THE NUTRITIONAL IMPACT OF FORTIFIED READY-TO-EAT CEREALS ON THE DIETS OF SCHOOL-AGE CHILDREN

by

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ABSTRACT

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The *Continuing Survey of Food Intakes by Individuals, 1995* data base was used to compare overall nutrient intake of cereal and noncereal eaters age 6 to 17 years-old. A total of 807 children were included in the study, 346 who ate cereal and 461 who did not eat cereal. Nutrients analyzed were total and percent of the Recommended Dietary Allowances (% RDA) for energy, protein, vitamin A, thiamin, riboflavin, niacin, calcium and iron.

Calorie intake did not differ significantly between the cereal and noncereal eaters (2075 and 2092, respectively). Neither group, however, met the RDA for energy (96% for cereal eaters and 94% for noncereal eaters). Likewise, cereal and noncereal eaters did not differ significantly on protein intake either (72 g and 71 g, respectively). However, both groups consumed twice the RDA for protein (211% and 191%, respectively).

School-age children who consumed cereal had significantly higher intakes of vitamin A (1074 RE) than those who did not eat cereal (721 RE). Cereal eaters exceeded the RDA (146%) while noncereal eaters did not even meet the RDA for vitamin A (94%). Intakes for cereal eaters of thiamin (2 mg), riboflavin (3 mg), and niacin (24 mg) were significantly higher than noncereal eaters (1 mg, 2 mg, and 18 mg, respectively). When compared to the RDA for thiamin, riboflavin, and niacin, both cereal eaters (183%, 199% and 169%, respectively) and noncereal eaters (127%, 130% and 118%, respectively) exceeded the RDA, although cereal eaters exceeded the RDA almost two-fold. Noncereal eaters consumed significantly less calcium than did cereal eaters (846 mg and 1061 mg, respectively). Cereal eaters were the only group to exceed the RDA for calcium (112%) while noncereal eaters fell below the RDA (85%). The total mean intake for iron was significantly higher for cereal eaters (20 mg) as opposed to noncereal eaters (12 mg). Again, both cereal and noncereal eaters met the RDA (178% and 104%, respectively), but the cereal eaters greatly exceeded the RDA.

The findings of this study demonstrate the positive impact of fortified RTE breakfast cereal on the nutrient intake of school-age children, however, with the exception of calcium, fortification of RTE breakfast cereals with the investigated nutrients should not be increased any further.

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Chapter I

Introduction

Food fortification has played a major role in the elimination of once widespread deficiency diseases in the United States and around the world (Popkins and Siega-Riz., 1996). The fortification of flour was first suggested in 1940, when the Committee on Food and Nutrition of the National Research Council considered the addition of thiamin, riboflavin, niacin and iron to flour. A standard of identity was proposed in 1941 and by 1943, these nutrients were added to flour (Mertz, 1997). Standards of identity were developed and implemented for other grain products in the following years (Leveille, 1984).

Ready-to-eat (RTE) cereals were fortified in 1941 to replace nutrients lost during processing. By 1943, nearly 95% of all cereal products were restored to whole grain levels of iron, niacin, riboflavin and thiamin. In 1984, 92% of all breakfast cereals were fortified to significant levels, thus contributing to the nutritional adequacy of the American diet (Leveille, 1984).

In recent years, concern has been growing about the quality of the diets of school-age children (Gibson and O'Sullivan, 1995). Many experts believe that dietary habits developed early in life will continue into later life. It is also believed that risk factors for chronic disease characterized by increased plasma lipids, blood pressure and body mass index appear to remain into adulthood as well (Lauer, Lee, and Clarke, 1988) (Webber et al., 1991). Heart disease and colon cancer have been associated with high fat, low fiber intakes and that good dietary habits developed at an early age can reduce the incidence of these diseases (Gibson and O'Sullivan, 1995).

Resnicow (1991) found that consumption of RTE cereals can contribute to lowering cholesterol because they are nutrient dense foods which are high in fiber and low in fat. Because breakfast cereals feature predominantly in the diets of school-age children, they make a valuable contribution to children's nutrient consumption levels (Morgan, Zabik, and Leveille, 1981).

Statement of Problem

The purpose of this study was to compare overall nutrient intake of cereal and noncereal eaters age 6 to 17 years-old using the *Continuing Survey of Food Intake by Individuals, 1995* (CSFII) data base. A total of 807 children were included in the study, 346 who ate cereal and 461 who did not eat cereal. Nutrients analyzed were total and percent of the Recommended Dietary Allowances (% RDA) for energy, protein, vitamin A, thiamin, riboflavin, niacin, calcium and iron.

Chapter II

Literature Review

This review of literature will cover nutrient recommendations and nutrient adequacy of energy, protein, vitamin A, thiamin, riboflavin, niacin, calcium and iron for children ages 6 to 17 years, as well as fortification, ready-to-eat cereals (RTE), nutrification and the nutritional impact of RTE cereals.

