

Serving a variety of vegetables and fruit as a snack increased intake in preschool children^{1–3}

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ABSTRACT

Background: Although serving a greater variety of food increases intake, this effect has not been well studied as a strategy to encourage consumption of vegetables and fruit in preschool children.

Objective: This study examined whether providing a variety of familiar vegetables or fruit to preschool children as a snack would lead to increased selection and intake.

Design: In a crossover design, 61 children (aged 3–5 y) ate a snack in their childcare facility on 8 afternoons. At 4 snack times, the children were offered vegetables: either a single type (cucumber, sweet pepper, or tomato) or a variety of all 3 types. At 4 other snack times, the children were offered fruit (apple, peach, pineapple, or all 3 types). Uniform-sized pieces were served family style, and children selected and ate as much as they desired.

Results: Offering a variety of vegetables or fruit increased the likelihood of selection ($P < 0.0001$); children chose some pieces in 94% of snacks with variety and in 70% of snacks without variety. Serving a variety also increased consumption of both vegetables and fruit ($P < 0.0002$); the mean (\pm SEM) increase was 31 ± 5 g, about one-sixth the recommended daily amount. Independent of the variety effect, children were less likely to select vegetables than fruit ($P < 0.0001$), and the mean intake was substantially less for vegetables than for fruit (22 ± 1 compared with 84 ± 3 g).

Conclusions: Providing a variety of vegetables and fruit as a snack led to increased consumption of both food types in a childcare facility. Serving a variety of vegetables or fruit as a snack could help preschool children meet recommended intakes. This trial was registered at clinicaltrials.gov as NCT01557218. *Am J Clin Nutr* 2013;98:693–9.

INTRODUCTION

National data indicate that most preschool children consume less than recommended amounts of vegetables and fruit (1–3). Offering children a variety of vegetables and fruit at meals has the potential to encourage consumption, but this strategy has not been well investigated. Eating a variety of vegetables and fruit has many benefits for children, including developing food and taste preferences (2, 4) and increasing intakes of nutrients and phytochemicals that are crucial for disease prevention (3, 5). In addition, vegetables and fruit are important in the reduction of dietary energy density to reduce the overconsumption of energy and thus can play a role in the prevention of early childhood obesity (6). The aim of the current study was to determine whether providing a variety of either vegetables or

fruit to preschool children as a snack would increase their selection and intake.

Many studies in adults have shown that the provision of a greater variety of foods at a meal leads to increased consumption, although much of the research has tested energy-dense foods rather than vegetables and fruit (7–11). Few studies of food variety, however, have been conducted in children. Two laboratory studies in 8- to 12-y-olds found that offering a variety of either high- or low-energy-dense food samples in succession increased intake compared with repeatedly offering the same food (12, 13). In contrast, a study in 4- to 6-y-old children in a restaurant setting found that vegetable consumption was not influenced by having 2 vegetables at the meal rather than 1 (14). Thus, the effects of increased variety of vegetables or fruit on intake have not been well-investigated nor has an effect of food variety been shown for children in their customary eating environment.

The current study explored the effect of variety by offering children in a childcare facility a variety of familiar vegetables or fruit as a snack and comparing this with offering each type individually. The snack was served family style, so that children chose for themselves as much as they wanted. With this serving method, we could test whether allowing children to choose from a variety influenced the amount and types of food they selected and whether this, in turn, affected the amount they ate. The objective was to investigate whether offering a variety of vegetables or fruit to children in their usual eating environment led to increased consumption, which could help to meet recommended intakes.

SUBJECTS AND METHODS

Experimental design

This experiment used a crossover design; on 8 occasions during 4 wk, 61 children ate an afternoon snack in their classrooms at a childcare facility. Across occasions, the snack was

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varied by the types of vegetables or fruit that were provided. At 4 of the snack times, vegetables were served; 3 times a single type of vegetable was offered (cucumber, sweet pepper, or tomato) and 1 time a variety of all 3 vegetables was offered. At 4 other snack times, fruit was served; 3 times a single type of fruit was offered (apple, peach, or pineapple) and 1 time a variety of all 3 was offered. Each week for 4 wk, the classrooms had a vegetable snack on 1 d and a fruit snack on another day, with ≥ 2 d between them. Within a classroom, the snacks were served on the same 2 weekdays each week. The orders of the experimental conditions across the weeks were counterbalanced by using Latin squares and were assigned to the classrooms by using a computerized random number generator.

