SUPPLEMENT

Nutrient Density and the Cost of Vegetables from Elementary School Lunches[1–3]

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ABSTRACT

Vegetables are the major source of the dietary fiber, magnesium, potassium, and vitamins A and C that are crucial in the diets of children. This study assessed the nutrient content of vegetables offered through the National School Lunch Program and examined the relation between the overall nutrient density of vegetable subgroups and the costs of nutrients offered and wasted before and after the changes in school meal standards. Using data collected from 3 elementary schools before and after the changes in school meal standards, we found that vegetable plate waste increased from 52% to 58%. Plate waste for starchy vegetables, exclusive of potatoes, was relatively high compared with other subgroups; however, plate waste for white potatoes was the lowest among any type of vegetable. Energy density; cost per 100 g, per serving, and per 100 kcal; and percentage daily value were calculated and used to estimate nutrient density value and nutrient density per dollar. Cost per 100 kcal was highest for red/orange vegetables followed by dark green vegetables; however, nutrient density for red/orange vegetables was the highest in the group and provided the most nutrients per dollar compared with other subgroups. Given that many vegetables are less energy dense, measuring vegetable costs per 100 g and per serving by accounting for nutrient density perhaps is a better way of calculating the cost of vegetables in school meals. *Adv Nutr* 2016;7(Suppl):254S–60S.

Keywords: National School Lunch Program, plate waste, vegetable, nutrient density, cost of nutrients

Introduction

The National School Lunch Program (NSLP)[6] is a federally funded school meal program operating in many public and nonprofit private schools to provide nutritionally balanced meals at low cost or for free to school children. Currently, the program operates in over 100,000 schools with >31 million children participating in the program on an average school day. The NSLP cost the federal government >$11 billion in cash payments and foods in FY 2012. (1).

In 2010, Congress passed the Healthy, Hunger-Free Kids Act of 2010 (2), which required the USDA to update the national school meal standards to reflect the most recent Dietary Guidelines for Americans (3). The USDA issued new nutrition standards for the NSLP, which took effect at the beginning of the 2012–1013 school year. With new nutrition standards in effect, schools across the country are now offering healthier school meals with more fruits, vegetables, and whole grains. Also, larger servings and a wider variety of fruits and vegetables are offered to students.

School food authorities (SFAs), usually aligned with school districts, establish meal program menus and ensure that meals meet federal nutrition requirements, along with other responsibilities. However, SFAs face multiple new challenges trying to meet new meal compositions and nutrition requirements on limited budgets while offering appealing meals that students enjoy eating. Another challenge SFAs face after implementing the new lunch requirements is plate waste. Most states' SFAs reported greater plate waste after implementation of the new regulations (2).

Fruits and vegetables are important components of a healthy diet. The 2010 Dietary Guidelines for Americans recommend consumption of nutrient-dense foods and beverages and control of calorie intake to achieve and maintain healthy weight (3). Different food groups make different

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[6] Abbreviations used: DV, daily value; NSLP, National School Lunch Program; SFA, school food authority.
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nutrient contributions to the total diet. Although most vegetables are considered nutrient-dense, many of them provide different nutrients in different proportions and are less energy-dense. Vegetables are the major sources of dietary fiber, magnesium, potassium, and vitamins A and C. As such, in this study, these nutrients are considered in calculating nutrient density, cost of vegetables, and cost of vegetables wasted.

The objectives of this study were 2-fold: *1*) to assess the nutrient content and nutrient density of different vegetables served during school lunches; and *2*) to examine the costs of nutrients offered and wasted before and after the implementation of the new school meal nutrition standards. Data were collected from 3 elementary schools (kindergarten through fifth grade) in 2 phases: phase 1 (April 2012 and May 2012) before the changes in standards; and phase 2 (October 2012 and November 2012) after the changes in standards. The menus for phase 2 were compliant with the new 2012 nutrition standards for school meals.

Methods

Participants. This study was conducted in 3 elementary schools in one independent school district in central Texas participating in the USDA's NSLP. The socioeconomic status of the schools differed in the percentage of students eligible to receive free, reduced-price, and paid lunches. Study participants were kindergarten through fifth grade students who selected at least one vegetable as part of the NSLP. The research did not involve personal identifiers of the participants and was approved as exempt from committee review by the Texas A&M University Institutional Review Board. In consultation with school food service directors, the researchers were permitted access to the schools for the purpose of data collection.