Energy

Energy has been defined by the World Health Organization (1985) as "the level of energy intake from food which will balance energy expenditure when the individual has a body size and composition and level of physical activity, consistent with long-term good health". Energy is necessary for growth, maintenance, and activity, which comes from consuming a variety of foods containing carbohydrates, fats, and protein (Berkow, Beers, and Fletcher, 1997).

The recommended energy allowances for children and adolescents are representative of the average needs of individuals. Recommended allowances for other nutrients were set to meet the upper level requirement of people within groups. The energy requirements for children between the ages of 6 to 10 are 1,800-2,000 calories per day based on reference individuals (National Research Council, 1989).

Before the age of ten years, no distinction is made between the sexes for calorie recommendations. Past the age of ten, females and males are separated into different categories because the energy needs of adolescents vary according to sex, age, body size, pubertal development and activity level (Lifshitz, Tarim, and Smith, 1993). The average calorie recommendation for girls age 11 to 17 is 2,200 calories based on reference females. The average calorie intake recommendation for males between 11 to 14 years is 2,500 calories a day, and for males 15 to 17 years, 3,000 calories (National Research Council, 1989).

In recent years, concern has been expressed about the dietary excesses in children's food intake patterns. A growing body of evidence links excessive dietary energy, total fat, saturated fat, and insufficient intake of dietary fiber to heart disease (Food and Nutrition Board, 1989) and some forms of cancer (Doll and Peto, 1981). Resnicow (1991) and Stanton and Kearst (1989) found that consumption of breakfast cereals, which are nutrient dense, low-fat foods, can contribute to lowering blood cholesterol levels in children. RTE cereals can also contribute to lowering the percentage of energy that comes from fat, while enhancing the intake of certain nutrients (Gibson and O'Sullivan, 1995).

Protein

Adequate intakes of protein are essential for growth, especially in children and adolescents (Williams, 1994). Protein's role in the body is to maintain, repair and sustain growth of tissues (Whitney and Rolf, 1993). The RDA for protein for children and adolescents was established by reviewing nitrogen balance studies (Hegsted, 1976). Growth and maintenance requirements were accounted for. However, large discrepancies in experimental data caused the WHO group (1985) to use a modified factorial approach when estimating the protein needs for all children (National Research Council, 1989).

Protein deficiencies are rarely seen in the United States because of the increased presence of high protein foods in the American diet (USDA, 1987). RTE cereals do not contribute a significant amount of protein to the diets of children, however, since 92% of the time milk is added to RTE cereal, children consume additional high biological value protein as a result (Nicklas, Myers, and Berenson, 1995 a). Recommended protein allowances can be found on Table 1.

Table 1 - Recommended Dietary Allowances (RDA) for Select Nutrients

Category	Age (years)	Protein (g)	Vit. A (mcg RE)	Thiamin (mg)	Riboflavin (mg)	Niacin (mg)	Iron (mg)	Calcium (mg)
Children	6	24	500	0.9	1.1	12	10	800
	7-10	28	700	1.0	1.2	13	10	800
Males	11-14	45	1,000	1.3	1.5	17	12	1,200
	15-17	59	1,000	1.5	1.8	20	12	1,200
Females	11-14	46	800	1.1	1.3	15	15	1,200
	15-17	44	800	1.1	1.3	15	15	1,200

(National Research Council, 1989)

Vitamin A

The RDA recommendations for vitamin A for children were set based on increased needs during rapid growth. The RDA remains somewhat uniform as growth rate stabilizes, but body weight increases (Underwood, 1984). RDA values were based on the body weight of adults, and extrapolated to children and adolescents (National Research Council, 1989). See Table 1 for reference values.

Vitamin A has been found to be low or insufficient in children’s diets (Alaimo, McDowell, and Briefel, 1994) though signs of malnutrition in American children are rare (Kennedy and Goldberg, 1995). Milk has long been fortified with vitamin A, and as was discussed in the protein section, most RTE cereal is consumed with milk. However, RTE cereal itself can be fortified during processing with vitamin A at the discretion of the manufacturer, so some of the vitamin A consumed can come from the RTE cereal (Leveille, 1984).

Thiamin, Riboflavin and Niacin

The B vitamins consist, of but are not limited to thiamin, riboflavin and niacin. Thiamin was the first of the B vitamins to be discovered. It plays a role in carbohydrate metabolism and nerve function (Mahan and Escott-Stump, 2000). Recommendations for the RDA for thiamin were set based on urinary thiamin excretion of adolescents (Boyden and Erikson, 1966) (Hart and Reynolds, 1957). See Table 1 for reference values.

