Using Herbs and Spices to Increase Vegetable Intake Among Rural Adolescents

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ABSTRACT

Objective: To test whether adding herbs and spices to school lunch vegetables increases selection and intake compared with lightly salted control versions among rural adolescents.

Design: This study compared intake of vegetables with herbs and spices with lightly salted controls (phase I) and tested whether 5 repeated exposures would increase students' intake of herb and spice seasoned vegetables (phase II).

Participants and Setting: A total of 600–700 students at a rural middle/high school (age 11–18 years).

Intervention: In phase I, herbs and spices were added to 8 vegetables and outcomes were compared with 8 control recipes. In phase II, the impact of repeated exposure to herb and spice blends served on different vegetables was assessed.

Main Outcomes: Vegetable selection rates, weighed intake, and willingness to eat again.

Analysis: Two-way ANOVAs tested effects of condition (herbs and spices vs control; before vs after exposure) and age (middle vs high school) on selection and intake.

Results: In phase I, students ate more control than seasoned broccoli ($P = .01$), cauliflower ($P = .006$), and green beans ($P = .01$), and high schoolers generally consumed more seasoned vegetables than did middle schoolers ($P < .03$). In phase II, repeated exposure to herbs and spices increased reported willingness to eat again for seasoned broccoli ($P = .003$).

Conclusions and Implications: In a short-term intervention, herbs and spices did not produce robust increases in school lunch vegetable intake among rural adolescents, but limited repeat exposure may increase students' willingness to consume these flavors. Additional work is needed to identify individual and school-level characteristics that affect students' willingness to select and consume vegetables with herbs and spices.

Key Words: adolescents, herbs, school, spices, vegetables (*J Nutr Educ Behav.* 2019; 51:806–816.)

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INTRODUCTION

The *National School Lunch Program* (NSLP) serves 30 million children each year and provides 33% of a child's daily energy needs.¹ Thus, it has a major role in the dietary health of American youths and is an

important target for interventions. After implementation of the Healthy Hunger Free Kids Act of 2010,² schools across the US updated their programs to offer larger vegetable portion sizes and greater vegetable variety.³ Whereas some schools found an increase in vegetable intake

since the new regulations^{4,5} others saw no change.⁶ Because of the mixed outcomes resulting from the new federal regulations, innovative strategies are needed to facilitate widespread change in vegetable intake.

One potential means to improve vegetable intake may be through the use of herbs and spices. Herbs and spices can enhance the flavor of a food without adding excess sugar, fat, or sodium. They are also shelf-stable, which makes them promising for sustainable use within school lunch programs.⁷ They can increase acceptability of reduced-fat foods⁸ and low-sodium soups.^{9,10} In addition, they can increase vegetable selection among adults in cafeteria settings.¹¹ These findings in adults suggest that the use of herbs and spices on vegetables served in schools may be a promising

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approach to increase student vegetable consumption.

Vegetables are vital to the diet because they are high in nutrients and low in calories, and their intake contributes to a reduction in chronic disease risk.¹² Even so, only 2.1% of American youths are meeting daily vegetable recommendations.¹³ Vegetables remain 1 of the least liked food groups among children,¹⁴ often owing to deterrents including bitterness, lack of sweetness, and unappealing texture and appearance.^{15–20} To improve vegetable intake at schools, researchers evaluated the effects of gardening programs,²¹ increased vegetable portion sizes,²² and repeated exposure.²³ In addition, 1 study²⁴ in preschool-age children found a benefit to using herb-seasoned dips to increase raw vegetable intake. Although these programs showed some benefit for improving vegetable intake, current efforts are insufficient to meet federally mandated goals and there is a need to conduct additional studies with herbs and spices in older children.^{25,26}

The current study tested the impact of adding herbs and spices to vegetables served in the NSLP as a strategy to increase intake in rural adolescents with minimal prior familiarity with seasoning.²⁷ Rural adolescents were targeted because they have higher rates of obesity compared with urban counterparts,²⁸ which highlights the need to develop novel strategies to improve dietary intake patterns in this population. When recipes were pilot-tested, high school students liked and preferred vegetables with added herbs and spices over those prepared with minimal salt and oil alone (ie, without herbs and spices).²⁷ Because of these promising results, a cafeteria-based intervention was implemented to determine whether adding these recipes to the school lunch line would increase vegetable intake.