Participants

The study was conducted in the Bennett Family Center at the University Park campus of The Pennsylvania State University from February to April 2011. Participants in the study were recruited by distributing letters to parents of children in 4 classrooms of the childcare facility that included children aged 3–5 y; these classrooms had a total of ~ 75 children present at snack time. Children who were allergic to any of the foods to be served at the snack were not included in the study. Parents and guardians provided informed written consent for the participation of their children. The Office for Research Protections of the Pennsylvania State University reviewed and approved all procedures.

The study included 61 children aged 3–5 y (32 girls and 29 boys). The children were racially diverse: 56% were white, 29% Asian, 11% black or African American, and 4% Pacific Islander. Anthropometric data for the children who participated in the assessment of height and weight are shown in **Table 1**. Seven (13%) of the children had a sex-specific BMI-for-age percentile above the 85th percentile for national data (15).

Test foods and meal procedures

The test foods in this experiment were 3 types of vegetables and 3 types of fruit, prepared as shown in **Table 2**. The vegetables and fruit were chosen from among those that had previously been served at the childcare facility and that could be cut into uniform pieces; within these constraints, the vegetables and fruit were selected to provide contrast in taste, color, and texture. The foods were categorized as vegetables or fruit according to the food groups defined in US national guidelines (17). Compared with the vegetables, the fruit had a higher content of sugar and energy and a lower content of water (Table 2). The vegetables

and fruit were served in uniform pieces with an average weight of 10 g/piece and an allowable range of 8 to 12 g/piece; the uniform pieces allowed observers to assess individual intakes of the children participating in the study. In terms of volume, 3–4 pieces were equivalent to a 0.25-cup serving (60 mL), which represents one-sixth of the recommended daily intake of either vegetables or fruit for most children aged 3–5 y (18).

The daily snacks customarily served at the childcare facility were grain-based items, such as crackers, muffins, and pretzels (3–4 times/wk), and vegetables or fruit (1–2 times/wk). The vegetable and fruit snacks were typically served as a variety of 2 or 3 types, but occasionally a single type was served along with a grain-based item such as bread. The grain-based snacks continued to be served in the facility on the days between study days.

The afternoon snack was provided at a standard time in each classroom after either a nap or a period of quiet play. At snack time, the children sat in their usual places in the same groups at the same tables. Each of the 4 classrooms had 3 tables that seated 5–7 children and 1 adult helper. Children at the table who were not participating in the study were provided with the same snack, but their intake was not recorded. The number of study participants in each of the 4 classrooms ranged from 9 to 19 children.

In accordance with the usual practice in the classrooms, the vegetables and fruit were served family style at each table. The tables were provided with 3 serving bowls, each of which contained 300 g (30 pieces). In the variety conditions, each of the 3 bowls contained a different type of vegetable or fruit; in the single-type conditions, all 3 bowls contained the same type of vegetable or fruit. The bowls were passed around the table, and the children used spoons or tongs to select as many pieces as they wanted and place them on their plates. Extra serving bowls of the vegetables or fruit were available in each classroom. When any serving bowl became empty, a full bowl was substituted by a member of the research team; during the study, 16 bowls were replenished (6% of all bowls). Thus, at each snack there was a sufficient amount of food that all children had access to each type of vegetable or fruit. All children were also provided with a small piece of pita bread (16 g; 43 kcal) and 250 mL water as a beverage, which were set at their places at the table before the snack began.

The adult helper at the table ensured that the serving bowls were passed around the table to each child, according to the usual practice at the facility, but did not eat any of the snacks. The adult did not encourage or comment on the children's selection or consumption of any food and redirected any of the children's comments about food to other topics. The adult helpers were unaware of the study hypotheses. The children were allowed to leave the table when they had eaten as much as they wanted.

TABLE 1

Characteristics of preschool children who were served a variety of vegetables and fruit as a snack

	Girls			Boys		
	No. of subjects	Mean \pm SEM	Range	No. of subjects	Mean \pm SEM ¹	Range
Age (y)	30	4.2 \pm 0.1	3.1–5.4	26	4.6 \pm 0.1*	3.1–5.6
Weight (kg)	30	17.2 \pm 0.4	12.0–21.7	28	18.9 \pm 0.5*	15.1–28.5
Height (cm)	30	105.0 \pm 1.1	93.5–118.2	27	108.5 \pm 1.0*	98.0–124.1
Sex-specific BMI-for-age percentile ²	29	52.7 \pm 4.8	2.4–91.5	26	58.5 \pm 4.6	11.0–94.8

¹*Significantly different from girls, $P < 0.03$ (unpaired t test).

²Calculated from sex, age, height, and weight by using a software program based on nationally representative data (15).