Riboflavin was first isolated from milk in 1879. It is essential in the metabolism of carbohydrates, proteins, and fats, and also serves as an antioxidant protectant (McCormick, 1994). Snyderman, et al. (1949) found that 0.4 mg for infants was sufficient to prevent ariboflavinosis. Values were extrapolated from this data for children (National Research Council, 1989). Reference values for children and adolescents can be found on Table 1.

Niacin is part of the coenzymes NAD and NADP which function as hydrogen donors in many metabolic processes including fatty acid metabolism, glycolysis, and respiration (Jacob and Swendseid, 1996). Niacin was discovered as a result of a search for the cause of pellagra, a niacin deficiency disease common in Italy and Spain in the 18^{th} century (Mahan and Escott-Stump, 2000). At this time there is no data for the niacin requirements of children and adolescents. Niacin recommendations are based on the standard set for adults and increase with energy intake (National Research Council, 1989). Niacin reference values may be found on Table 1.

In 1940, the committee on Food and Nutrition recommended that wheat flour be fortified with thiamin, riboflavin and niacin. In 1941, the addition of these nutrients were added to RTE cereals and by 1943, RTE cereals contained levels of these nutrients equivalent to those levels found in whole grains (Leveille, 1984). As a result of this fortification effort, children who consume RTE cereals have been shown to have significantly higher intakes of thiamin, riboflavin, and niacin than those children who do not eat cereal (Nicklas, Myers, and Berenson, 1995 b). Payne and Belton (1992) also found that breakfast cereals were important sources of thiamin, riboflavin and niacin in the diets of British pre-school children.

Calcium

Calcium is essential in the diets of both children and adolescents and is the most abundant mineral in the body. Calcium is needed for building bone, blood clotting, teeth formation, and preventing osteoporosis (Neumark-Sztainer, et al., 1997). The RDA for calcium for adolescents is based on an absorption rate of 40%, and calcium losses of 200-250 mg per day. During adolescence, accumulation of calcium can be as high as 400 to 500 mg per day (Garn, 1970). Recommendations were set high enough to accommodate for peak bone development and natural calcium losses (National Research Foundation, 1989). See Table 1 for reference calcium values.

In the third National Health and Nutrition Survey, Alaimo, McDowell, and Briefel (1994) found that adolescent males consumed more calcium than did adolescent females. In fact, adolescent females consumed only 68% of the RDA for calcium (Congressional Record, 1994). Since 92% of the time RTE cereal is consumed with milk, promoting

RTE cereal consumption could help provide additional calcium needed by children and adolescents (Morgan, Zabik, and Stampley, 1986).

Iron

Iron has long been recognized as an essential nutrient in the human body. Iron is an integral part of hemoglobin, myoglobin and other enzymes. It functions to transport oxygen through the body. Iron can be found in foods in one of two forms: heme and nonheme iron. Heme iron can be found in animal products and nonheme iron is found primarily in plant sources, such as RTE cereals (Dallman, Yip, and Johnson, 1984).

Iron is needed in greater amounts during periods of growth, such as in childhood and adolescence (Hudnall, 1996). Anemia, caused by insufficient stores of iron, is a result of decreased iron intake and has been seen in children during periods of growth (Kanarek and Marx-Kaufman, 1991). Therefore, the RDA for iron for children and adolescents was set to maintain hemoglobin stores and also to increase total iron mass during growth (National Research Council, 1989). Table 1 contains iron values for children and adolescents.

According to Kanarek and Marx-Kaufman (1991) 3% to 12% of adolescent males and 2.5% to 14% of adolescent females have an inadequate iron status. Numerous studies have shown that consuming fortified RTE cereals have significantly increased the iron intake of children and adolescents (McNulty et al., 1996).

Food Fortification

Food fortification has historically been used in the United States to improve the nutritional quality of the food supply. Fortification programs have decreased the incidence of deficiency diseases such as goiter and rickets, which were widespread at the turn of the century (Crane et al., 1995).

Several terms are used when discussing the topic of fortification. *Restoration* is the addition of nutrients to a food to make up for losses during processing. *Fortification*, on the other hand, is the addition of nutrients to levels higher than those found in the original food. *Enrichment* is the addition of nutrients to levels to meet certain standards of identity, and *supplementation* is a general term meaning the addition of a nutrient at any level (Leveille, 1984). *Nutrification* is defined as the addition of one or more nutrients to one or more commonly consumed foods that can improve the dietary intake of a given population. Nutrification is a term that will be used here interchangeably with fortification and as a replacement term for enrichment, restoration, and supplementation (Bauerfeind, 1988).

History of Fortification

Nutrient fortification is believed to have started in 1833, when a French chemist advocated for the addition of iodine to table salt to prevent goiter in South America. In 1900, iodization of table salt became a reality in Europe (Leveille, 1984). Vitamin A deficiency became apparent in Denmark during World War I, and in 1918, margarine was fortified with vitamin A concentrate. Soon after, vitamin D was added to whole milk in the United States (Leveille, 1984).

