an ideal means to soften the strong flavor of whole-grain foods. Given that 30 million school lunches are served on a daily basis in school cafeterias across the country it is apparent that studies are needed to examine approaches that might facilitate increased consumption of whole-grain foods such as pizza among school-aged children (Food and Nutrition Service, U.S. Department of Agriculture, 2006). The purpose of this study was to determine whether WWW flour can be partially substituted for RW flour in pizza crust without affecting consumption by school children.

METHODOLOGY

Subjects included children in the first through sixth grades from one elementary school in a large suburban school district. Enrollment consisted of 324 boys and 314 girls with the majority being white (69%) and the remaining 31% African American, Hispanic, and Asian. About 37% of students were eligible for free or reduced price school meals. At the time of the study, about 550 meals were served each day. This project was approved by the Hopkins School District Research Committee and the Institutional Review Board of the University of Minnesota.

A hard white winter whole-wheat (WWW) flour (Ultragrain) and a refined hard red winter wheat flour were used to make the cheese pizza products that were developed and manufactured by ConAgra Foods, Inc., Omaha, NE. All the flour in the RW pizza crust was hard red winter wheat. The 50:50 blend pizza crust (50:50 blend) contained a blend of 50% WWW flour and 50% RW flour. The RW

cheese pizza crust was served on two days, two weeks apart. The 50:50 blend pizza was then served on four days, also at two week intervals. Both types of pizza were made with a cheese topping and served with an accompanying salad of the day, either tossed, broccoli, or Caesar.

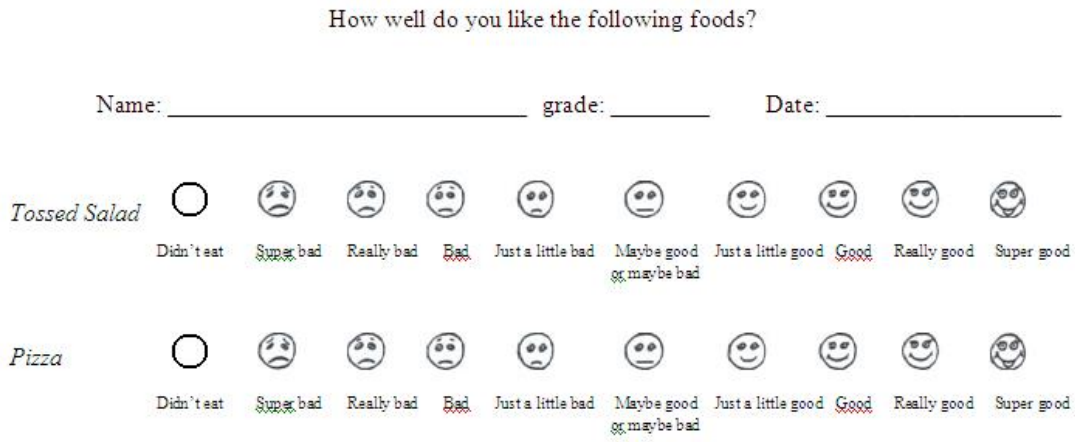
The finished 50:50 blend pizza (mean serving size, 144g) contained 16g of WWW flour, equivalent to one serving of whole-grain (U.S. Department of Agriculture and Agricultural Research Service, 1997). The RW pizza weighed 129g with no whole-grain flour. Based on a 100g serving, the nutrition profile for both types of pizza was similar for calories, protein, carbohydrate, fat, vitamins, and minerals and slightly higher in dietary fiber for the 50:50 blend [Genesis R&D Nutrition and Labeling Software (ESHA Research, Inc., Salem, OR, February 2005)] (Table 1).

Plate waste was collected based upon previous study protocols (Adams, Pelletier, Zive, & Sallis, 2005; Comstock, Symington, Chmielinski, & McGuire, 1979) by grade level for grades one through six on a table near the food disposal area. As children left the serving line with their trays, trained research assistants counted the number of students who were served pizza within each grade level. After the meal, students placed their uneaten pizza in plate waste collection containers. Research assistants supervised this process to ensure that all uneaten pizza was collected. A scale (DHAUS C-11) was used to weigh pizza waste for each grade separately after correcting for bag weight. Initial training sessions were conducted with research assistants to assure that the counting and weighing procedures were accurate and reliable. Accuracy was monitored regularly throughout the data collection process by independent observers verifying the number of items served and that all waste was collected. Greater than 99% agreement was observed in the number of items served when counted by two observers on each occasion.