Data collection and plate waste measurement. As has been reported in the literature (4), accurate measurement of school children's food consumption is challenging. Direct observations of plate waste are considered preferable to self-reporting. The most precise method for assessment of plate waste is measuring the pre- and postconsumption weight of a participant's food (5).

We followed a modification of the aggregate plate waste method of Chu et al. (6). A total of 30 d of plate waste during lunchtime meals was collected. Phase 1 comprised 10 d in April and May 2012, whereas phase 2 involved 20 d in October and November 2012. Altogether, aggregate plate waste data from 8430 students—corresponding to 4145 students before implementation and 4285 students after implementation of new school meal standards—were collected by grade and school for each vegetable served during the data collection days. As a result, a total of 144 observations of vegetable plate waste by grade and school (11 distinct vegetables) were collected before the changes in school meal standards, and a total of 305 observations of vegetable plate waste by grade and school (22 distinct vegetables) were collected after the changes in school meal standards.

The independent school district provided district cost per menu item and serving, nutrient content of food items per serving, meal counts (free, reduced, and full price), meals served on the day of the plate waste collection, school demographic profiles, and the lunch menu calendar. Data were collected for each school, grade, gender of students, and type of vegetable, as well as the number of students consuming each vegetable and the vegetable preweight.

For each data collection day, 5–10 servings of each sampled vegetable on test trays were obtained. The test trays were used to measure preweights for each food item in grams. Plate waste for each vegetable at each lunch period was scraped into a dedicated trash container lined with a plastic bag. Weight of the aggregated waste per vegetable and per grade at each of the 3 schools was recorded and divided by the number of children that selected the item in order to obtain plate waste per student. Plate waste was calculated with the use of the following formula:

$$\%\ \text{plate waste per student} = \frac{\text{plate waste per student(g)}}{\text{preweight of vegetable served (g)}} \times 100 \qquad (1)$$

Vegetable consumption (in grams) can be interpreted as the inverse of plate waste as follows:

$$\text{weight of vegetable consumed (g)} = [\text{preweight of vegetable served (g)}] - [\text{weight of vegetable waste (g)}] \qquad (2)$$

Nutrient density. Ranking and classifying foods based on their nutrient composition is known as nutrient profiling (7). We calculated the nutrient density and cost of nutrients provided for 11 vegetables that were offered in school lunches before the changes in standards and 22 vegetables offered after the changes in standards. The respective vegetables were grouped into vegetable subgroups as follows: *1*) dark green, *2*), red/orange, *3*) beans and peas, *4*), starchy vegetables including white potatoes, *5*) other vegetables (green beans and whole dill pickle), and *6*) additional vegetables, which contain more than 1 vegetable subgroup as defined by the 2010 Dietary Guidelines for Americans. In addition, we separated white potatoes from starchy vegetables and regrouped all the vegetables as follows: *1*) white potatoes, *2*) other starchy, and *3*) nonstarchy. We then looked closely into white potato products, because these products usually are popular among children.

For 5 nutrients of interest (dietary fiber, potassium, magnesium, and vitamins A and C) the percentage daily values (DVs) per 100 g of vegetable was calculated. The energy density was calculated as the amount of energy per 100 g of vegetable (kilocalories per 100 g). The nutrient adequacy score (8) was then calculated by taking the mean of percentage daily value of these 5 nutrients as follows:

$$\text{nutrient adequacy score} = \frac{\sum_{i=1}^{5}\left(\frac{\text{nutrient}_i}{\text{DV}_i}\right) \times 100}{5} \qquad (3)$$

Dividing the nutrient adequacy score by the energy density of the food yielded a measure of nutrient density score (8) as follows:

$$\text{nutrient density score} = \frac{\text{nutrient adequacy score}}{\text{energy density}} \times 100 \qquad (4)$$

Nutrient adequacy scores were calculated based on a standard weight (100 g) of food, and nutrient density scores were based on 100 g of food. Nutrient density per dollar was calculated by dividing the nutrient adequacy score by cost per 100 g of vegetables. This value is commonly referred to as the affordable nutrient index, and it is designed to identify foods with the most affordable nutritional value (9, 10).

Cost of nutrients and cost of wasted nutrients. With the use of the information on nutrient content of vegetables and cost of nutrient per serving of vegetable provided by the school district, cost in dollars per 100 g and cost in dollars per serving of vegetables were calculated. Energy cost was calculated as the cost in dollars of 100 kcal provided by each vegetable.