Food fortification began to increase during the 1930s and 1940s. Nutrient deficiencies began to appear in the United States, which were feared to be widespread. A series of events took place at this time, which accelerated the cereal grain nutrification program. In 1936, the American Medical Association (AMA) Committee on Foods issued a policy statement about the need for increased amounts of vitamins in the general food supply. At the same time, large quantities of pure thiamin were produced in the laboratory. Niacin was identified as the anti-pellagra factor in 1937, and was already available as a result of chemical synthesis. Riboflavin was chemically synthesized in 1935, but only in limited quantities until several years later (Bauerfeind and DeRitter, 1988). The addition of these nutrients to foods did not adversely affect the acceptability by the consumer of the nutrified product (Baurerfeind and DeRitter, 1988).

In 1940, the Committee on Foods and Nutrition, now the Food and Nutrition Board (FNB), was established. This committee endorsed the supplementation of wheat flour with thiamin, niacin, riboflavin, and iron. In 1941, the Food and Drug Administration established a standard of identity for enriched flour. The standard became effective on January 1, 1942, but was soon amended in 1943 to require the addition of thiamin, niacin, riboflavin, and iron to flour with the option of adding calcium and vitamin D. Standards of identity were developed and implemented for other grain products in the following years (Leveille, 1984).

Fortification Rationale

The AMA Council on Foods and Nutrition, and the FNB endorse food supplementation with nutrients under the following conditions (Council on Foods and Nutrition, 1973):

1. The intake of the nutrient is below the desirable level in the diets of a significant number of people.

2. The food used to supply the nutrient is likely to be consumed in quantities that will make a significant contribution to the diet of the population in need.

3. The addition of the nutrient is not likely to create an imbalance of essential nutrients.
4. The nutrient added is stable under proper conditions of storage and use.
5. The nutrient is physiologically available from the food.
6. There is reasonable insurance against excessive intake to a level of toxicity.
7. The additional cost should be reasonable to the intended consumer.

Fortification is not an exact science. It depends largely on the judgment of the food industry, and upon the understanding of the implications that arise from available dietary information (Leveille, 1984). It has been suggested, however, that breakfast cereals be fortified to provide up to 25% of the Recommended Dietary Allowance (RDA) per ounce of the nutrients common to cereals because they are primarily used as a breakfast entree (Council on Foods and Nutrition, 1973).

Ready To Eat (RTE) Cereal Nutrification Process

RTE cereals or the "dry" breakfast cereals are processed cereal grain products that are made up of either flaked, gun puffed, oven puffed, extruded, shredded, or granola, and are made from wheat, corn, rice, oats and other grains. They are precooked and are usually consumed with milk (Fast and Caldwell, 1990).

In the nutrification of RTE cereals, heat stable nutrients such as riboflavin, niacin, and minerals can be added directly to the dough prior to cooking. Nutrients which are destroyed by heat such as thiamin, and vitamins A and C are usually sprayed onto the cereals after they leave the oven. If vitamin D is to be added, it can be applied with vitamin A. Vitamin E can be added as an oil to the dough phase (Bauernfeind and Lachance, 1988).

Vitamins and minerals can also be added all together in a liquid formulation after heat treatment. In a liquid spray such as this, homogeneity, pH, temperature control, and the use of an antioxidant system are all important factors. Analytical control methods are used to confirm correct addition of all nutrification products (Fast and Caldwell, 1990).

Potential problems such as production losses, spray formulation systems, and shelf stability continually challenge the food industry. However, since nutrification began, millions of tons of cereal have been nutrified, attesting to the success of application methods (Bauernfiend and Lachance, 1988).

The cost of nutrification depends largely on the nutrients to be added, as well as operational and control expenses (Austin, 1979) (Vetter, 1982). As food chemists have developed better techniques of synthesizing nutrients, the cost of fortification has decreased. For example, in 1941, the cost of three enrichment ingredients niacin, thiamin, and iron was between $0.14-0.17 per 100 pounds of flour (Brooke, 1968). As of 1991, the cost had decreased to $0.05-0.06 per 100 pounds of flour (Bauernfiend and Lachance, 1988). Other costs for adding nutrients to foods include equipment for spraying on the nutrients and labor costs (Austin, 1979).

Acceptability of nutrified cereals is high. Since 1973, RTE cereals have been nutrified with at least 7 vitamins and iron. United States consumption of these RTE cereals has continued to increase annually, indicating consumer acceptance. However, amino acid nutrified cereals have not been as readily accepted by consumers (Bauernfiend and Lachance, 1988).