METHODS

Study Design

The study consisted of 2 phases: (I) a cafeteria intervention in which vegetables with added herbs and spices and lightly salted (control) vegetables were offered on the school lunch

line and intake was measured (March to May, 2017), and (II) a follow-up phase to determine whether repeated exposure to specific blends of herbs and spices would increase student vegetable consumption across a semester (October to December, 2017). Before phase I, the researchers assessed school lunch vegetables for baseline selection, intake, and ratings of willingness to eat again to gauge usual intake before the intervention. During phase I, an intervention was conducted to compare students' selection, intake, and reported willingness to eat again of 8 lightly salted control vegetables and 8 vegetables with added herb and spice blends (2 sessions/recipe for 32 total sessions). The order in which students were presented with each vegetable condition (ie, control vs herb and spice) was randomized. For phase II, the impact of repeated exposure on selection, intake, and willingness to eat again was measured for 2 seasoned vegetable recipes (Dillicious Broccoli and Fiesta Black Beans and Corn). Two trials of preexposure measurements and 2 of postexposure measurements were conducted; in between measurement periods, students received 5 exposures to the specific blends of herbs and spices used in these recipes (ie, Dillicious Broccoli, which contained dill weed, garlic powder, onion powder, and black pepper; and Fiesta Black Beans and Corn, which contained cumin, dried oregano, cayenne, garlic powder, and onion powder). The study received approval from the Institutional Review Board of Pennsylvania State University. Written consent from students was not required. Parents were sent an informational letter about the study and passively consented to their child's participation.

Participants

This study was conducted at a combined middle and high school within a rural Pennsylvania school district composed of about 97% Caucasian students.²⁹ Approximately 75% of students participated in the school lunch program and 44% received free or reduced-price lunches because they were at $\leq 185\%$ of the federal poverty line.³⁰ Between 600 and 700

students aged 11–18 years were served lunch in the cafeteria daily from 10:30 to 1 PM; these numbers remained consistent throughout all phases of the study. The first and third lunch periods contained only high school students (ie, aged 14–18 years) and the second lunch contained primarily middle school students (ie, aged 11–14 years).

Baseline Data Collection

To collect data on the consumption of vegetables typically served within the cafeteria before the intervention, the researchers measured the intake at baseline of steamed broccoli, California blend (broccoli, cauliflower, and carrots), corn, cheesy cauliflower, baked beans, and assorted raw vegetables served with Ranch dressing. All vegetables were served in 8-oz square black plastic cups. Methods to measure intake were developed based on previous plate waste studies⁵ in cafeterias in which subset of approximately 30 vegetable cups were preweighed and all returned cups were weighed again. Production records at the school included data on the total pounds of vegetables prepared and the amount left at the end of the day; however, they did not include the number of servings prepared and sold during each lunch period. To confirm that the weights collected by the research team were accurate, they were compared with the total amount sold according to production records at the end of each testing day. Researchers made periodic announcements requesting that students return vegetable cups at the end of lunch to a tray rack that had been divided into sections marked with signs stating Would Eat Again or Would Not Eat Again (Figure 1). This provided the measure of willingness to eat again that enabled students to report quickly whether they would eat the vegetable again, through the placement of the returned cup. Incorporating this novel measure into the baseline phase also allowed an opportunity to pilot test the procedure to ensure student comprehension. During the lunch period, members of the research team were strategically placed by the tray racks

Figure 1. Students reported willingness to eat again by placing trays in the correct place on a designated tray rack. The picture of this tray rack shows the placement of laminated signs with clearly marked wording and facial hedonic descriptors to help students quickly place their tray in the correct spot.

and wastebaskets to remind students to place their vegetable cups on the racks and save any vegetables that were accidentally discarded, and to record observations to assess student compliance. After each lunch period, post-weights were collected for all vegetable cups that were returned. Vegetable selection was determined by adding the number of cups returned to the number that research staff observed students to throw away. Daily selection rates were calculated by dividing the sum of the number of cups returned and seen accidentally thrown away by the total number of vegetable cups sold.