Nutrition standards for foods require that all food items sold in schools must contain 10% DV (11) of one of the nutrients of public health concern in the 2010 Dietary Guidelines for Americans (calcium, potassium, vitamin D, and dietary fiber) (3). A food that provides 10% or more of the DV for a nutrient is considered a good source of that nutrient (12). Therefore, we calculated the cost of each nutrient per 10% DV and, using the percentage of plate waste from each vegetable, we calculated the wasted cost per 10% DV.

Statistical analysis. Data were analyzed with the use of the statistical software package SAS 9.4 (13). Values are means ± SDs. Differences in means of vegetable plate waste, nutrients, and costs were assessed before and after the changes in school meal standards. The Welch F test was used to test equality of means, which accounts for unequal variances (14). The level of statistical significance chosen was set at $P < 0.05$, typically the standard for statistical analyses.

Results

Total enrollment, percentage of students eligible for free/reduced–price meals, number of meals served and sampled during the data collection days, and race/ethnicity of students are reported in **Table 1**. The demographic characteristics of the schools in our sample varied considerably. The percentage of students eligible to receive free/reduced–price lunches varied from 31% to 99%, and the percentage of students who were white varied from 3% to 69%, whereas the percentage of students who were Hispanic varied from 20% to 77%. School A had the highest percentage of students eligible for free/reduced–price lunches compared with schools B and C, which had a moderate and low percentage eligible for free/reduced–price lunches, respectively. In 2012, 66% of children in the Texas public school system received free/reduced–price lunches, up from 54% in 2002 (15). The mean percentage eligible for free/reduced–price lunches across the 3 schools in our sample was 66%, nearly 2 out of every 3 children.

Information on mean energy density, cost per 100 g, cost per serving, and cost per 100 kcal, as well as the nutrient density score and nutrient density per dollar for different vegetable subgroups before and after the changes in school nutrition standards are provided in **Table 2**. The higher the nutrient density score, the better, because this score measures the mean % DV per 100 kcal of vegetable. All the costs, energy density, nutrient density scores, and nutrient density per dollar differed across vegetable subgroups. The number of observations reported in Table 2 is the number of observations of vegetable plate waste by grade and school.

Energy density for red/orange vegetables was one of the lowest compared with other subgroups, but cost per 100 kcal was the highest compared with other vegetables. Nutrient density for red/orange vegetables was the highest compared with other vegetable subgroups; after accounting for costs, this group provided the most nutrients per dollar, followed by dark green vegetables. The "other vegetables" subgroup was the least energy-dense and had the least nutrient density per dollar compared with other vegetable subgroups. However, the "other vegetables" subgroup cost the most per 100 g, per serving, and per 100 kcal compared with the vegetable subgroups considered.

Starchy vegetables, including white potatoes, had the highest energy density among the vegetable subgroups both before (120 kcal/100 g) and after (109 kcal/100 g) the changes in school meal standards. After regrouping the vegetables and separating white potatoes from starchy vegetables, white potatoes were identified as the main contributor to energy density in the starchy vegetable category, both before and after the changes. Further disaggregation showed that among white potato products, tater tots had the highest energy density (174 kcal/100 g) in both periods. White potatoes as a subgroup had the highest energy density and the lowest cost per 100 g, cost per serving, and cost per 100 kcal compared with the "other starchy" and "nonstarchy" vegetable subgroups. Although the nutrient density score for white potatoes was the lowest among the vegetable subgroups, the nutrient density per dollar for white potatoes was one of the highest after red/orange and dark green vegetables. Among the 4 white potato products, mashed potatoes had the least energy density and cost and provided the most nutrients per dollar, whereas tater tots had the highest energy density and lowest nutrient density per dollar.