RTE Cereal Nutrification

RTE cereals were fortified in 1941 to replace nutrients lost during processing, and by 1943, nearly 95% of all cereal products were restored to whole-grain nutrient levels (Leveille, 1984). In 1955, nutrients were added on the basis of a percentage of the daily recommended allowance per serving. By 1969, 11% of all ready-to-eat (RTE) cereals had been fortified at higher levels. The contribution of cereals to nutrient intake was recognized in the White House Conference on Food, Nutrition, and Health (1970). Cereal manufacturers increased nutrient fortification as a result. By 1984, about 92% of all breakfast cereals were fortified to significant levels, contributing to the nutritional adequacy of the United States diet (Leveille, 1984).

A widely used standard is 25% of the United States RDA for thiamin, riboflavin, niacin, pyridoxine, folate, ascorbic acid, vitamin A and iron per ounce of cereal (Bauernfeind and Lachance, 1988). Some cereal manufacturers have added calcium to foods to provide up to 20% of the United States RDA; a few have added vitamin D. RTE cereal consumption has increased significantly over the last 20 years to a level of 10.6 pounds per person annually in the United States in 1985 (Bauernfeind and DeRitter, 1988). Thus, determining the effect of the increased use of fortified cereals to nutrient intake of children ages 6 to 17 years would contribute significantly to our knowledge of the nutritional status of this age group.

Chapter III

Methods

This study was conducted using the United States Department of Agriculture's 1994-1996 Continuing Surveys of Food Intake by Individuals (1995 CSFII). A copy of the 1995 CSFFII survey can be found in Appendix A. The objectives and methods of the thesis study were approved by the University of Wisconsin-Stout Institutional Review and the Human Subjects Committee.

Participants

The sample derived from the USDA food intake data included 807 school age children 6 to 17 years of age. The participants were placed into one of two groups, the "cereal eaters" and the "non-cereal eaters" based on their intake of ready-to-eat (RTE) cereals.

Design

The 1995 CSFII was designed to obtain a nationally representative sample of noninstitutionalized people living in households in the United States. Homeless persons, military personnel, and people residing in group homes or institutions were not included in the survey (Tippett et al., 1995).

The 1995 CSFII is a stratified, multistage area probability sample (Westat Inc., 1995). Estimates of the US population in 1990 were used to organize the sampling frame. The stratification procedure accounted for geographic location, degree of urbanization, and socioeconomic characteristics. Low income (<130% of the poverty level) were oversampled in the survey (Cypel and Tippett, 1995).

The survey was designed to obtain dietary intake data using in-person 24-hour food recalls over two nonconsecutive days. Proxy interviews were conducted for children in the sample under the age of six. Parents, guardians, or caregivers were asked to provide intake information. Children age 6-11 were allowed to provide their own food intake data assisted by an adult household member. Multiple people in the household could participate in the survey if specific, predetermined criteria were met (FSRG, 1998).

After the sample data was collected, it was coded into the database. By the end of 1995 CSFII, 7, 314 food codes were entered, each bearing a complete description of the food and preparation method. Each food code categorized foods into one of nine food groups, including RTE breakfast cereals (Tippett et al., 1995)

The data was further organized into “record type” (RT) files. All of the survey participants can appear in each RT file. Each RT file contains specific types of information pertaining to the survey. Pertinent data from the RT 30 and RT 40 files were combined for this thesis study. The RT 30 file contains food code information. The RT 40 file contains nutrient composition data and percentage of the Recommended Dietary Allowance (% RDA) of specific nutrients.

By defining the characteristics of interest, the software will select only the records that meet those given criteria. For example, in the RT 30 file, data of interest was; food records of children between 6 to 17 years of age, 24-hour food recall on day 1 of the survey, and food codes corresponding to RTE cereals. The RT 30 file was the only file that contained food codes for cereal eaters, which distinguished these children from the total population of children 6-17 years old.

From the RT 40 file, data of all children age 6-17 years, who had completed day 1 of the 24-hour food recall was extracted. This file provided total intake and %RDA for energy, protein, vitamin A, thiamin, niacin, riboflavin, calcium, and iron for both cereal and noncereal eaters, which was not available in the RT 30 file.

After merging the RT 30 and RT 40 files, condensing the data, and renaming some variables, two well defined groups remained: those who ate RTE cereals (cereal eaters) and those who did not eat RTE cereals (noncereal eaters). Comparisons of nutrient intakes of the two groups could be achieved.

Statistical Analysis

Statistical Analysis was performed using SPSS software. Statistical t-tests for independent samples were conducted on the two groups (cereal eaters and noncereal eaters), for the following variables: total intake and % RDA for energy, protein, vitamin A, thiamin, riboflavin, niacin, calcium, and iron. The data was then analyzed for significance.