TABLE 2
 Characteristics of vegetables and fruit served as a snack to preschool children

Food	Preparation	Composition per 100 g ¹				
		Energy	Carbohydrate	Sugar	Fiber	Water
		<i>kcal</i>	<i>g</i>	<i>g</i>	<i>g</i>	<i>g</i>
Vegetables						
Cucumber	Raw slices with half the peel removed in strips ²	14	2.9	1.5	0.6	96.0
Sweet pepper	Raw strips of yellow type ²	27	6.3	4.2 ³	0.9	92.0
Tomato	Raw whole grape type ²	18	3.9	2.6	1.2	94.5
Fruit						
Apple	Raw unpeeled slices ⁴	52	13.8	10.4	2.4	85.6
Peach	Slices canned in juice, drained ⁴	61	15.7	10.6	0.7	83.4
Pineapple	Rings canned in juice, drained, and cut in half ⁵	60	15.6	14.3	1.3	83.5

¹ Food-composition data from the National Nutrient Database (16).

² Giant Food Stores.

³ Sugar content of red sweet pepper; no data are available for yellow sweet pepper.

⁴ Sysco Corp.

⁵ Dole Food Company Inc.

Assessments

The number of pieces of vegetables or fruit selected by each child in the study was recorded independently by 2 observers seated near each table. The counts recorded by each pair of observers agreed for 450 of the 458 observations (98%). The discrepancies were resolved by using the count from the observer who sat nearest to the child. After the meal, the number of uneaten pieces on each child’s plate was recorded as well as any dropped pieces. All uneaten food and beverage items were weighed after the meal with digital scales (models PR5001 and XS4001S; Mettler-Toledo Inc). These weights were used to determine intake of pita bread and water and also to verify the accuracy of the counts of uneaten vegetable and fruit pieces.

Ratings of liking for the 6 vegetables and fruit were assessed 1 wk after completion of the snack sessions by using a procedure developed for preschool children (19). Children were instructed about the use of 3 cartoon faces to indicate whether they thought a food was “yummy,” “okay,” or “yucky.” The children were presented with the 6 food samples in a randomly assigned order and were asked to taste each food and indicate their liking for it by placing it on a card with the appropriate cartoon face. The ratings were completed by 54 children; the 7 other children declined to participate or were absent.

Body weight and height of the children were measured 1 wk after completion of the snack sessions. Body weight was measured in duplicate to the nearest 0.1 kg with a portable digital scale (model 843; Seca Corp), and height was measured in duplicate to the nearest 0.1 cm with a portable stadiometer (model 214; Seca Corp). Sex-specific BMI-for-age percentiles were calculated from the children’s height, weight, age, and sex by using a software program based on US national data (15).

Data analysis

This experiment investigated several related outcome measures. First, it was of interest to assess the binary outcome of whether or not children chose any pieces of vegetables or fruit as a snack, because the act of selection was the first step in determining intake. Next, the main outcomes of the study were the number of pieces that children selected and the number that they

consumed. Finally, the effects of food liking were examined in the subset of children who provided these ratings.

The main outcomes of the number of pieces of vegetables and fruit that were selected and eaten were not normally distributed. Instead, these outcomes had characteristics that are typical of episodically consumed foods, namely, having a large proportion of zero values (zero-inflated) and a skewed distribution with a few very high values (overdispersed) (20, 21). In addition, because selection and intake were measured by counting pieces, the values were categorical rather than continuous (22, 23). Because of these characteristics, the main outcomes were analyzed with nonlinear mixed models, as appropriate for nonnormal categorical data with repeated measures (PROC NL MIXED, SAS 9.3; SAS Institute Inc). The zero-inflated counts were analyzed by using 2 linked models: the first model estimated the likelihood of a zero count by using binary logistic regression, and the second estimated the magnitude of the nonzero counts by using a regression model with a negative binomial distribution (24, 25). To examine the binary outcomes of likelihood (such as selecting compared with not selecting any pieces), repeated-measures binary logistic regression was performed (PROC GLIMMIX).

The factors in all models were the variety condition (single type or a variety of all 3 types), food group (vegetable or fruit), and snack occasion. A random effect was included to account for the correlation among repeated observations for the same child. The main outcomes were examined for the influence of individual characteristics, such as age, sex-specific BMI-for-age percentile, and the number of vegetables rated as yummy or yucky.