Mean cost for 5 nutrients (dietary fiber, potassium, magnesium, and vitamins A and C) per 10% DV from vegetables served during school lunches before and after implementation of the new nutrition standards are shown in **Table 3**. The mean cost for dietary fiber, potassium, and magnesium was the lowest for beans and peas ($0.07 for dietary fiber, $0.16 for potassium, and $0.07 for magnesium) among the vegetable subgroups. With respect to vitamin A, red/orange vegetables had the lowest cost ($0.01) per 10% DV, followed by dark green vegetables ($0.05). For vitamin C, dark green vegetables ($0.02) and white potatoes ($0.16) had the lowest cost per 10% DV among the subgroups. When white potatoes were separated from starchy vegetables, the mean cost of dietary fiber ($0.22 before and $0.24 after), potassium ($0.15 before and $0.19 after), and magnesium ($0.15 both before and after) for white potatoes was one of the lowest compared with "other starchy" and "nonstarchy" vegetables, and second lowest after beans and peas compared with vegetables in the NSLP vegetable subgroups.

TABLE 1 Total student enrollment, percentage of students receiving free/reduced–price meals, percentage of lunches served and sampled, and race/ethnicity of students before and after the changes in standards

	Total students		Lunches served			Race/ethnicity			
	n	% Free/reduced	*n*	% Free/reduced	Lunches sampled, %	Black, %	Hispanic, %	White, %	Other, %
Before									
School A	666	95.8	598	97.8	56.9	20.6	76.6	2.5	0.3
School B	585	69.1	487	79.3	63.0	33.2	36.0	28.1	2.7
School C	519	33.0	309	44.7	67.3	9.7	20.1	68.5	1.7
After									
School A	677	98.7	609	98.5	33.7	19.5	76.3	3.6	0.6
School B	601	73.9	437	83.8	51.0	37.2	32.5	27.7	2.6
School C	516	31.4	302	45.0	56.3	8.7	20.9	68.2	2.2

TABLE 2 Energy and nutrient densities and costs of vegetables by school lunch vegetable subgroups before and after the changes in standards[1]

	n		Energy density, kcal/100 g		Cost, $/100 g		Cost, $/serving		Cost, $/100 kcal		Nutrient density score, % DV/100 kcal		Nutrient density per dollar	
	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After
NSLP vegetable subgroups														
Dark green vegetables[2]	7	44	35[a] ± 0.0	83[b] ± 57.1	0.18[a] ± 0.0	0.3[b] ± 0.12	0.14 ± 0.0	0.17 ± 0.05	0.52[a] ± 0.0	0.49[b] ± 0.3	99 ± 0.0	77 ± 58.2	188 ± 0.0	143 ± 71.0
Red/orange vegetables[3]	20	57	25 ± 0.0	43 ± 41.4	0.15 ± 0.0	0.14 ± 0.06	0.11 ± 0.0	0.11 ± 0.04	0.59[a] ± 0.01	0.49[b] ± 0.2	117[a] ± 0.1	111[b] ± 11.0	198 ± 0.11	413 ± 328
Beans and peas[4]	5	35	92 ± 0.0	92 ± 6.04	0.13[a] ± 0.0	0.12[b] ± 0.01	0.17 ± 0.0	0.17 ± 0.02	0.14[a] ± 0.0	0.12[b] ± 0.01	12[a] ± 0.0	9.0[b] ± 1.96	83[a] ± 0.0	71[b] ± 8.50
Starchy vegetables[5]	91	106	120[a] ± 32	109[b] ± 32.1	0.18 ± 0.10	0.16 ± 0.06	0.13 ± 0.06	0.13 ± 0.04	0.17 ± 0.12	0.16 ± 0.09	9.0 ± 5.8	11 ± 6.02	87 ± 75.0	96 ± 86.1
Other vegetables[6]	21	40	17 ± 0.5	17 ± 0.62	0.22 ± 0.02	0.2 ± 0.05	0.17[a] ± 0.01	0.15[b] ± 0.04	1.31[a] ± 0.05	1.16[b] ± 0.3	22 ± 7.9	18 ± 9.21	17 ± 5.75	19 ± 16.7
Additional vegetables[7]	—	23	—	37 ± 2.63	—	0.27 ± 0.09	—	0.22 ± 0.07	—	0.73 ± 0.2	—	39 ± 0.08	—	47 ± 0.11
Vegetable subgroups[8]														
White potatoes	62	63	135 ± 28	127 ± 32.1	0.12 ± 0.04	0.12 ± 0.04	0.1 ± 0.02	0.1 ± 0.03	0.09 ± 0.01	0.09 ± 0.03	8.0 ± 6.5	11 ± 7.38	111 ± 105	133 ± 111
Potato wedges	11	12	141 ± 0.0	141 ± 0.01	0.14 ± 0.01	0.13 ± 0.01	0.12 ± 0.01	0.12 ± 0.01	0.1 ± 0.0	0.1 ± 0.0	4.7[a] ± 0.01	5.0[b] ± 0.01	50[a] ± 0.04	49[b] ± 0.06
French fries	22	11	143 ± 0.01	143 ± 0.01	0.14 ± 0.01	0.14 ± 0.01	0.1 ± 0.01	0.1 ± 0.01	0.1 ± 0.0	0.1 ± 0.0	5.2[a] ± 0.0	5.1[b] ± 0.02	52[a] ± 0.12	51[b] ± 0.16
Tater tots	12	12	174 ± 0.01	174 ± 0.01	0.14 ± 0.01	0.14 ± 0.01	0.12 ± 0.01	0.12 ± 0.01	0.08 ± 0.0	0.08 ± 0.0	3.0 ± 0.01	3.0 ± 0.01	34 ± 0.15	34 ± 0.08
Mashed potatoes	17	28	94 ± 0.01	94.0 ± 0.01	0.06[a] ± 0.01	0.09[b] ± 0.05	0.06[a] ± 0.01	0.09[b] ± 0.05	0.07[a] ± 0.0	0.09[b] ± 0.1	19 ± 0.01	19 ± 0.01	281[a] ± 0.21	243[b] ± 76.1
Other starchy	29	43	88 ± 6.5	92 ± 23.6	0.27[a] ± 0.09	0.16[b] ± 0.07	0.21[a] ± 0.02	0.16[b] ± 0.04	0.31[a] ± 0.1	0.18[b] ± 0.1	11 ± 3.3	17 ± 22.3	43[a] ± 24.5	205[b] ± 172
Nonstarchy	53	199	23[a] ± 6.2	42[b] ± 40.9	0.18[a] ± 0.04	0.22[b] ± 0.01	0.14 ± 0.03	0.15 ± 0.06	0.9[a] ± 0.4	0.73[b] ± 0.4	73 ± 45.8	71 ± 51.4	117 ± 89.0	119 ± 84.0