Phase I: Intervention

Ingredients and recipes used in the intervention were informed by a previous study²⁷ conducted in the same school and are detailed in the [Supplementary Table](#). For each vegetable, the control and herb and spice recipes were matched for oil and salt content; all fit within the NSLP guidelines. The addition of a modest amount of salt and oil was essential to enhance the perceived flavor of

the herbs and spices and increase their adherence to the target vegetable. To increase the likelihood that schools would continue to use the recipes after the intervention, the vegetables that were chosen were canned (ie, black beans) or frozen (ie, broccoli, carrots, cauliflower, green beans, and corn and peas), with the exception of fresh vegetable combinations served with dips. Before the start of the intervention, the industry partner who developed the recipes conducted a half-day training session with cafeteria staff to demonstrate how to prepare all recipes and allow staff to taste the prepared vegetables. In addition, a detailed illustrated recipe manual was created for the school to help cafeteria staff prepare the recipes after the intervention.

Before each testing day, blends of herbs and spices and the fresh dips were prepared in the laboratory and transported to the school before lunch so that the vegetables could be mixed with spice blends and portioned by research staff in the cafeteria. During the intervention phase, all vegetables were served on the cafeteria line in 8-oz circular clear plastic cups. Although the usual serving size for vegetables at the school was 0.5 cup, to avoid ceiling effects, the serving size was increased to 1 cup for the target vegetables served during the intervention. After portioning and pre-weighing, vegetable servings were covered and placed into holding cabinets until service. To ensure that students knew what the vegetables were, labels for each vegetable type (ie, new plain [vegetable name] or new seasoned [vegetable name]) were added to the serving line. On the lunch line, students were typically provided 2–3 fruit options (eg, canned fruits, fresh fruits, and 100% fruit juices daily) and 2–3 vegetable options (eg, fresh vegetables, steamed vegetable and/or potato product) with the intervention vegetable as 1 of these choices. Vegetable selection, intake, and willingness to eat again were assessed as previously described.

Phase II: Follow-Up Assessment

The follow-up study tested the influence of repeated exposure to 2 recipes, *Dillicious Broccoli* and *Fiesta Black Beans and Corn*, on students'

acceptance and intake across a school semester. These recipes were selected by working with the school foodservice director and cafeteria staff, who helped the researchers identify vegetables they were most interested in integrating into the regular menu. Vegetables were prepared, measured, and served using the methods similar to those in the intervention phase, except 8-oz square black plastic containers were used to present vegetables, to improve visual appeal. Baseline intake, selection, and willingness to eat again were measured for each recipe twice during October, 2017 (preexposure) and twice in December, 2017 (postexposure). Between collection dates, 2 blends of herbs and spices were served 5 times on a variety of vegetables over 2 months. In this phase, the 2 herb and spice blends were served with a greater variety of vegetables to prevent the target vegetables from becoming monotonous and to allow cafeteria staff greater autonomy in how they complied with federal regulations. The ultimate goal of these studies was to develop sustainable recipes that might be continued after the intervention, so staff members were encouraged to prepare the vegetables themselves in phase II (ie, effectiveness vs efficacy), although researchers were on-site to check compliance.

Analysis

For all studies, weights were excluded from analysis if cheese, dressings, or sauces were added to the vegetable cups. Weights were also excluded if vegetables were taken out of the cups by students and/or thrown away. These exclusions accounted for no more than 9 weights removed during an individual testing day. Baseline intake and selection rates were summarized with descriptive statistics. The effect of age group on the willingness to eat again was analyzed using a chi-square goodness of fit test.

To assess the effect of the intervention on vegetable selection and intake, data were averaged across the 2 trial days for each vegetable recipe (control or herb or spice). A 2-way ANOVA was then conducted for each vegetable with either selection or intake as the dependent variables and condition (phase I: control or herb

and spice; and phase II: baseline or follow-up) and age group (middle or high school) as factors. Fisher's least significant difference (LSD) analyses were conducted for planned comparisons when appropriate. Because the spice blends used on each vegetable were different, each was treated as an independent hypothesis; thus, no Bonferroni adjustment was performed.

