Energy Density, Nutrient Adequacy, and Cost per Serving Can Provide Insight into Food Choices in the Lower Mississippi Delta

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ABSTRACT

Objective: To compare differences across food groups for food cost, energy, and nutrient profiles of 100 items from a cross-sectional survey of 225 stores in 18 counties across the Lower Mississippi Delta of Arkansas, Louisiana, and Mississippi.

Methods: Energy, nutrient, and cost profiles for food items were calculated by using Naturally Nutrient Rich methodology and converting price per 100 g edible portion to price per serving. Foods were grouped into 6 food groups. Mean differences were compared with ANOVA.

Results: Significant differences existed by food group for each measure. Energy density was highest for fats/oils/sweets, whereas nutrient density was highest for vegetables. Price per serving was lowest for fats/oils/sweets and highest for meats.

Conclusions and Implications: Educational messages focusing on a complete diet should consider the role of food costs and provide specific recommendations for increasing nutrient-dense foods by replacing a portion of the meat serving at meals with culturally acceptable lower-cost nutrient-dense foods.

Key Words: price per serving, nutrient adequacy, energy density, food store survey (*J Nutr Educ Behav*. 2012;44:148-153.)

INTRODUCTION

Recent attention has focused on the role of the food environment, including food access, availability, and cost as it relates to the increasing prevalence of obesity and other chronic diseases, particularly in populations experiencing health disparities.[1-3] Food prices are clearly a consideration in food purchasing and consumption decisions, especially for low-income populations who report lower intake of fruits, vegetables, milk, meat, poultry, and fish compared with high-income adults.[4-6] Some researchers suggest that consumption of fats and sweets provides greater value to low-income populations because of their high energy density and low price-to-energy ratio.[4,7] To date, more analyses examining food costs in relation to nutrient content have assessed the "value" of particular foods or food groups, using either standard food composition units (eg, 100 g, pound, or cup amounts) or standard energy units (1,000 or 2,000 kcal).[8-10] Dietary intake recommendations for the general public, however, use serving amounts or equivalents such as ½ cup or 1 oz to frame consumption recommendations.[11] Currently, only 1 published report provides price-per-serving information, and it focuses solely on fruits and vegetables.[12]

The Lower Mississippi Delta (LMD) region of Arkansas, Louisiana, and Mississippi is a health-disparate area exhibiting overall poor diet quality among its residents and environmental constraints on food access, with more than 70% of low-income households located less than 30 miles from a supermarket.[13-15] Additionally, compared with supermarkets, smaller grocery stores in the region have significantly fewer fruits and vegetables and other items composing the Thrifty Food Plan.[13] Likewise, little has been published regarding the cost of foods in this rural region.

The objectives of this study were to (1) determine food cost, energy, and nutrient profiles for food groups according to the United States Department of Agriculture (USDA)'s MyPyramid food guidance tool and the Dietary Approaches to Stop Hypertension (DASH), using a data set of 100 food items surveyed across the LMD

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region; and (2) compare differences for these indices across food groups.

METHODS

Dataset and Food Prices

During the summer of 2000, a food store survey was conducted in 18 counties representative of a 36-county region in the LMD. The sample included 225 food stores randomly selected from a universe of 557 (final sample included 62 supermarkets, 77 small/medium grocery stores, 86 convenience stores). A complete description of the sample selection, methods, and data collection instrument has been previously published.[13,15] The study was exempt from Institutional Review Board approval at the University of Southern Mississippi because data collection did not involve human subjects. The dataset included 102 individual food items (Table 1), for which the lowest unit selling price (in US dollars) was recorded for each store surveyed, following methodology of the USDA Authorized Food Retailers' Characteristics and Access Study.[16] Food items were derived from the weeks 1 and 2 shopping lists of the 1999 Thrifty Food Plan, the food list of the Authorized Food Retailers' Characteristics and Access Study and from culturally important foods identified through a regional dietary intake study.[16-18] Culturally important foods were defined as those foods traditionally associated with southern culture that contributed 0.5% or more of energy or any other nutrient in a regionally representative dietary intake study that were not found in the access study or TFP food lists, including grits, fresh okra, shellfish, catfish, fresh greens, and sweet potatoes.[18]