Ten servings of pizza were selected from the school kitchen for each day of data collection and weighed using a scale (Edlund, model SR-2, Burlington, VT) to calculate the mean weight of one serving. The total weight of pizza served was determined by the mean weight of one pizza serving multiplied by the total number served to students during the lunch meal. The total amount of pizza consumed per student for a specific grade level was calculated by dividing the total weight of pizza served by the number of students who took the pizza slice. All data were analyzed using SAS version 9.1 (Cary, NC), with comparisons made at a = 0.05. An analysis of variance was applied in making comparisons of pizza consumed per student. The total amount of pizza consumed per student was the dependent variable; grade and grain-type were the independent variables, and serving size was a covariate. A Student-Newman-Keuls (SNK) multiple-range test was used to determine which grades had different levels of consumption.

Children in grades four and five were asked to rate their liking of the pizza each time it was served. The developmental level of fourth and fifth graders (aged 9-11) was more appropriate for assessing liking of whole-grain pizza than for younger students. In addition, other grade levels were not included due to a lack of personnel to distribute, administer, and collect liking surveys for all grade levels. Given that students are rating only one food, the term liking was used in this study as it more closely reflects our survey objectives. Liking is defined by Mela (2000) as the immediate experience or anticipation of pleasure from the orosensory stimulation of eating a food. Preference was not used as a measure in this study. It is defined as the selection of a food relative to other alternatives at the point of choice. A nine-point hedonic facial scale was used along with a Peryam and Kroll word description scale ranging from 1 = super bad to 9 = super good (Kroll, 1990; Popper & Kroll, 2003) (Figure 1). The liking rating procedure was pilot-tested prior to data collection. Liking rating forms and pencils were distributed on the dining tables for fourth and fifth graders who had pizza on their trays. Children were allowed to talk and interact as usual while completing the forms. Upon completion, researchers collected forms. For data analysis, a score of 1 to 9 was assigned to the corresponding level of liking (ranging from super bad = 1 to super good = 9). Data for each food item was combined for all students in grade four and grade five who completed the forms. All data were analyzed using SAS version 9.1 (Cary, NC), with comparisons made at a = 0.05 using an analysis of variance (PROC GLM) followed by SNK multiple comparison test if appropriate. The liking score was the dependent variable, while grain-type and grade were the independent variables.

Figure 1. A sample of liking rating form



RESULTS AND DISCUSSION

The mean weight per serving of pizza made with RW flour versus the 50:50 blend based on daily weighing of ten random samples was 129g vs. 144g. There was no difference in children's consumption of the 50:50 blend pizza (106g) compared to the refined counterpart (100g). The portion size of the 50:50 blend pizza served was larger (144g vs. 129g, Table 1) and this portion size was a significant covariate ($P = 0.003$, $F = 11.21$). Recent studies (Diliberti, Bordi, Conklin, Roe, & Rolls, 2004; Fisher, Rolls, & Birch, 2003; Rolls, Roe, Meengs, & Wall, 2004; Wansink & Kim, 2005) also have shown large portion size increases the amount of consumption. With the introduction of the 50:50 blend pizza, some fourth and fifth graders participated in a program including several classroom whole-grain lessons and several community child-parent activities related to increasing their consumption of whole-grains. Although students may have been aware of the 50:50 blend pizza through an accompanying nutrition education program, we did not intentionally advertise/promote that the pizza contained whole-grains. The influence of this program on the liking and consumption of pizza was not examined as part of this study (the educational component will be reported elsewhere).

Table 1. Nutrient content for the 50:50 blend and refined-wheat pizza slice* based on a 100g serving.

Nutrient content	Refined-wheat pizza	50:50 blend pizza
Weight of pizza slice, g	100	100
Energy, kcal	204	204
Total fat, g	7	8
Total carbohydrate, g	24	23
Total protein, g	11	11
Cholesterol, mg	8	8
Total fiber, g	2	3
Vitamin A, IU	458	458
Vitamin C, mg	0	0

Calcium, mg	180	190
Iron, mg	4	4
Sodium, mg	702	622

* Provided by ConAgra foods, Inc. The nutritional data were generated using Genesis R&D nutrition and labeling software by ESHA Research, Inc., Salem, OR, February 2005.