[1] Values are means ± SDs. *n* is the number of vegetables in the subgroup by grade and school. Labeled means for "before" and "after" in a row without a common letter are significantly different, $P < 0.05$. NSLP, National School Lunch Program.
[2] Steamed broccoli, steamed broccoli with cheese, raw broccoli florets, and garden salad (mostly raw spinach).
[3] Sweet potato fries, raw sweet potato sticks, veggie dippers (mostly raw baby carrots), and raw baby carrots and celery sticks.
[4] Baked beans, ranch-style beans, and pork and beans.
[5] Green peas, corn on the cob, whole-kernel corn, potato wedges, french fries, tater tots, and mashed potatoes with gravy.
[6] Green beans and whole dill pickle.
[7] Vegetables that contain more than one vegetable subgroup as defined by the 2010 Dietary Guidelines for Americans Sonoma vegetables (combination of sugar snap peas, carrots, yellow carrots, and broccoli) and mixed Normandy vegetables (combination of broccoli, cauliflower, and carrots).
[8] All vegetables were regrouped as white potato, other starchy, and nonstarchy.

TABLE 3 Mean cost of nutrients per 10% DV by school lunch vegetable subgroups before and after the changes in standards[1]

Vegetable subgroups	*n*		Cost of potassium, $/10% DV		Cost of dietary fiber, $/10% DV		Cost of magnesium, $/10% DV		Cost of vitamin A, $/10% DV		Cost of vitamin C, $/10% DV	
	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After
NSLP vegetable subgroups												
Dark green vegetables	7	44	0.57[a] ± 0.0	0.47[b] ± 0.1	0.14[a] ± 0.0	0.42[b] ± 0.22	0.34[a] ± 0.0	0.26[b] ± 0.06	0.05 ± 0.0	0.07 ± 0.11	0.02[a] ± 0.0	0.05[b] ± 0.05
Red/orange vegetables	20	57	0.30 ± 0.01	0.27 ± 0.9	0.21 ± 0.01	0.22 ± 0.06	0.32[a] ± 0.01	0.50[b] ± 0.22	0.02 ± 0.0	0.02 ± 0.00	0.24 ± 0.0	0.24 ± 0.06
Beans and peas	5	35	0.16 ± 0.0	0.15 ± 0.0	0.07[a] ± 0.0	0.09[b] ± 0.01	0.07 ± 0.0	0.07 ± 0.01	0.17[a] ± 0.0	0.37[b] ± 0.21	—	2.69 ± 0.01
Starchy vegetables	91	106	0.32 ± 0.25	0.32 ± 0.2	0.2 ± 0.08	0.21 ± 0.09	0.18[a] ± 0.07	0.16[b] ± 0.05	0.27[a] ± 0.07	0.43[b] ± 0.21	0.28 ± 0.07	0.17 ± 0.15
Other vegetables	21	40	1.08[a] ± 0.09	0.86[b] ± 0.2	0.38[a] ± 0.01	0.31[b] ± 0.11	0.41 ± 0.02	0.41 ± 0.11	0.32[a] ± 0.0	0.26[b] ± 0.09	1.21[a] ± 0.01	1.01[b] ± 0.36
Additional vegetables	—	23	—	0.84 ± 0.0	—	0.32 ± 0.11	—	0.54 ± 0.54	—	0.05 ± 0.04	—	0.09 ± 0.03
Vegetable subgroups[2]												
White potatoes	62	63	0.15[a] ± 0.03	0.19[b] ± 0.1	0.22 ± 0.06	0.24 ± 0.10	0.15 ± 0.05	0.15 ± 0.05	0.33[a] ± 0.01	0.45[b] ± 0.25	0.16 ± 0.14	0.15 ± 0.19
Other starchy	29	43	0.62[a] ± 0.21	0.38[b] ± 0.2	0.23[a] ± 0.12	0.15[b] ± 0.08	0.28[a] ± 0.08	0.17[b] ± 0.08	0.18[a] ± 0.01	0.35[b] ± 0.22	0.28[a] ± 0.08	0.64[b] ± 0.27
Nonstarchy	53	199	0.57[a] ± 0.35	0.55[b] ± 0.3	0.26 ± 0.10	0.31 ± 0.16	0.34[a] ± 0.05	0.43[b] ± 0.17	0.14[a] ± 0.15	0.18[b] ± 0.09	0.24[a] ± 0.51	0.27[b] ± 0.16