Another question of interest was whether serving a variety of vegetables or fruit affected the variety that was selected, ie, the number of different types that were chosen out of the 3 types offered. This was assessed by comparing the number of types that children selected in the variety snack (either vegetable or fruit) with the number of types chosen across the 3 single-type snacks. This comparison could indicate whether the variety selected was influenced by food preference. If children had strong preferences, it might be expected that they would choose only their favorites when all 3 types were served together, even if they chose some of all 3 types when the foods were served separately. The non-parametric Friedman test was used to test whether offering the

different types simultaneously rather than separately had an effect on the number of types that were selected and consumed.

Differences between vegetables and fruit in the distribution of the number that were rated as yummy or yucky were assessed by Bowker's test of symmetry—a nonparametric test for repeated measures. Differences in characteristics of girls and boys were analyzed with an unpaired *t* test. Results for likelihood outcomes are reported as ORs with 95% CIs, and results for count outcomes are reported as predicted counts from the nonlinear mixed model (mean \pm SEM). Results were considered significant at $P < 0.05$.

RESULTS

Effects on the likelihood of food selection and intake

Offering a variety of types of either vegetables or fruit increased the likelihood that children would select some pieces for their snack, rather than not choosing any ($P < 0.0001$; **Figure 1**). Children were more likely to select some vegetables or fruit in the snacks with variety than they were in the snacks with a single type (OR: 7.3; 95% CI: 3.3, 15.9). Across all observations, children selected some pieces at 94% of the variety snacks and 70% of the single-type snacks. After selection, there was no further effect of variety on the probability of eating the selected pieces (OR: 1.8; 95% CI: 0.8, 3.9; $P = 0.14$). Children ate some of the selected pieces at 90% of both the variety and single-type snacks.

Independent of the variety effect, a significant difference was found between the vegetable and fruit snacks in the probability of selecting any pieces ($P < 0.0001$); children were more likely to select some pieces of fruit than of vegetables (OR: 4.4; 95% CI: 2.8, 7.1). Across all observations, children selected some pieces at 88% of the fruit snacks and 63% of the vegetable snacks.

Effects on the amount of food selected and consumed

In addition to increasing the likelihood that children would select some vegetables and fruit, serving a variety of types also significantly influenced the number of pieces that children selected and ate, which was the main outcome of the study. Compared with offering a single type, offering a variety of types of either vegetables or fruit increased both the amount selected ($P < 0.0001$; **Table 3**) and the amount consumed ($P = 0.0002$; **Figure 2**). The increase in intake due to variety was not significantly different for the vegetable snacks and the fruit snacks. Across all observations, children ate a mean of 7.7 ± 0.5 pieces at the snacks with variety and 4.6 ± 0.2 pieces at the snacks without variety. Thus, when a variety of types of either vegetables or fruit was served as a snack, intake was increased by an average of 3.1 pieces, or 67%. The increase in consumption was ~ 31 g or 0.25 cups (60 mL), equivalent to one-sixth of the recommended daily intake of either vegetables or fruit for most preschool children.

Independent of the variety effect, there was a significant difference between the vegetable and fruit snacks in the amount selected and consumed (both effects $P < 0.0001$; **Table 3**). Across all snacks, children ate a mean of 2.2 ± 0.1 pieces of vegetables and 8.4 ± 0.3 pieces of fruit.

The provision of a variety of vegetables and fruit also increased the amount of uneaten food, ie, the number of pieces selected but left on the plate ($P < 0.0001$). Children left a mean of 1.9 ± 0.1

pieces in the variety snacks and 0.6 ± 0.02 pieces in the single-type snacks—a difference of 1.3 pieces (~ 13 g). Analysis of the weight of uneaten items showed that the mean difference between the snacks with and without variety was 13.0 ± 1.0 g, which was in good agreement with the count data. Across all snacks (both variety and single-type), children left uneaten food on a minority of occasions (45%); at most of the snacks, children ate everything that they selected.

The children's age, sex, and sex-specific BMI-for-age percentile did not significantly influence the effect of variety or food group on vegetable and fruit intake (all $P > 0.20$). Across all of the snacks (both with and without variety), however, a negative relation was found between children's age and the intake of vegetables and fruit; the mean decrease was 1.4 ± 0.3 pieces (~ 14 g) for each additional year of age ($P < 0.0001$).

Consumption of bread at the snack was not significantly influenced by the factors of variety or food group (both $P > 0.32$). Thus, differences in energy intake of the snacks depended only on intake of vegetables and fruit. Energy intake was 40 ± 3.0 kcal for the single-type snacks and 54 ± 4.5 kcal for the variety snacks. Energy intake was 24 ± 2.2 kcal for the vegetable snacks and 70 ± 5.2 kcal for the fruit snacks.