Children in grades one and two ate less pizza than children in grade six (P = 0.02, F = 3.37, Table 2). The interaction between grain type and grade approached significance (Table 2, grain type x grade, P = 0.08, F = 2.27).

Table 2. Mean (± standard error) consumption (g) of pizza for refined and 50:50 blend flours for the entire school by grade[1].

Grades	**Refined**		**50:50 blend**		**Total consumption of pizza[3]**	
	Mean ± SE	N (Days)	Mean ± SE	N (Days)	Mean ± SE	N (Days)
All grades	100 ± 2	11	106 ± 4	24	104 ± 3	35
Grade 1	100 ± 4	2	88 ± 6	4	92 ± 5 [a]	6
Grade 2	98 ± 1	2	91 ± 6	4	93 ± 4 [a]	6
Grade 3	95 ± 8	2	108 ± 6	4	104 ± 5[ab]	6
Grade 4	100 ± 8	2	107 ± 5	4	105 ± 4[ab]	6
Grade 5	104 ± 4	2	119 ± 9	4	114 ± 7 [ab]	6
Grade 6	101 ± 02	1	126 ± 5	4	120 ± 6 [c]	5

[1]Values are means of two measurements for the refined pizza and four measurements for the 50:50 blend pizza.
[2]Only one day of measurement of refined-wheat pizza for the 6th graders.
[3]Values with different superscript letters are significantly different according to GLM procedures (P= 0.02, F=3.37) and Students Newman Keuls test.

For liking, there was no difference in mean ± SE for pizza crust made with RW flour compared to the pizza crust made with the 50:50 blend flour (6.7 ± 0.2 with n=203 vs. 7.0 ± 0.1 with n=358,). However, liking ratings of fourth graders were higher than the fifth graders (7.4 ± 0.1 with n=304 vs. 6.3 ± 0.2 with n=257, p<0.0001, F=25.31).

To our knowledge, there are no studies in the literature that have examined consumption of pizza made with partial WWW flour vs. RW flour. In a study by Lukow et al. (2004) breads made with WWW flour were shown to be acceptable, whereas a study conducted by Bakke and coworkers (Bakke, Vickers, Marquart, & Sjoberg, 2007) suggests the contrary in an adult population. Lukow and coworkers used sensory tests to examine preference for breads made with WWW flour compared to red whole-wheat flour. The authors found that the ratio of children who preferred the pan bread made with lighter colored 100% WWW flour was two and one-half times higher for appearance as

compared to the bread made with darker traditional 100% red whole-wheat flour. Twice as many children also preferred the taste of bread made with WWW flour as opposed to bread made with red whole-wheat flour. In contrast, Bakke and coworkers showed that in adults the WWW bread was liked equally to the hard red spring whole-wheat bread. Bread made with WWW flour was liked less well than bread made with refined red wheat flour.

Similar to previous studies, our data suggests that grade level may influence the amount of whole-grains children consume. Based on the 1994-1996 Continuing Survey of Food Intakes by Individuals, Harnack, Walters, and Jacobs (2003) indicated that older children (12-18 years) consumed more total grain servings per day than younger children (2-11 years) with pizza contributing 5-9% of total grain servings for older children. This was consistent with our results showing that first grade children consumed about 10g (nearly two-thirds of a 16g serving; 16g is equivalent to one serving of whole-grain) of WWW flour while sixth grade children consumed about 13g (over three-quarters of a serving). Since the modified pizza crust was made with a 50:50 blend of WWW flour (16 g whole-grain) and RW flour (16 g refined-grain), offering the modified pizza could make an important contribution to intake of whole-grain food by children. Other studies focusing on the use of fat substitutions (Adair et al., 2001; Rankin & Bingham, 2000) suggest the level of substitution of ingredients was an important factor that determined the acceptability of the modified product. Further studies are needed to explore the use of whole-grain flour at various levels for pizza and grain-based products.

The limitations of the study include a relatively small sample of students from only one elementary school in the mid-western United States. This preliminary trial should be repeated over a longer period of time with more schools from diverse economic and socio-cultural backgrounds to verify the results.

CONCLUSIONS AND APPLICATIONS

This study suggests that a modified pizza product made with a crust containing a 50:50 blend of WWW flour was as well accepted by children as pizza crust made entirely with RW flour. Substituting WWW flour for refined-flour in cheese pizza allowed for consumption of nearly a full serving of whole-grain in the fifth and sixth graders.