To determine the effect of the intervention on students' willingness to eat the vegetable again, Mantel–Haenszel tests were performed with *would eat again* (yes or no) as the outcome variable, condition (phase I: control or herb and spice; or phase II: baseline or follow-up) as the predictor variable, and age group (middle or high school) as the layered variable.

All statistical analyses were conducted using SPSS Statistics software (version 23, IBM Corporation, Armonk, NY, 2009); $P < .05$ denotes significant differences.

RESULTS

Baseline Selection, Willingness to Eat Again, and Intake

Of the 625–660 students served daily during the baseline measurement period, 6.6% to 17.6% chose the measured vegetable. Of those students,

approximately 1.3% to 8.1% were in middle school (aged 11–14 years) and 5.3% to 10.4% were in high school (aged 14–18 years), depending on the vegetable. The lowest proportion of students chose the California blend (6.6% total from both age groups), whereas the corn (17.6%), cheesy cauliflower (16.7%), and fresh vegetables with Ranch dressing (14.8%) were more frequently selected.

Vegetables consumed in greatest quantities were the cheesy cauliflower (176.5 ± 62.8 g), baked beans (164.5 ± 86.6 g), and fresh vegetables with dip (140.9 ± 48.7 g). During cup return, a higher percentage of high school compared with middle school students chose *would eat again* for 2 vegetables: baked beans (91.8% vs 75.7%, $\chi^2 [1, n = 86] = 4.3$; $P = 0.04$) and fresh vegetables served with Ranch dressing (98.2% vs 91.0%, $\chi^2 (1, n = 179) = 5.0$; $P = .03$). Other vegetables did not show an age effect during the baseline period.

Intervention Selection, Willingness to Eat Again, and Intake

Table 1 lists results for intervention selection and willingness to eat again. Because high schoolers consumed more vegetables than did

middle schoolers at baseline, all analyses during the intervention were performed with age group (middle or high school) as a between-subjects covariate. There was a significant main effect for age group ($F_{1,60} = 40.7$, $P < .001$) on target vegetable selection but no effect of condition (control or herb and spice) ($P > .05$) or condition $\times$ age interaction ($P > .05$). *Post hoc* tests found that selection rates were greater for high school compared with middle school students regardless of seasoning condition ($P < .001$).

Mantel–Haenszel tests showed significant differences in students' willingness to eat again for all vegetables except for black beans and corn and fresh vegetables with dip (Table 2).

Intervention Intake of Vegetables With Significant Condition by Age Interactions

Table 2 provides intake results for vegetables with significant condition (plain vs seasoned) $\times$ age interactions; visual representations are shown in Figure 2A. For black beans and corn, there was a main effect of age ($F_{1,97} = 10.4$, $P = .002$) and a condition $\times$ age interaction ($F_{1,97} = 4.8$, $P = .03$) but no main effect

Table 1. Intervention Selection Rates and Willingness to Eat Again percentages Divided by Age Group for Vegetable Conditions (ie, Lightly Salted Control and Added Herbs and Spice)

Vegetable	Middle School Selection (%)		High School Selection (%)		Middle School Would Eat Again (%)		High School Would Eat Again (%)		Mantel–Haenszel (2-Sided) P
	Plain	Seasoned	Plain	Seasoned	Plain	Seasoned	Plain	Seasoned	
Broccoli	4.2	3.6	9.4	8.5	98.1	78.3	94.9	82.9	< .001
Cauliflower	3.2	3.6	4.8	5.5	94.9	68.9	93.4	82.1	.001
Carrots	2.3	3.1	4.4	5.9	93.1	82.9	93.0	77.9	.01
Black beans and corn	1.1	1.0	3.6	2.6	91.7	69.2	71.7	73.5	.81
Green beans	4.2	3.8	7.2	7.3	95.8	89.4	97.6	88.4	.02
Corn and peas	4.0	4.7	6.1	5.8	96.1	76.3	93.6	84.5	.002
Fresh vegetable variety 1 with dip	3.8	5.5	9.5	9.6	82.6	78.8	82.5	84.5	.92
Fresh vegetable variety 2 with dip	4.2	4.6	9.9	9.2	82.7	67.2	77.5	81.2	.69