The unit price of each food item as determined and recorded by trained surveyors was converted to price per 100 g edible food portion ($/100 g EP) after adjusting for preparation and waste, using USDA Agricultural Handbook No. 102.[19] Unit price is the standardized price per pound, quart, or other unit of weight or volume. For example, price per 100 g EP for bananas was calculated in this way: \$0.59 per pound / 454 g per pound × 100 g EP / .65 (65% yield) = \$0.1999 per 100 g EP. Although several items priced in the fresh form could be consumed in both raw and cooked form (eg, carrots, cabbage, celery, peppers, onions), only the raw form was included in the analyses to avoid duplication. For this study, 2 items in the dataset were dropped from the analyses (pudding mix and organ meats) because of potential error in pricing imputations or wide variation in nutrient content of items priced (liver vs chitterlings). The final dataset used for analyses consisted of 100 individual food items.

Energy and nutrient profiles for each 100 g EP food item were estimated with the USDA *National Nutrient Database for Standard Reference*.[20] Energy density was calculated as the amount of energy in kilocalories per 100 g EP. Using methods published by Drewnowski,[21] a nutrient adequacy score referred to as the Naturally Nutrient Rich (NNR) score was calculated with 15 nutrients (NNR_{15}). The NNR score is a nutrient-to-calorie ratio based on percentage daily value according to the Dietary Reference Intakes[22] of 15 nutrients and calculated as Σ ({Nutrient$_i$ / daily value$_i$} × 100) / 15. The 15 nutrients included protein, vitamins A, C, B_{12}, D, and E, folate, thiamine, riboflavin, calcium, iron zinc, potassium, monounsaturated fatty acids, and fiber.[21] To avoid undue contribution of one or more nutrients in a food item to the total NNR score, percentage daily value of any nutrient exceeding 2,000% was truncated to 2,000.[21,23] Following the procedures of Darmon et al,[23] a measure of nutrient density, which takes into account the relationship between energy density and nutrient adequacy, was calculated and based on 100 kcal as (NNR_{15} / energy density) × 100.

Information from the *Dietary Guidelines for Americans 2005*[24] and the DASH eating patterns was used to assign each of the 100 food items to one food group—grains, vegetables, fruits, meats, milk, fats/oils, or sweets—and to determine common serving sizes for each food item within the groups.[25] Because of interest in the potential economic influence on consumption of low-cost, energy-dense food items, we created a separate category for food items high in added sugars that we named "sweets." Sweets are not a distinct category in the current MyPyramid food guidance tool, so the DASH eating patterns were used to identify serving sizes for food items categorized as sweets. According to the *Dietary Guidelines for Americans 2005*, beans can be placed in the meat or the vegetable group, whereas they are considered a separate food grouping in the DASH eating patterns. Because residents of the LMD commonly consider beans a vegetable, beans were grouped with the vegetables for establishing serving size and conducting price analyses. With these sources, the following standard serving sizes were established for each food group: grains = 1 oz equivalent; vegetables = ½ cup cooked or 1 cup raw; fruits and fruit juice = ½ cup; milk = 1 cup fluid, 1.5 oz cheese, 2 cups cottage cheese, 1 each fudge popsicle; meats = 3 oz; fats/oils = 1 tablespoon (example: vegetable oil); and sweets = 1 tablespoon jam, sugar, or syrup or 1 cup fruit-flavored drink.[11,24,25] Next, we calculated weight in grams of a standard serving size for each food by using the USDA *National Nutrient Database Standard Reference*.[20] We then divided 100 g EP of each food by the grams per standard serving to derive the measure servings per 100 g EP. Price per serving was then calculated by dividing the price per 100 g EP by the derived conversion factor, servings per 100 g EP.