All	144	305	0.43 ± 0.33	0.41 ± 0.3	0.23 ± 0.08	0.25 ± 0.14	0.24[a] ± 0.11	0.28[b] ± 0.04	0.19 ± 0.13	0.21 ± 0.12	0.31 ± 0.21	0.34 ± 0.18

[1] Values are means ± SDs. *n* is the number of vegetables in the subgroup by grade and school. Labeled means for "before" and "after" in a row without a common letter are significantly different, $P < 0.05$. NSLP, National School Lunch Program.
[2] All vegetables were regrouped as white potato, other starchy, and non-starchy.

Percentage plate waste for vegetables and mean wasted cost per 10% DV for the 5 nutrients of interest are shown in **Table 4**. After the changes in school meal standards, greater mean vegetable plate waste was evident relative to the period before the changes. Specifically, mean percentage plate waste increased significantly from 52% before to 58% after the changes in school meal standards.

Plate waste for dark green vegetables was one of the lowest (44% before and 55% after) and plate waste for starchy vegetables, including white potatoes, was one of the highest (71% before and 72% after), followed by beans and peas (71% before and 54% after) and red/orange (57% before and 62% after) vegetables. When white potatoes were separated from starchy vegetables, plate waste for white potatoes was the lowest, both before (42%) and after (43%) the changes in standards, among the respective vegetable subgroups. Furthermore, plate waste for white potatoes varied by product type with tater tots having the lowest percentage plate waste (27% before and 17% after) compared with other potato products (this result is not provided in the table). Except for plate waste for beans and peas, plate waste for vegetables in other subgroups increased from before to after, but the increase was not significant.

Wasted cost per 10% DV for vitamin A was the lowest for red/orange ($0.01 before and after) followed by dark green vegetables ($0.02 before and $0.04 after); however, red/orange vegetables were one of the top 3 most wasted vegetables in terms of cost per 10% DV among the vegetables considered. For vitamin C, dark green vegetables ($0.01 before and $0.03 after) and white potatoes ($0.06 before and $0.04 after) had the lowest wasted cost per 10% DV compared with other vegetables, and these vegetables were wasted the least. For potassium, white potatoes ($0.06 before and $0.08 after) had the lowest wasted cost, followed by beans and peas ($0.11 before and $0.08 after); however, white potatoes were wasted the least and beans and peas were one of the most wasted vegetables among vegetables considered in the analysis. With respect to dietary fiber, beans and peas ($0.05 both before and after) had the lowest wasted dollars per 10% DV, followed by white potatoes ($0.09 before and $0.11 after).