Notes: An average is provided of 2 trials conducted for each lightly salted vegetable and each herb and spice-seasoned vegetable. A total of 569–670 students bought a lunch on intervention data collection days. Two-sided Mantel–Haenszel tests were used to compare *willingness to eat again* measures. When $P < .05$, a significant difference existed between the 2 age groups (middle and high school) for the relation between the condition (lightly salted and herb and spice–seasoned) and the *willingness to eat again* response (yes or no). For middle school, $n = 12$ –66 responses were collected, depending on the vegetable. For high school, $n = 34$ –120 responses were collected, depending on the vegetable.

Table 2. Vegetable Intake (Control Vs Herb and Spice Seasoned) Among Middle and High School Students (Mean $\pm$ SD)

Vegetable	Middle School Students		High School Students	
	Lightly Salted Control	Herb and Spice Seasoned	Lightly Salted Control	Herb and Spice Seasoned
<i>Vegetables with condition $\times$ age group interactions</i>				
Black beans and corn, g [*]	112.1 $\pm$ 57.9 ^{a,b}	71.5 $\pm$ 69.5 ^a	128.4 $\pm$ 66.9 ^{a,b}	156.5 $\pm$ 64.9 ^b
Corn and peas, g [†]	120.5 $\pm$ 62.9 ^a	95.1 $\pm$ 61.7 ^b	146.3 $\pm$ 41.6 ^{a,b}	129.7 $\pm$ 50.4 ^a
<i>Vegetables with main effects but not condition $\times$ age interactions</i>				
Carrots, g [‡]	97.6 $\pm$ 51.2	103.6 $\pm$ 54.1	105.6 $\pm$ 49.1	98.6 $\pm$ 55.8
Green beans, g [§]	96.9 $\pm$ 48.9	104.0 $\pm$ 43.2	109.0 $\pm$ 44.2 ^a	93.9 $\pm$ 45.5 ^b
Fresh vegetable with dip (cucumbers, cherry tomatoes, carrots), g	98.5 $\pm$ 57.3 ^a	118.2 $\pm$ 50.0 ^b	112.4 $\pm$ 4	111.0 $\pm$ 55.1
Fresh vegetable with dip (celery, cauliflower, cucumbers, cherry tomatoes), g [¶]	106.6 $\pm$ 60.5 ^a	121.3 $\pm$ 54.6 ^b	115.2 $\pm$ 53.9	118.2 $\pm$ 59.7
Broccoli, g [#]	110.6 $\pm$ 53.5 ^a	124.4 $\pm$ 46.7 ^b	126.2 $\pm$ 47.1 ^a	113.7 $\pm$ 50.7 ^b
Cauliflower, g ^{**}	106.9 $\pm$ 63.2 ^a	137.9 $\pm$ 47.0 ^b	136.5 $\pm$ 52.2 ^a	115.5 $\pm$ 57.6 ^b

*Black beans and corn intake in cups ranged from approximately 1/3 to 2/3; [†]Corn and peas intake in cups range from approximately 3/4 to 1; [‡]Carrot intake in cups range from approximately 2/3 to 7/10; [§]Green bean intake in cups ranged from approximately 2/3 to 4/5; ^{||}Fresh vegetables with dip (cucumbers, cherry tomatoes, carrots) intake in cups ranged from approximately 2/3 to 3/4; [¶]Fresh vegetables with dip (celery, cauliflower, cucumbers, cherry tomatoes) intake in cups ranged from approximately 3/4 to 4/5; [#]Broccoli intake in cups ranged from 2/3 to 4/5; ^{**}Cauliflower intake in cups ranged from 4/5 to 1. ^{a,b}Different letter superscripts in the table are used to denote mean values that are statistically different from one another at $P < .05$. Data were analyzed with 2-way ANOVA testing the impact of age group and condition (control vs herb and spice seasoned) on vegetable intake.

of condition ($P > .05$). However, *post hoc* tests indicated that the large quantitative increase for herb and spice vegetables relative to control among high schoolers was not significant ($P = .06$). High school students also consumed more seasoned black beans and corn than did middle school students ($P < .001$). For corn and peas, middle school students ate more control vegetables than herb and spice seasoned ones ($F_{1,248} = 13.7$, $P < .001$) whereas high school students ate more herb and spice seasoned corn and peas than did middle schoolers ($F_{1,248} = 10.2$, $P = .002$).