Effects on the variety of food selected and consumed

For vegetables, no significant difference were found between the number of types that children selected at the single-type and variety snack times ($P = 0.24$, Friedman test). For example, 11 children (26%) selected some vegetables at all 3 of the single-type snack times, and 12 children (29%) selected some of all 3 vegetables at the vegetable variety snack time. At the fruit snack times, however, children selected fewer types at the fruit variety snack time than they did at the 3 single-type snack times ($P = 0.0007$). For example, 35 children (65%) selected some fruit at all 3 of the single-type snack times, whereas 22 children (41%)

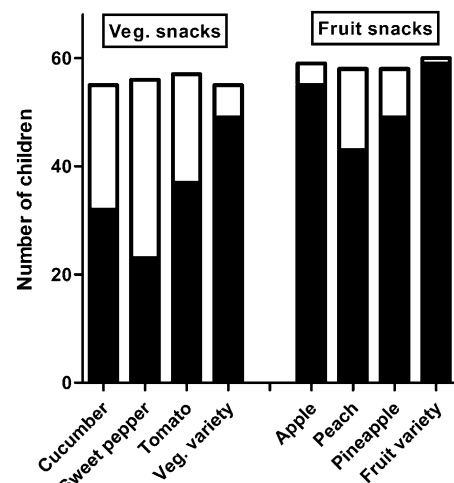


FIGURE 1. Number of preschool children who selected (■) or did not select (□) some pieces of vegetables or fruit at snack time. On different occasions, the children were offered 3 single types of vegetables and a variety of all 3 types; similar offerings of fruit were made. Children were more likely to choose some pieces when a variety of types was offered than when a single type was offered ($P < 0.0001$, repeated-measures logistic regression). Because of occasional absences, the number of children at a given snack time was less than the total of 61 children in the study. Veg., vegetable.

TABLE 3
Number of pieces of vegetables and fruit selected and eaten by preschool children as a snack

	No. of children present	No. of pieces selected ¹			No. of pieces eaten ¹		
		Mean ± SEM ²	Median	Range	Mean ± SEM ²	Median	Range
Vegetable snacks							
Cucumber	59	1.6 ± 0.1*	1	0–7	1.1 ± 0.1*	0	0–7
Sweet pepper	58	1.7 ± 0.1*	0	0–11	1.3 ± 0.1*	0	0–10
Tomato	58	3.2 ± 0.2*	1	0–45	2.6 ± 0.2*	1	0–40
Vegetable variety (all 3 types)	60	5.4 ± 0.3	4	0–26	3.6 ± 0.2	2	0–26
Fruit snacks							
Apple	55	7.3 ± 0.4*	6	0–26	6.1 ± 0.4*	6	0–26
Peach	56	9.0 ± 0.5*	5	0–45	8.5 ± 0.5	5	0–43
Pineapple	57	8.0 ± 0.4*	6	0–51	7.5 ± 0.5*	6	0–45
Fruit variety (all 3 types)	55	14.1 ± 0.8	12	0–46	11.4 ± 0.7	10	0–45

¹ Pieces were of uniform size and had a mean weight of 10 g and an allowable range of 8 to 12 g.

² Mean values were estimated from a nonlinear mixed model, which estimated the likelihood of a zero count by using binary logistic regression and then estimated the magnitude of the nonzero counts by using a regression model with a negative binomial distribution. The analysis showed that, compared with the single-type snacks, serving the variety snacks increased both the amounts selected ($P < 0.0001$) and eaten ($P < 0.0002$). Independent of the variety effect, the amount of fruit selected and eaten was greater than the amount of vegetables (both $P < 0.0001$). *In a pairwise comparison, the mean in the single-type condition differed significantly from the mean in the associated variety condition, $P < 0.05$ (nonlinear mixed model).

selected some of all 3 fruit at the fruit variety snack times. These results were similar for the outcome of consumption rather than selection.

Effects of liking for vegetables and fruit

Ratings of liking for the 6 types of vegetables and fruit are shown in **Table 4** for the 54 children who completed these assessments. The items with the highest number of yummy ratings were tomato for the vegetables (54% of children) and apple for the fruit (87%). Comparison of the variety snacks with the single snacks most preferred by the group showed that that intake of the vegetable variety snack was significantly greater than the tomato snack (3.6 compared with 2.6 pieces), and intake of the fruit variety snack was significantly greater than that of the apple snack (11.4 compared with 6.1 pieces; overall $P = 0.007$).