Discussion and Conclusions

In recent years, schools have been criticized for providing access to energy-dense and nutrient-poor foods through vending machines or serving á la carte alternatives to school meals. Some low-nutrient and energy-dense items may also be available to children as part of a school meal. Frequent consumption of energy-dense items such as sugar-sweetened beverages and high-fat goods have been shown to be associated with obesity and overweight (16–19). In response to making school meals healthier and to align school meals with the Dietary Guidelines for Americans (3), the new school meal standards were implemented in the beginning of the 2012–2013 school year. The standards mandated schools to make substantial nutrition improvements in school meals by requiring increases in the amount and

TABLE 4 Mean percentage plate waste and mean wasted cost of nutrients per 10% DV before and after the changes in standards[1]

	n		Plate waste, %		Cost of potassium, $/10% DV		Cost of dietary fiber, $/10% DV		Cost of vitamin A, $/10% DV		Cost of vitamin C, $/10% DV		Cost of magnesium, $/10% DV	
Vegetable subgroups	**Before**	**After**	**Before**	**After**	**Before**	**After**	**Before**	**After**	**Before**	**After**	**Before**	**After**	**Before**	**After**
NSLP vegetable subgroups														
Dark green vegetables	7	44	44 ± 29	55 ± 20	0.25 ± 0.16	0.26 ± 0.11	0.06[a] ± 0.04	0.22[b] ± 0.14	0.02 ± 0.01	0.04 ± 0.03	0.01 ± 0.00	0.03 ± 0.03	0.15 ± 0.15	0.14 ± 0.06
Red/orange vegetables	20	57	57 ± 23	62 ± 17	0.17 ± 0.07	0.17 ± 0.08	0.12 ± 0.05	0.12 ± 0.05	0.01 ± 0.01	0.01 ± 0.00	0.14 ± 0.06	0.14 ± 0.06	0.18[a] ± 0.2	0.31[b] ± 0.2
Beans and peas	5	35	71 ± 12	54 ± 19	0.11[a] ± 0.02	0.08[b] ± 0.03	0.05 ± 0.01	0.05 ± 0.02	0.12 ± 0.02	0.23 ± 0.17	—	0.46 ± 0.40	0.05 ± 0.05	0.04 ± 0.01
Starch vegetables	91	106	71 ± 22	72 ± 24	0.2 ± 0.21	0.2 ± 0.18	0.12 ± 0.08	0.12 ± 0.07	0.16[a] ± 0.04	0.27[b] ± 0.14	0.09 ± 0.08	0.08 ± 0.07	0.1[a] ± 0.10	0.09[b] ± 0.05
Other vegetables	21	40	50 ± 24	56 ± 21	0.5 ± 0.23	0.5 ± 0.26	0.18 ± 0.08	0.21 ± 0.10	0.15 ± 0.07	0.18 ± 0.08	0.57 ± 0.07	0.67 ± 0.30	0.22 ± 0.22	0.22 ± 0.10
Additional vegetables	—	23	—	75 ± 14	—	0.66 ± 0.15	—	0.25 ± 0.09	—	0.04 ± 0.04	—	0.05 ± 0.03	—	0.42 ± 0.10
Vegetable subgroups[2]														
White potatoes	62	63	42 ± 19	43 ± 21	0.06[a] ± 0.03	0.08[b] ± 0.06	0.09 ± 0.06	0.11 ± 0.07	0.17[a] ± 0.04	0.24[b] ± 0.13	0.06[a] ± 0.06	0.04[b] ± 0.04	0.06 ± 0.03	0.05 ± 0.03
Other starchy	29	43	71 ± 13	64 ± 20	0.43[a] ± 0.17	0.22[b] ± 0.18	0.16[a] ± 0.09	0.09[b] ± 0.07	0.12[a] ± 0.03	0.24[b] ± 0.18	0.16[a] ± 0.07	0.44[b] ± 0.37	0.17[a] ± 0.06	0.09[b] ± 0.07
Nonstarchy	53	199	52[a] ± 24	60[b] ± 19	0.33 ± 0.23	0.32 ± 0.22	0.13[a] ± 0.07	0.19[b] ± 0.11	0.06 ± 0.08	0.05 ± 0.07	0.27[a] ± 0.28	0.18[b] ± 0.15	0.19[a] ± 0.09	0.25[b] ± 0.14
All	144	305	52[a] ± 23	58[b] ± 21	0.24 ± 0.22	0.24 ± 0.20	0.12[a] ± 0.08	0.14[b] ± 0.08	0.1 ± 0.08	0.13 ± 0.08	0.15 ± 0.10	0.21 ± 0.10	0.13[a] ± 0.08	0.16[b] ± 0.12