Intervention Intake of Vegetables With Main Effects but No Condition by Age Interactions

Intake results for vegetables with main effects but not interactions are shown in Figure 2B and Table 2.

Students consumed more control compared with herb and spice seasoned broccoli ($F_{1,314} = 6.5$, $P = 0.01$) irrespective of age. Students also consumed more control compared with seasoned cauliflower ($F_{1,196} = 7.6$, $P = .006$), and high schoolers consumed more cauliflower than did middle schoolers regardless of seasoning condition ($F_{1,196} = 15.5$, $P < .001$). For green beans, students consumed more control than herb and spice seasoned vegetables ($F_{1,251} = 6.3$, $P = .01$). Intake of both fresh vegetable options was higher among high schoolers than middle schoolers ($P < .03$) but was not influenced by seasoning of the dip. These results suggest that for some vegetables, intake of lightly salted control vegetables was higher than for vegetables with added herbs and spices, and high schoolers consumed more vegetables than did middle schoolers.

Follow-Up Exposure Study Selection, Willingness to Eat Again, and Intake

For both Dillicious Broccoli and Fiesta Black Beans and Corn, little change in selection rates occurred from before to after exposure (Table 3). There was an effect of exposure on the proportion of students who chose *would eat again* for the Dillicious Broccoli ($\chi^2_{MH} = 9.0$, 1 degree of freedom [DF], $P = .003$). A higher percentage of students in both age groups chose the *would eat again* option after compared with before exposure (Table 2). The apparent increase in the proportion choosing *would eat again* from before to after exposure (66.7% to 92.3%) for black beans and corn ($\chi^2_{MH} = 1.5$, 1 DF, $P = .22$) was not significant.

For broccoli, the 2-way ANOVA showed a main effect on intake of

age group ($F_{1,300}=16.3$, $P < .001$) demonstrating greater intake among high schoolers before and after exposure (Figure 3). The small increase in intake of Delicious Broccoli from before (130.1 ± 59.2 g) to after exposure (140.9 ± 49.1 g) also was not significant ($P=.06$). Conversely, for black beans and corn, no main effects on intake were seen for condition, age, or the condition $\times$ age interaction ($P > .05$ for all).

DISCUSSION

Previous multicomponent educational programs^{31,32} administered in schools demonstrated minimal effectiveness at increasing vegetable intake among youths. Furthermore, on a practical level, those programs are difficult to implement and sustain within the school lunch setting.³³ To overcome

these challenges, the current study used herbs and spices as a simple, cost-effective approach to improving vegetable palatability in the NSLP. The results demonstrated that the changes met or improved students' baseline consumption without using excess sauces, sugar, and fat. However, the use of herbs and spices alone did not produce substantial increases in students' vegetable selection or consumption (compared with adding small amounts of oil and salt) when delivered as part of a short-term intervention. Even so, whereas the intake and selection of lightly salted vegetables was initially higher among this population of rural adolescents, limited exposure to spice blends in the school cafeteria increased students' reported willingness to eat the seasoned vegetables again. This suggests that herbs and spices can be

incorporated into school lunch menu planning without adversely affecting intake, even when students have low prior exposure to these flavors. Because herbs and spices were shown to offer protection against a number of chronic diseases,^{34–36} their introduction to adolescents in the context of school lunch may provide broader public health benefits.