Analyses

Analyses were conducted with SPSS (version 15, SPSS, Inc, Chicago, IL, 2006). All variables except energy density and NNR_{15} were log transformed to normalize their distribution. Items in the fats/oils food group (n = 3) were combined with the sweets category (final n = 14) for inferential analyses. One-way analysis of variance was used to determine whether there were mean differences in energy density, nutrient adequacy, nutrient density, and price per serving by the 6 pyramid food groups. Levene's test of homogeneity of variance indicated unequal variances for some variables; therefore, Tamhanes 2 post hoc test was used for pairwise comparisons of pyramid groups within each variable for simplicity. Significant differences were determined to exist if $P \leq .05$.

Table 1. Foods Included in the Lower Mississippi Delta Food Store Survey by Food Group

Fruits	Vegetables	Grains	Meats	Milk	Fats/Oils/Sweets
Apples, fresh	Beans, dried/lima	Bagels, plain	Eggs, whole	Cheese, cheddar	Mayonnaise, salad dressing, regular
Bananas, fresh	Beans, green, canned	Bread crumbs, plain	Chicken, whole, broiler, or fryer	Cheese, Mozzarella, whole milk	Vegetable oil
Grapes, fresh	Beans, kidney, canned	Bread, French	Chicken, thighs	Cottage cheese	Shortening, vegetable
Melon, cantaloupe, fresh	Beans, lima, canned	Bread, white, commercial	Turkey breast	Milk, whole, 3.5% milk fat	Stick margarine
Oranges, fresh	Beans, navy, canned	Bread, whole wheat	Ground turkey	Milk, 1% milk, fat	Fat-free margarine, tub
Orange juice, frozen concentrate	Beans, Great Northern, canned	Cornmeal, yellow, enriched	Pork chops	Milk, skim, nonfat	Fruit drink, prepared
Mandarin oranges, canned	Pork and beans, canned	Crackers, saltines, low salt	Bacon, cured	Milk, evaporated, canned	Chocolate chips, semisweet
Peaches, light, canned	Broccoli, frozen, spears	Egg noodles, enriched	Beef roast	Fudge popsicle, milk-fat free	Pancake syrup
Strawberries, fresh	Cabbage, raw head	English muffins, plain	Fish fillets, frozen, unbreaded		Jelly
Applesauce, canned	Carrots, raw	Flour, white, all purpose	Tuna, light, in oil, canned		Molasses
Pears, light, canned	Celery, raw	Grits, enriched	Shellfish (shrimp)		Sugar, brown
	Frozen french fries	Hamburger buns	Catfish, fresh or frozen		Sugar, granulated
	Beans, green, frozen	Macaroni, enriched	Fish, fillet, frozen, breaded		Powdered sugar
	Peas, green, frozen	Oatmeal, regular	Ground beef, 80% lean		
	Greens, mustards, fresh	Popcorn, butter flavored (microwave)	Turkey ham, sliced, extra lean, prepackaged		
	Mushrooms, canned	Cornflakes			
	Okra, fresh	Toasted oat cereal			
	Onions, raw	Rice, white, long grain			
	Black-eyed peas, dried	Rolls, dinner, plain			
	Black-eyed peas, frozen	Spaghetti, enriched			
	Green bell peppers, raw				
	Sweet potato, raw				
	Potatoes, white, raw				
	Salad mix				
	Pasta sauce, spaghetti				
	Spinach, canned				
	Yellow squash, summer				
	Zucchini				
	Winter squash, acorn				
	Tomatoes, red, ripe, raw				
	Tomato sauce, canned				
	Tomato soup, canned				

RESULTS

Significant mean differences were indicated among the food groups for price per serving (Table 2). Fats/oils/sweets had the lowest price per serving, whereas meats had the highest. Meats were also significantly higher in price per serving than vegetables. Grains were significantly lower in price per serving compared with meats ($P < .001$) as well as with vegetables ($P < .001$) and fruits ($P < .001$). Vegetables and fruits were not significantly different from one another or from milk in price per serving. However vegetables, but not fruits, were significantly lower in price per serving than meat ($P = .008$).