Differences were found in liking for vegetables and fruit as assessed by the number of types that children rated as yummy ($P = 0.004$, Bowker’s test of symmetry) and yucky ($P = 0.0002$); no significant differences were found in the number rated as okay ($P = 0.45$). For example, 13 children (24%) rated all 3 of the vegetables as yummy, whereas 29 children (54%) rated all 3 of the fruit as yummy. For vegetables, the number of types that a child rated as yummy or yucky did not influence the effect of variety on vegetable consumption; thus, the provision of a variety of vegetables increased intake compared with the single-vegetable snacks, regardless of the number that were liked. Across all 4 vegetable snacks, however, the number of pieces of vegetables eaten was positively related to the number of types of vegetables that a child rated as yummy ($P = 0.001$). For fruit, there was insufficient statistical power to assess the effect of the liking ratings on intake, because few children rated any of the fruit as yucky.

DISCUSSION

This study showed that the provision of a variety of familiar vegetables and fruit promotes their consumption as a snack by

preschool children. Serving 3 types of vegetables or fruit rather than a single type not only increased the likelihood that children would select some, but also increased the amount that they chose and ate. Although consumption of vegetables was substantially less than that of fruit, intake of both was increased by providing a variety of types; the mean increase was 31 g (67%), or about one-sixth of the recommended daily amount for preschool children. These results provide some of the first evidence that variety influences the food intake of children in their usual eating environment.

Research has established that serving a variety of palatable energy-dense foods to adults leads to increased food consumption, which may promote excess energy intake in some individuals

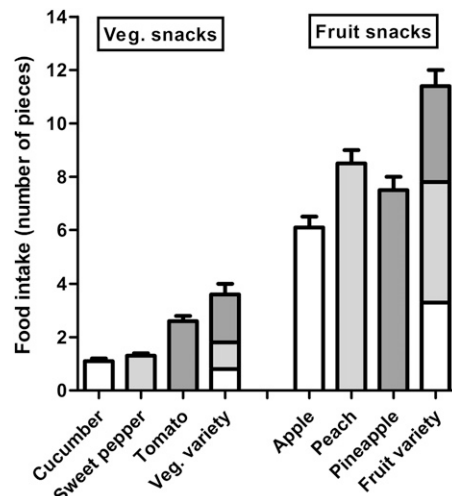


FIGURE 2. Mean (±SEM) number of pieces of vegetables and fruit consumed by 61 preschool children at a snack. On different occasions, the children were offered 3 single types of vegetables and a variety of all 3 types; similar offerings of fruit were made. Children ate a greater number of pieces when a variety of types was offered than when a single type was offered ($P = 0.0002$, nonlinear mixed model). Children also ate a greater number of pieces of fruit than of vegetables ($P < 0.0001$). The pieces were of uniform size and had a mean weight of 10 g and an allowable range of 8 to 12 g. Veg., vegetable.

TABLE 4
Ratings of liking for vegetables and fruit served to preschool children as a snack¹

Food	Liking rating					
	Yummy		Okay		Yucky	
	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%
Vegetables						
Cucumber	27	50	15	28	12	22
Sweet pepper	23	43	7	13	24	44
Tomato	29	54	9	17	16	30
Fruit						
Apple	47	87	6	11	1	2
Peach	39	72	10	19	5	9
Pineapple	45	83	7	13	2	4

¹Ratings were provided by 54 of the 61 children in the study.

(7–11). The potential for variety to promote intake of vegetables and fruit, however, has not been well investigated. Two previous studies that tested the provision of a variety of vegetables or fruit found no effect on consumption. In one of the few experiments of variety in children, 4- to 6-y-olds were served dinner with a parent in a restaurant setting. The results showed that vegetable intake did not differ significantly between children who were served 2 types of moderately liked vegetables and those who were served a single type, whether it was chosen by the child or randomly assigned (14). A study in adults compared a snack of 4 courses of highly liked fruit with 4 courses of the favorite fruit and showed a nonsignificant difference in fruit consumption of 26 g (~8%) (26). In contrast, another study in adults found that serving 3 vegetables at lunch increased intake by a mean of 46 g (~27%) compared with serving each type alone (27). The current study strengthens the suggestion that the variety effect can occur at different levels of food energy density (12, 13) and shows that offering a variety of fruit and vegetables can have beneficial effects in children by enhancing intake of low-energy-dense, nutrient-rich vegetables and fruit.

The children in this study were familiar with the vegetables and fruit, yet on many occasions they did not select any pieces for a snack, particularly of the vegetables. The ratings showed that the children liked the vegetables less than the fruit—a result that was shown previously and was related to differences in sweetness, energy density, or texture (28–30). The lower liking for vegetables than for fruit was reflected in the smaller amounts selected and eaten; across all snacks, as the number of liked vegetables increased, intake of vegetables also increased. Despite the generally low liking for vegetables, offering a variety still increased consumption compared with offering a single type, and this outcome was not influenced by the number of vegetables that were liked.