Throughout all phases of the intervention, selection rates were low for both control and seasoned vegetables, ranging from approximately 3% to 18% of students choosing the target vegetable in any given lunch period. These values were consistent with those observed in other studies conducted in school cafeterias.²² Other work³⁷ indicated that children's food choices were guided by taste, as opposed to healthfulness, and youths were more likely to

Figure 2. Intake for all intervention vegetables (Veg). (A) Vegetables with significant condition $\times$ age group interactions. (B) Vegetables with main effects but not significant condition $\times$ age group interactions. Average (Avg.) pre-weight of vegetable and baseline intake measures (when available) are marked on each graph with dotted lines. Intakes from each 2 trials conducted for each control and each seasoned vegetable were compiled before analysis. For the middle school age group, $n = 10$ – 66 , depending on the vegetable. For the high school age group, $n = 34$ – 118 , depending on the vegetable. Statistical tests performed with 2-way ANOVA with independent variables of condition (control vs herb and spice seasoned) and age group (middle school vs high school) and statistical significance at $P < .05$. *Significant differences between groups.

Figure 2. (Continued)

choose unhealthy than healthy snacks when provided with both.³⁸ Furthermore, children were more likely to choose fruit than vegetable snack options.³⁹ Thus, it seems likely that the low selection rates observed here may have been caused by the presence of competing food choices. That is, students were offered a variety of choices (eg, juices, fresh and canned fruits, other vegetables) and were not compelled to take the target vegetable, so it is reasonable to speculate that competing fruits and vegetables reduced selection of the target recipes. Although selection rates did not vary between conditions (control vs herb and spice), high schoolers selected both varieties more often than did middle schoolers. Because older adolescents likely had more exposure to a variety of foods and tend to be less neophobic compared with younger children,⁴⁰ they may have been more willing to try the new vegetable preparations.

Nonetheless, selection rates in both age groups remained low, which underscores the need to identify additional strategies that can increase vegetable selection in the school lunch setting. Other studies^{41–45} observed increases in students' vegetable selection in response to interventions that combined environmental nudges with improvements in vegetable palatability. For example, Cohen and colleagues⁴¹ encouraged fruit and vegetable selection by offering them at the beginning of the line, serving them in attractive containers, and pairing them with colorful images and signage. After 3 months' exposure to the intervention, the researchers observed a > 10% increase in the proportion of students selecting vegetables.⁴¹ Comparatively, the scaled-down approach used in the current study may have been of insufficient dose and length to see meaningful improvements in vegetable selection.

During the intervention, most students (67.2% to 98.1%) who chose the vegetable said that they would eat it again regardless of whether it was served lightly salted or with added herbs and spices. This suggests that novel seasoning blends could be added to enhance the variety of flavors served in the school lunch program without adversely affecting students' willingness to consume the products again. However, students were more likely to choose the *would eat again* option when the lightly salted control vegetables were served, potentially owing to the novelty of the herbs and spices. Prior interventions^{41,46,47} that used herbs and spices to improve palatability of school lunch offerings observed increased consumption, but only after several months of repeated exposure to the new preparations. In addition to a lack of familiarity with the spice blends, it is possible that adding herbs and spices might

Table 3. Follow-Up Exposure Study Selection Rates and Willingness to Eat Again Proportions When Returning Their Vegetable Cups

Vegetable Recipe	Middle School Selection (%)		High School Selection (%)		Middle School Would Eat Again (%) ^a		High School Would Eat Again (%) ^b		Mantel–Haenszel (2-sided) <i>P</i> ^c
	Pre-exposure	Postexposure	Pre-exposure	Postexposure	Pre-exposure	Postexposure	Pre-exposure	Postexposure	
Dillicious	6.2	6.4	6.9	7.2	77.9	91.5	86.2	96.2	.003
Broccoli									
Fiesta Black Beans and Corn	1.6	1.3	2.1	1.3	72.2	78.6	66.7	92.3	.22

^aFor middle school students' willingness to eat again, *n* = 77 in preexposure and *n* = 71 in post-exposure when served broccoli, and *n* = 18 in preexposure and *n* = 14 in post-exposure for black beans and corn; ^bFor high school students' willingness to eat again, *n* = 87 in preexposure and *n* = 78 in post-exposure for broccoli, and *n* = 24 in preexposure and *n* = 13 in post-exposure for black beans and corn; ^cTwo-sided Mantel–Haenszel tests were used to compare willingness to eat again measures between pre- and post-exposure. When *P* < .05, a significant difference existed between the 2 age groups (middle and high school) for the relation between the condition (preexposure or post-exposure) and the willingness to eat again response (yes or no).