Significant mean differences by pyramid group were also indicated for each of the measures of nutrient quality (Table 2). Energy density was highest for fats/oils/sweets and lowest for fruits, and the difference was significant ($P = .002$). Likewise, vegetables were similar to fruits in energy density and were significantly lower than fats/oils/sweets ($P = .002$). The remaining food groups were not significantly different from fats/oils/sweets. The milk group was not significantly different from any of the other groups. With regard to nutrient adequacy, vegetables had the highest score and fats/oils/sweets the lowest, and the difference was statistically significant ($P < .001$). The nutrient adequacy score for vegetables was significantly higher than for all other food groups except fruits ($P < .001$ for vegetables compared to grains and meat; $P < .008$ for vegetables compared to milk). As stated previously, nutrient density scores take into account both energy density and nutrient adequacy. Vegetables had the highest nutrient density score, whereas grains had the lowest, and the difference was statistically significant ($P < .001$). The nutrient density scores of vegetables, fruits, and milk were not significantly different from one another, nor did nutrient density scores of fats/oils/sweets and grains differ from one another.

DISCUSSION

This study is unique from the perspective of comparing food costs and nutrient quality according to recommended serving size amounts. The dataset is representative, consisting of 100 food items surveyed in 225 representative food stores, using a multicounty sampling design. Because poor diet quality is implicated in numerous chronic diseases, describing nutrient density and price per serving of food groups can help focus nutrition education efforts for health-disparate populations.

Perhaps most noteworthy are the findings regarding price per serving. In contrast to other studies of cost based on various parameters,[8-10,26] only one report to date has published the price per serving of food items, and that was fruits and vegetables only,[12] while our study included all food groups. In that study, more than half of the vegetables and fruits could be purchased for less than \$0.25 per serving. Our data, collected in a similar period, combined all forms of vegetables and all forms of fruits for the price per serving analysis because of the limited number of items in each category. Despite the slight difference in methods, we found that vegetables and fruits sold in LMD food stores were more expensive on a price-per-serving basis than nationally (\$0.29 vs \$0.17 and \$0.37 vs \$0.31, respectively).

The price-per-serving data from this study provide insight into findings from regional food availability and food intake studies that may partially explain the poor Healthy Eating Index scores and low consumption of vegetables and fruits reported for adults in this region.[15,27] As previously documented, 4 of the 10 most available foods in the LMD food stores (found in > 80% of the 225 food stores) were from the fats/sweets/oils group, and only 2 items could be considered vegetables (pork and beans, tomato sauce).[28] Furthermore, 5 of the 10 least available foods (found in ≤ 12% of the 225 food stores) were from the vegetables group and only 3 were low-fat items.[28]

In our analyses, the 2 food groups with the highest energy density scores (fats/oils/sweets and grains) had the lowest price per serving. Several of the foods reported as top contributors

Table 2. Untransformed Means and Standard Deviations for Energy Density, Nutrient Adequacy, Nutrient Density, and Price Per Serving by Food Group

Food Group	Energy Density[1] Mean	SD	Nutrient Adequacy[2] Mean	SD	Nutrient Density[3] Mean	SD	Price per Serving Mean	SD
Fruits (n = 11)	53.8[b]	18.0	160.2[a,b,c]	121.2	390.5[b,c]	372.3	0.36[b,c]	0.22
Vegetables (n = 33)	55.6[b]	42.8	305.4[b]	182.6	1,292.4[b]	1,346.1	0.29[b]	0.13
Grains (n = 20)	273.3[a]	125.3	102.1[a,c]	78.2	46.2[a,d]	32.6	0.09[a,d]	0.06
Meats (n = 14)	198.9[a]	64.8	132.3[a]	47.6	80.8[a,c]	55.5	0.90[c]	0.93
Milk (n = 8)	155.4[a,b]	132.2	146.2[a,c]	73.8	241.7[a,b]	290.6	0.40[a,b,c]	0.49
Fats/oil/sweets (n = 14)	416.0[a]	247.3	44.3[c]	74.2	54.9[d]	175.1	0.07[d]	0.07
Analysis of variance, $F_{(5,94)}$	23.3		12.1		31.6		25.8	
P value	< .001		< .001		< .001		< .001	