Environmental approaches such as introducing pizza made with WWW flour addressed children's barriers to consuming whole-grain foods. These included the use of popular and familiar products that allow children to consume whole-grain foods without varying too far from their familiar eating patterns. Children were unable to discern any substantial differences between the two types of pizza which might be attributed to the use of WWW which tends to have a lighter color, less bitter taste and comparable texture to refined-grain pizza. Pizza is an ideal food to introduce whole-grain flour as the cheese topping and sauce tend to mask any whole-grain flavors that may be detected in the crust.

With the introduction of the 50:50 blend pizza, some fourth and fifth graders participated in a program including classroom whole-grain lessons and several community child-parent activities related to increasing their consumption of whole-grains. Some students were aware of the use of whole-grain foods in the school cafeteria through this program. However, we did not emphasize the fact that whole-grain pizza was being served in the school cafeteria. We cannot draw any conclusion regarding the impact of the whole-grain education program on the consumption of whole-grain pizza due to the limitation of research design (lack of control group).

Additional research is needed to examine school foodservice personnel's perceptions about children's whole-grain requirements and ability to overcome barriers in whole-grain selection, purchasing, preparation, and service and the assessment of students' dietary intake of whole-grain foods. Directors and managers should have a sound working knowledge of the whole-grain ingredients and whole-grain food definitions along with the type (white whole-wheat vs. red whole-wheat) and level (25, 50, 100%) of whole-grain flour that might be used in a child friendly whole-grain product. The flavor tends to be milder in products made with white whole-wheat with a lighter colored appearance. Flour milled to a smaller particle size can reduce visible bran specks, lighten

the crumb color and provide softer textured grain foods. The quality of the grain product and functionality of the flour and ingredients, including protein content, absorption, and dough strength, need to be taken into account. Purchasing agents should be scanning the marketplace for new opportunities to introduce whole-grain foods into their schools. A conscious effort must be made in order to balance the cost to benefit ratio of selecting certain types of whole-grain foods that may be higher in cost than other brands or their refined-grain counterparts. This is necessary to successfully communicate with bakers and food distributors about the selection and purchase of appropriate whole-grain foods. This is linked also with the directors' knowledge about the barriers (taste, texture, flavor, color) that may prevent students from selecting and consuming these whole-grain foods. In whole-grain preparation, staff should be aware of the use of additional water/moisture, dough preparation, proofing and baking time to achieve optimal products. In the service of whole-grain foods encouragement by foodservice staff may provide additional incentive for students to taste and eventually accept whole-grain foods.

The aggregate plate waste method in this study is a valid approach to assess the intake of whole-grain foods in a school cafeteria. However, it is labor-intensive, requiring an individual to account for the number of students that select the particular item, along with several staff responsible for collecting the plate waste. A more practical approach may be casual observation of students' acceptance of whole-grain foods. A staff member or parent volunteer records the observed amount of the whole-grain item consumed/wasted for a selected number of students in each grade level.

The use of a sensory evaluation form may provide another technique to assess students' liking for whole-wheat foods. This is also somewhat labor intensive where an individual will need to devote their full attention to the distribution of sensory forms and writing utensil as well as collecting the finished surveys. The liking rating of the 50:50 blend pizza remained relatively constant over the four times that we assessed students' liking. This would be expected as it takes eight to ten exposures to alter children's liking towards a new food item (Birch, Birch, Marlin, & Rotter, 1982).

On the contrary, we would also expect little change in liking given that the 50:50 blend pizza was perceived by students to be quite similar in liking as the RW pizza. In addition, the four exposures were not carried out over a long enough period of time in order to allow students to become tired with the same pizza product. A periodic use of this survey with random samples at each grade level in an elementary school cafeteria may provide some valuable feedback.

Particular attention that is paid to the selection, production, service and assessment of whole-grain intake among children will provide a strong base to more successfully introduce whole-grain foods into schools. The gradual introduction of lower level whole-grain foods may be one approach to successfully introduce familiar products that are accepted and readily consumed by children.

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BIOGRAPHY

Chan, graduate student; **Burgess Champoux**, postdoctoral associate; **Reicks**, professor; **Vickers**, professor; and **Marquart**, assistant professor, are with the Department of Food Science and Nutrition at the University of Minnesota in St. Paul, MN.