It was of interest to identify which strategy led to a greater intake of vegetables and fruit in the classrooms: serving the variety snacks or serving the snacks most preferred by the group of children, as indicated by the highest number of yummy ratings. This comparison showed that intake was greater for the variety snacks than for the children's most preferred snacks. The items with the greatest number of yummy ratings were also those most likely to be chosen, but were not always those with the highest intake. Although providing a variety of vegetables and fruit to

a group of children may not necessarily increase intake by every child compared with their most preferred type, this strategy has other benefits. Serving a variety provides exposure to different types of foods, which can lead to eventual acceptance (31); provides a wide range of nutrients and beneficial phytochemicals (3, 5); and offers children a choice.

The opportunity to choose among options is one proposed explanation for the variety effect; offering choice may promote autonomy (14) or may simply allow individuals to select the foods they like best (10). In this study, offering a variety increased the likelihood that children would select some items, but had no further effect on the likelihood of eating them once chosen. Thus, these results support the proposition that choosing among options is a critical determinant of the effect of variety on intake. Furthermore, the findings imply that preference can influence the act of choosing from a variety. When the fruit types were offered simultaneously rather than individually, children chose fewer different types, which suggested that their increased intake of the fruit variety snack was a result of selecting their favorites. For the vegetable snacks, however, no such effect was observed; having a variety increased intake but did not affect the number of types chosen among these generally less preferred items. In the study of children in a restaurant setting, the researchers stated that the lack of effect of choice on intake may have been a result of the single exposure or to the novel environment (14). The current study, which involved multiple exposures in a familiar setting, found that choice played a role in the effect of variety. An alternative explanation for the variety effect is sensory-specific satiety (7–11, 32). Although it was not possible to test this phenomenon in classroom groups of preschool children, research indicates that it can sustain consumption from a variety of foods. Further investigation is needed in other settings to explore the processes underlying the effects of variety on children's intake.

A strength of this study was its setting, because the children ate in their customary environment and had regularly been offered vegetables and fruit individually and as a variety. Thus, the results showed that, even after multiple exposures, serving a variety had a beneficial effect. In addition, the family-style service at the facility allowed measurement of the effects on children's selection and intake. A consequence of this was the finding that serving a variety led to a small but measurable increase in the amount of uneaten food. It seems likely, however, that the family-style service reduced waste compared with serving the same snack individually to each child, because most of the children ate everything that they chose. The setting of the study was also a potential limitation. Although the children in this study were racially diverse and had a wide range of body sizes, their enrollment in a university-based childcare facility indicated they were from relatively well-educated families, which may have affected the generalizability of the results. In addition, the data analysis had a limitation common to episodically consumed foods, ie, that statistical modeling with nonnormal distributions may not fit the zero-inflated, overdispersed data as closely as does the modeling of normally distributed data.

The preschool years present an opportunity for promoting intake of vegetables and fruit at a time when eating attitudes and behaviors are still developing (4). This study showed that offering a variety of vegetables or fruit as a snack can increase selection and consumption by preschool children. Furthermore, it showed that the opportunity for choice is an important determinant of the

effect. In group settings such as childcare facilities, this strategy is relatively easy to implement and may be especially beneficial for enhancing intake of vegetables, despite their generally lower liking. The provision of a variety of vegetables and fruit as a snack for the preschool children is one approach for bringing dietary intakes closer to recommended amounts.