[1] Values are means ± SDs. *n* is the number of vegetables in the subgroup by grade and school. Labeled means for "before" and "after" in a row without a common letter are significantly different, $P < 0.05$. NSLP, National School Lunch Program.
[2] All vegetables were regrouped as white potato, other starchy, and nonstarchy.

variety of fruits and vegetables served, limiting calories, and reducing saturated fat and sodium, as well as improving the overall quality of foods sold at school, including competitive foods.

The findings of this research show that elementary school students did not consume the majority of vegetables offered by school lunches. Plate waste for vegetables was over 50% both before and after the changes in school meal standards. As a result, NSLP participants did not consume nutrients provided from vegetables served during the school lunches. Making school lunches healthier and offering more variety of vegetables can only be effective if children consume what is served. Because the extant literature shows that children eat fewer than the recommended servings of vegetables, packed lunches are of lower nutritional quality than school lunches (20). Given that, on an average school day, school lunch participants consume more fruits and vegetables at school than do nonparticipants (21), encouraging students to participate in the NSLP and educating students to eat nutrient-dense foods is important for healthy growth and development and for good dietary habit formation.

Several studies measured plate waste under the previous NSLP standards across different age groups, regions, and specific meal components (22–28). The percentage of plate waste for vegetables reported in those studies ranged from 34% to 75%. The percentage of plate waste for vegetables reported in studies after the changes in NSLP standards (22, 26–28) ranged from 36% to 59%. The percentage of plate waste for vegetables for our study falls within the ranges both before and after the changes in regulation. The key finding of this study and findings from the existing literature suggest that high amounts of plate waste was a problem both before and after the implementation of the new standards.

Providing nutrient-dense foods such as fruits and vegetables that are affordable and at the same time appealing to elementary school students can be a challenge. It is evident that not all vegetables in school lunches are accepted and consumed by the students (22–28). SFAs would benefit from knowing which vegetables are more accepted by students and at the same time provide the most nutrients per dollar. In the current study, costs of vegetables and nutrients, nutrient density of vegetables, and nutrient density per dollar were calculated and the most affordable vegetables and nutrients were identified. Red/orange and dark green vegetables were the most nutrient dense vegetables and the cheapest sources of vitamins A and C, but red/orange vegetables were wasted more than were dark green vegetables. Red/orange and dark green vegetables, as well as white potatoes and beans/peas, provided the most nutrients per dollar among the vegetables considered. Beans/peas and white potatoes were the cheapest sources of potassium; however, beans and peas were one of the most wasted and white potatoes were the least wasted vegetables. Starchy vegetables were one of the most wasted vegetables, and when white potatoes were separated from starchy vegetables, other starchy vegetables remained the most wasted, whereas white potatoes were least wasted.

Significant differences in energy and nutrient density, costs, and nutrient density per dollar were observed for some of the vegetables for the period before compared with the period after the changes in standards. These observed differences may have been caused by the increase in the number and variety of vegetables served after the changes in standards compared with before.

Different food groups have different nutrient contributions to the overall diet of individuals (7–10). As a group, vegetables are referred to as nutrient-dense or nutrient-rich foods. They provide many vitamins and minerals to the diet of individuals that may have positive health effects, with relatively few calories. In general, we found that vegetables with a lower energy density had a tendency to have a higher nutrient density and provide more nutrients per cost. However, because of their low energy density, these vegetable subgroups have a higher energy cost. Costs calculated on a per-100-kcal basis make some of the nutrient-dense vegetables seem much more expensive when compared with costs per 100 g or costs per serving. Given that many vegetables are less energy dense, measuring vegetable costs per 100 g and per serving by accounting for the nutrient density is perhaps a better way to help manage the cost of vegetables and nutrients in school lunches.

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