Chapter IV

Results

The purpose of the study was to compare the overall nutrient intake of cereal and noncereal eaters, ages 6 to 17 years using the 1995 CSFII data base. There were 807 total participants, 346 who ate cereal and 461 who did not eat cereal. Of the 807 participants, 396 were male and 411 were female. Nutrients analyzed were total and % RDA for energy, protein, vitamin A, thiamin, riboflavin, niacin, calcium and iron.

Total Energy Intake and Percent RDA

The total mean energy intake for cereal and non-cereal eaters was non-significant at 2075 Kcals and 2092 Kcals respectively ($p \leq 0.78$). The percent energy RDA was also non-significant between cereal and noncereal eaters (96% and 94%) ($p \leq 0.36$). See Table 2.

TABLE 2 Total Energy and % RDA for Cereal and Noncereal Eaters Ages 6-17 Years

Group	Number	Mean (Kcal)	± Standard Error Mean (SEM)	Mean (%) RDA	± SEM
Cereal	346	2075	46.14	96	2.02
Noncereal	461	2092	43.00	94	1.76

Total Protein Intake and Percent RDA

Mean total protein intake as shown in Table 3 was non-significant for cereal and noncereal eaters (72 g and 71g, respectively) ($p \leq 0.51$). Those who ate cereal had a significantly higher percentage of the RDA for protein, 211%, than did noncereal eaters (191%) ($p \leq 0.001$).

TABLE 3 Total Protein and % RDA for Cereal and Noncereal Eaters Ages 6-17 Years

Group	Number	Mean (gram)	± SEM	Mean (%) RDA	± SEM
Cereal	346	72	1.61	211[a]	5.16
Noncereal	461	71	1.67	191[b]	4.70

[a,b] means are significantly different at $p \leq 0.05$

Total Vitamin A (RE) Intake and Percent RDA

Those who ate cereal had a significantly higher intake of vitamin A, 1074 RE, than those who did not eat cereal (721 RE) ($p \leq 0.001$). Furthermore, cereal eaters met and exceeded the percentage of the RDA for vitamin A, while noncereal eaters did not meet the RDA (146% and 94%, respectively) ($p \leq 0.001$). See Table 4.

TABLE 4 Total Vitamin A and % RDA for Cereal and Noncereal Eaters Ages 6-17 Years

Group	Number	Mean (RE)	± SEM	Mean (%) RDA	± SEM
Cereal	346	1074[a]	47.75	146[a]	8.19
Noncereal	461	721[b]	34.62	94[b]	4.41

[a,b] means are significantly different at $p \leq 0.05$

Total Thiamin Intake and Percent RDA

The mean intake for thiamin as shown in Table 5, was significantly higher for those who ate cereal (2 mg) compared to those who did not eat cereal (1mg) ($p \leq 0.001$). Although both cereal and noncereal eaters exceeded 100% of the RDA for thiamin, those who consumed cereal had a significantly higher percentage of the RDA for thiamin than noncereal eaters (183% and 130%, respectively) ($p \leq 0.001$).

TABLE 5 Total Thiamin and % RDA for Cereal and Noncereal Eaters Ages 6-17 Years

Group	Number	Mean (mg)	+ SEM	Mean (%) RDA	+ SEM
Cereal	346	2[a]	0.05	183[a]	4.63
Noncereal	461	1[b]	0.04	127[b]	2.85

[a,b] means are significantly different at $p \leq 0.05$

Total Riboflavin Intake and Percent RDA

The total mean intake and percentage of the RDA for riboflavin are presented in Table 6. The mean intake for riboflavin was significantly different between cereal and noncereal eaters (3 mg and 2 mg, respectively) ($p \leq 0.001$). Both groups met and exceeded 100% of the RDA for riboflavin; however, those who ate cereal consumed close to 200% of the RDA, whereas the percent RDA for the noncereal eaters was lower (199% and 130%, respectively) ($p \leq 0.001$).

TABLE 6 Total Riboflavin and % RDA for Cereal and Noncereal Eaters Ages 6-17 Years

Group	Number	Mean (mg)	+ SEM	Mean (%) RDA	+ SEM
Cereal	346	3[a]	0.06	199[a]	4.83
Noncereal	461	2[b]	0.04	130[b]	2.87

[a,b] means are significantly different at $p \leq 0.05$

Total Niacin Intake and Percent RDA

Those who ate cereal had a significantly higher intake of niacin, 24 mg, than noncereal eaters (18 mg) ($p \leq 0.001$). See Table 7. The mean percentage of the RDA for niacin was significantly higher compared to those who did not eat cereal (169% and 118%, respectively) ($p \leq 0.001$).