Notes: Selection rates for both trial days are averaged. A total of 507–637 students bought a lunch on follow-up data collection days.

have masked other positive sensory attributes in the vegetables. For example, Carney and colleagues⁴⁸ found that in descriptive panels with adults, carrots seasoned with oil and salt alone were perceived as more buttery than were carrots seasoned with oil, salt, herbs, and spices, so it is possible that adding some seasonings had unintended effects on the sensory profile of the vegetables. In addition, salt can reduce the perception of bitterness,⁴⁹ which may further explain why students initially favored the control vegetables.

For the main intervention, it was hypothesized that students would consume more vegetables with herbs and spices because those recipes were liked and preferred over the control recipes in an earlier study conducted in the same setting.²⁷ Contrary to expectations, students tended to consume more control vegetables. Although the high school students liked the seasoned recipes better during taste tests, this did not necessarily translate to greater intake. There are several possible explanations for this discrepancy. First, lower intake than expected of seasoned vegetables might have been caused by low herb and spice exposure more generally, as supported by previous work.²⁷ The high schoolers might have had relatively low herb and spice exposure, but they tended to consume more seasoned vegetables than did the middle schoolers. This suggests that the younger age group might be more limited in dietary exposure. Second, because vegetable selection rates were low owing to the number and variety of competing food choices, it is likely that selection bias might have influenced the results of the intervention. That is, students who selected the target vegetable probably did so because they had high liking for the taste of the vegetable itself. For those students, the herbs and spices might have been unexpected, particularly if they were accustomed to consuming that vegetable without seasonings.

Limitations of the current work should be recognized. First, the study lacked a true control group to account for the effect of time on vegetable intake, and although the researchers collected baseline measurements to

Figure 3. Average intake and SE bars for Dillicious Broccoli and Fiesta Black Beans and Corn at pre- and postexposure time points. For broccoli, 2-way ANOVA showed a main effect on intake of age group (middle or high school) ($F_{1,300} = 16.3$, $P < .001$). The main effect of condition (pre- vs postexposure) on intake was not significant ($F_{1,300} = 3.3$, $P = .07$). Fisher's least significant difference *post hoc* tests showed that high schoolers ate more broccoli than did middle schoolers ($P < .001$). For black beans and corn, no main effects on intake were seen for condition, age, or condition by age ($P > .05$ for all). For middle school students, $n = 74$ (pre-exposure) and 71 (postexposure) for broccoli and $n = 18$ (pre) and 15 (post) for black beans and corn. For high school students, $n = 83$ (pre) and 76 (post) for broccoli and $n = 23$ (pre) and 15 (post) for black beans and corn. $*P < .05$.

estimate student intake before the intervention, the serving sizes and preparation methods differed, which limited the statistical comparisons that could be made. Second, there were small sample sizes for most analyses, and because entrées and other side dishes offered were at the

discretion of the cafeteria staff during the intervention phase, variability owing to competing foods might have reduced student selection and intake of the target vegetables. Related to this, there were large SDs in intake, particularly for vegetables that were novel to the school

(eg, black beans). This affected the power of the statistical analyses. To maximize participation, students were not required to complete consent forms; however, as a result, individual students could not be tracked, and thus conclusions can be made only at the school level.

IMPLICATIONS FOR RESEARCH AND PRACTICE

Findings of the current study demonstrate that within the context of a short-term intervention, herbs and spices did not increase consumption of vegetables among rural adolescents, but with minimal repeated exposure, these flavors might become accepted. Introducing novel herbs and spices on familiar vegetables first might be beneficial to encourage children and adolescents to taste and gain exposure to these flavors. Identifying strategies to increase selection, particularly in the school cafeteria setting, is also imperative. For these reasons, if school food service directors choose to integrate herbs and spices into school lunches, they could provide them over multiple exposures. A greater understanding of the individual- and school-level variables that affect the acceptance and intake of vegetables seasoned with herbs and spices is an important area for future investigation.

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SUPPLEMENTARY DATA

Supplementary data related to this article can be found at <https://doi.org/10.1016/j.jneb.2019.04.016>.

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CONFLICT OF INTEREST

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