[1]Energy density = kcal/100 g; [2]Nutrient adequacy = NNR_{15} score; [3]Nutrient density = (NNR_{15}/energy density) × 100 kcal.
Note: Means within columns with different superscripts are significantly different at $P \leq .05$ according to the Tamhanes 2 post hoc test. The number of types of foods within a specific food group category for which price data were collected across 62 supermarkets, 77 small/medium grocery stores, and 86 convenience stores in the Lower Mississippi Delta.

to LMD adult energy intake were foods from these 2 groups. The exception was meats, which were the third highest in energy density but the highest in price per serving. The importance placed on meat in this region is reflected in these food intake studies[15,18] and voiced by residents who describe the "typical" meal as consisting of meat first before any other food item (unpublished focus group data). Careful consideration should be given to crafting relevant and culturally sensitive educational messages that target smaller meat servings and shifting a portion of the food budget toward the purchase of vegetables, given the preference for meat as a meal component in this region.[15,18]

Similar to that of Reed et al,[12] our data indicate that some traditional foods in the LMD with high nutrient density were relatively inexpensive in fresh or dried form, such as greens at \$0.17/serving, cabbage at \$0.10/serving, and dried beans at an average of \$0.22/serving (data not shown).

The limitations of this study indicate important food sampling issues and highlight the need for more research related to relationships among food costs and actual consumption. The majority of grains included in this study were not whole grains because the sources from which the food lists were constructed did not specify whole grains. Therefore, the nutrient quality and price per serving for this group may not reflect a cross-section of whole and mixed-grain products. Additionally, these data were collected in 2000. During intervening years, slight changes in types of food available may have occurred. Costs of foods are likely to have increased, following national trends.[29] However, longitudinal research on regional food costs has shown that costs of energy-dense foods remain lower than those of nutrient-dense foods over time.[9]

IMPLICATIONS FOR RESEARCH AND PRACTICE

Although the approach of this study is theoretically sound, future surveys could be strengthened by deriving lists of foods to be surveyed from data on commonly consumed foods in the region studied, along with foods considered to be part of a healthful diet, to better assess the potential for population groups to adjust their purchases toward a healthier diet within their means. Use of standardized food lists from the Authorized Food Retailers' Characteristics and Access Study and the TFP to derive the majority of the food items included in our survey strengthens the potential for use of the instrument in similar populations. When constructing a sampling plan for a food availability study, researchers need to account for common foods from the region in addition to the most current version of food guidance recommendations, which would allow investigation of the link between price and nutrient indices for individual foods with actual consumption patterns across the lifecycle and help inform and substantiate both environmental and community interventions aimed at improving dietary behaviors.

When promoting increased consumption of nutrient-dense foods among health-disparate groups, nutrition educators should consider that healthful changes could increase the cost of feeding the family if parallel reductions are not made in consumption of costlier items such as meat. Beans and raw vegetables are less expensive on a price-per-serving basis, are nutrient dense, are well accepted by this population, and may also help provide satiety, an important consideration when working with populations experiencing high rates of food insecurity and hunger such as the LMD.[30] Modifying traditional mixed dishes to incorporate more beans/legumes and less meat may also be a cost-effective way to improve diet quality. Other low-income populations may also benefit from similar education.

Policy approaches such as the Elderly Farmers' Market and Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) Farmers' Market vouchers can help to increase access to vegetables and fruits among low-income populations. Recent revisions in the WIC food package will likely help to encourage increased consumption of beans and legumes. Nutrition educators working in the community can be instrumental in encouraging consumers to request and purchase more nutritious foods from local stores so that both consumers and store owners benefit.

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