TABLE 7 Total Niacin and % RDA for Cereal and Noncereal Eaters Ages 6-17 Years

Group	Number	Mean (mg)	± SEM	Mean (%) RDA	± SEM
Cereal	346	24[a]	0.59	169[a]	4.03
Noncereal	461	18[b]	0.43	118[b]	2.72

[a,b] means are significantly different at $p \leq 0.05$

Total Calcium Intake and Percent RDA

Noncereal eaters consumed significantly less of the total intake for calcium, 846 mg, compared to those who ate cereal (1061 mg) ($p \leq 0.001$). See Table 8. Cereal eaters met and exceeded the RDA for calcium, 112%, while intake for noncereal eaters fell below the RDA (85%) ($p \leq 0.001$).

TABLE 8 Total Calcium and % RDA for Cereal and Noncereal Eaters Ages 6-17 Years

Group	Number	Mean (mg)	± SEM	Mean (%) RDA	± SEM
Cereal	346	1061[a]	30.9	112[a]	3.27
Noncereal	461	846[b]	24.1	85[b]	2.46

[a,b] means are significantly different at $p \leq 0.05$

Total Iron Intake and Percent RDA

The total mean intake for iron as shown in Table 9 was significantly higher for those who ate cereal compared to noncereal eaters (20 mg and 12 mg, respectively) ($p \leq 0.001$). Although both groups exceeded 100% of the RDA, those who ate cereal consumed a significantly higher percentage of iron, 178%, than did noncereal eaters (104%) ($p \leq 0.001$).

TABLE 9 Total Iron and % RDA for Cereal and Noncereal Eaters Ages 6-17 Years

Group	Number	Mean (mg)	± SEM	Mean (%) RDA	± SEM
Cereal	346	20[a]	0.61	178[a]	5.54
Noncereal	461	12[b]	0.28	104[b]	2.45

[a,b] means are significantly different at $p \leq 0.05$

Chapter V

Discussion

Energy

Interestingly, in this study, which used the data set from the CSFII 1995, calorie intake did not differ significantly between the cereal and noncereal eaters (2075 and 2092, respectively). Nicklas, Myers and Berenson (1991 b), found no significant calorie difference in the calorie intake of cereal vs. noncereal eaters in their study either. Other researchers, such as McNulty et al. (1996), and Morgan, Zabik, and Stampley (1986) all report similar findings. In contrast, Albertson and Tobelmann (1993) found that the daily calorie intake of noncereal eaters was significantly lower than those who ate cereal. In spite of higher total calorie intakes, however, cereal eaters had lower average fat intakes that noncereal eaters.

Comparing energy intake to the RDA, neither cereal eaters nor noncereal eaters met the RDA recommendations in this study (96% and 94%, respectively). Gibson and O'Sullivan (1995) reported that average energy intakes for 10 to 15 year olds met only 90% of the RDA for calories, though the researchers could find no evidence that energy intakes below the RDA impaired growth. Other studies have found that RTE cereal consumption resulted in lower calories, total fat, saturated fat, and cholesterol in both children and adults (Morgan, Zabik, and Stampley, 1986)

Protein

A significant difference was not found in the protein consumption between the cereal and noncereal eaters (72 g and 71 g, respectively). Other studies, such as Nicklas, Myers and Berenson (1995 b) also researched the impact of fortified RTE cereals on the diets of 568 ten year-old children in the Bogalusa Heart Study and found no significant difference in protein intake between cereal and noncereal eating groups.

Our study found that protein consumption for both cereal and noncereal eaters was twice that of the RDA (211% and 191%, respectively). The National Research Council (1989) has found that protein in the diets of Americans often exceed the RDA. However, it is not recommend to consume protein above two-times the RDA.

Vitamin A

School age children who ate cereal in this study had significantly higher intakes of vitamin A (1074 RE) than those who did not eat cereal (721 RE). Nicklas, Myers, and Berenson (1995 a) found that 10 year-olds and young adults who ate RTE cereals consumed significantly higher amounts of vitamin A than those who did not eat cereal.

Cereal eaters in this study exceeded the RDA (146%), but noncereal eaters fell below the RDA for vitamin A (94%). Nicklas, Myers, and Berenson (1995 a) found that the cereal eaters in their study met at least two-thirds of the RDA, while some of the noncereal eaters fell short of this. In addition, Albertson and Tobelmann (1993), who studied 824 seven to twelve year-old children using data from two Market Research Corporation of America Menu Census Panel Surveys, also found that RTE cereal eaters consumed over 100% of the RDA intake of vitamin A with RTE cereal intake.

Thiamin, Riboflavin and Niacin

In this study, cereal eaters consumed significantly higher amounts of thiamin (2 mg), riboflavin (3 mg) and niacin (24 mg) than noncereal eaters (1 mg, 2 mg and 18 mg, respectively). Nicklas, Myers and Berenson (1995 b) report similar findings. Cereal eaters in their study consumed, on average, 1.5 mg of thiamin, 1.8 mg of riboflavin and

20.0 mg of niacin. Noncereal eaters in their study consumed 1.0 mg, 1.9 mg and 13.3 mg, respectively. All of this data was significant.

When compared to the RDA, our study found that for thiamin, riboflavin and niacin, both cereal eaters (183%, 199%, and 169%, respectively) and noncereal eaters (127%, 130% and 118%, respectively) exceeded the RDA. However, cereal eaters exceeded the RDA almost two-fold. A study by McNulty et al., (1996) found similar results. They researched the impact of RTE cereal on the diet using 1051 children between the ages of 12 and 15 in Northern Ireland and found that those children who did not eat fortified RTE cereals had intakes below the lower reference nutrient intake (LRNI) for both riboflavin (23%) and niacin (13%). These results demonstrate the impact of RTE cereal fortification on the nutrient intake of children.

Calcium

Noncereal eaters in this study consumed significantly less calcium than did cereal eaters (846 mg and 1061 mg, respectively). Gibson and O'Sullivan (1995) also found that mean daily intakes for calcium of cereal eaters was greater than noncereal eaters. RTE cereal eaters among adolescents had greater intakes of calcium, likely due to increased milk consumption (Gibson and O'Sullivan, 1995). Similarly, Nicklas, Myers and Berenson (1995 a) reported that 96 % of school age children who ate RTE cereals also consumed at least one product from the dairy group, compared to 83% of the noncereal eaters.

Cereal eaters in this study exceeded 100% of the RDA (112%), while noncereal eaters fell below the RDA (85%). Albertson and Tobelmann (1993) found that noncereal eaters were below the RDA for calcium as well, whereas frequent cereal eaters were above 100% of the RDA.

The Food and Drug Administration amended the standard of identity for enriched flour in 1943 to include the option of adding calcium to wheat flour (Bauernfeind and Lachance, 1988). Today, there has been a marked increase in the number of food products fortified with calcium including RTE cereals to help the public meet calcium requirements.

Iron

The total mean intake for iron was significantly higher for those who ate cereal (20 mg) compared to noncereal eaters (12 mg). This study is consistent with other studies in its findings. For instance, Nicklas, Myers, and Berenson (1995 b) found that mean daily intake of iron was higher for cereal eaters than noncereal eaters (12.6 mg and 9 mg, respectively).

Both cereal eaters and noncereal eaters exceeded the RDA for iron in this study (178% and 104%, respectively). However, in other studies cereal eaters fell slightly below the RDA for iron, whereas noncereal eaters fell well short of the RDA for iron. Nicklas, Myers, and Berenson (1995 a) showed that the percent of intake from iron of 10 year-old children was approximately 85% for cereal eaters compared to noncereal eaters at 65% of the RDA for iron. Albertson and Tobelmann (1993) found that 50% of 7 to 12 year-old children who did not eat RTE cereal failed to meet the RDA for iron. These studies suggest that those children who consume RTE cereals have increased iron intakes.

Summary and Conclusion

Our study, which used the data set from the CSFII 1995, which also oversampled lower income groups, has yielded some surprising findings. The noncereal eaters sampled appear to be meeting or are very close to the RDA for the nutrients investigated with the exception of calcium. Nutrient intakes for cereal eaters which were approximately 51-74 percentage points higher than noncereal eaters include: vitamin A (52%), thiamin (56%), riboflavin (69%), niacin (51%), and iron (74%) based on the RDA. This would indicate that fortification of RTE cereals with the investigated nutrients should not be increased any further. Calcium intake for cereal eaters was only 27% higher compared to noncereal eaters. Other means to increase calcium in the diet of children, such as fortification of flour with calcium may be nutritionally sound.

The largest limitation of this study is that it included only one day's food intake data. A more accurate approach would be to have the target population keep a food record for a longer period of time and then analyze the data for nutritional differences between cereal and noncereal eaters. In addition, the RDA has undergone revisions since this data set was created. The results would probably be different if analyzed using the new Dietary Reference Intakes, especially for calcium, which was increased for some age groups.

Other data of interest that could be included if this study was done again are total dietary fat, saturated fat and cholesterol intakes between the cereal and noncereal eaters. Most of the other studies found significant differences between the cereal and noncereal eating groups for these variables. Further research studying the impact of folate fortification of RTE cereal on the diets of school-age children could be done using the new CSFII database. The 1995 survey did not include this information because approval for the addition of folate to flour occurred after this survey was completed. Assessments of nutritional programs, such as WIC, Food Stamp, and School Breakfast, which encourage the use of RTE breakfast cereals, could be achieved using the CSFII database as well. Because the data set is large and includes intake information for all age groups, the possibilities for further RTE cereal consumption research are limitless.

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Appendix A - CSFII 1995 Day 1 Food Intake Survey