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REFERENCES

- Krebs-Smith SM, Guenther PM, Subar AF, Kirkpatrick SI, Dodd KW. Americans do not meet federal dietary recommendations. *J Nutr* 2010; 140:1832–8.
- Fox MK, Condon E, Briefel RR, Reidy KC, Deming DM. Food consumption patterns of young preschoolers: are they starting off on the right path? *J Am Diet Assoc* 2010;110:S52–9.
- Lorson BA, Melgar-Quinonez HR, Taylor CA. Correlates of fruit and vegetable intakes in US children. *J Am Diet Assoc* 2009;109:474–8.
- Cooke L. The importance of exposure for healthy eating in childhood: a review. *J Hum Nutr Diet* 2007;20:294–301.
- Liu RH. Health benefits of fruit and vegetables are from additive and synergistic combinations of phytochemicals. *Am J Clin Nutr* 2003;78 (suppl):517S–20S.
- Institute of Medicine. Early childhood obesity prevention policies. Washington, DC: The National Academies Press, 2011.
- Rolls BJ, Rowe EA, Rolls ET, Kingston B, Megson A, Gunary R. Variety in a meal enhances food intake in man. *Physiol Behav* 1981;26: 215–21.
- Rolls BJ, van Duijvenvoorde PM, Rolls ET. Pleasantness changes and food intake in a varied four-course meal. *Appetite* 1984;5:337–48.
- Raynor HA, Epstein LH. Dietary variety, energy regulation, and obesity. *Psychol Bull* 2001;127:325–41.
- Remick AK, Polivy J, Pliner P. Internal and external moderators of the effect of variety on food intake. *Psychol Bull* 2009;135:434–51.
- McCrary MA, Burke A, Roberts SB. Dietary (sensory) variety and energy balance. *Physiol Behav* 2012;107:576–83.
- Temple JL, Giacomelli AM, Roemmich JN, Epstein LH. Dietary variety impairs habituation in children. *Health Psychol* 2008;27:S10–9.
- Epstein LH, Robinson JL, Temple JL, Roemmich JN, Marusewski AL, Nadbrzuch RL. Variety influences habituation of motivated behavior for food and energy intake in children. *Am J Clin Nutr* 2009;89:746–54.
- Zeinstra GG, Renes RJ, Koelen MA, Kok FJ, de Graaf C. Offering choice and its effect on Dutch children's liking and consumption of vegetables: a randomized controlled trial. *Am J Clin Nutr* 2010;91:349–56.
- CDC. A SAS program for the CDC growth charts. Version current 1 September 2012. Available from: <http://www.cdc.gov/nccdphp/dnpao/growthcharts/resources/sas.htm> (cited 14 March 2013).
- US Department of Agriculture, Agricultural Research Service. 2012. USDA national nutrient database for standard reference, release 25. Available from: <http://www.ars.usda.gov/ba/bhnrc/ndl> (cited 14 March 2013).
- US Department of Agriculture. ChooseMyPlate.gov website. Food groups. Available from: <http://www.choosemyplate.gov/food-groups/> (cited 14 March 2013).
- US Department of Agriculture, US Department of Health and Human Services. Dietary guidelines for Americans 2010. Washington, DC: US Government Printing Office, 2010.
- Birch LL. The relationship between children's food preferences and those of their parents. *J Nutr Educ* 1980;12:14–8.
- Tooze JA, Midthune D, Dodd KW, Freedman LS, Krebs-Smith SM, Subar AF, Guenther PM, Carroll RJ, Kipnis V. A new statistical method for estimating the usual intake of episodically consumed foods with application to their distribution. *J Am Diet Assoc* 2006;106:1575–87.
- Kipnis V, Midthune D, Buckman DW, Dodd KW, Guenther PM, Krebs-Smith SM, Subar AF, Tooze JA, Carroll RJ, Freedman LS. Modeling data with excess zeros and measurement error: application to evaluating relationships between episodically consumed foods and health outcomes. *Biometrics* 2009;65:1003–10.
- Atkins DC, Gallop RJ. Rethinking how family researchers model infrequent outcomes: a tutorial on count regression and zero-inflated models. *J Fam Psychol* 2007;21:726–35.
- Min Y, Agresti A. Random effect models for repeated measures of zero-inflated count data. *Stat Model* 2005;5:1–19.
- Littell RC, Milliken GA, Stroup WW, Wolfinger RD, Schabenberger O. SAS for mixed models. 2nd ed. Cary, NC: SAS Institute Inc, 2006.
- Jones B, Kenward MG. Design and analysis of cross-over trials. 2nd ed. Monographs on statistics and applied probability 98. Boca Raton, FL: Chapman & Hall/CRC, 2003.
- Raynor HA, Osterholt KM. Greater variety of fruit served in a four-course snack increases fruit consumption. *Appetite* 2012;59:662–7.
- Meengs JS, Roe LS, Rolls BJ. Vegetable variety: an effective strategy to increase vegetable intake in adults. *J Acad Nutr Diet* 2012;112: 1211–5.
- Krølner R, Rasmussen M, Brug J, Klepp KI, Wind M, Due P. Determinants of fruit and vegetable consumption among children and adolescents: a review of the literature. Part II: qualitative studies. *Int J Behav Nutr Phys Act* [serial online] 2011;8:112. Available from: <http://www.ijbnpa.org/content/8/1/112> (cited 14 March 2013).
- Zeinstra GG, Koelen MA, Kok FJ, de Graaf C. Cognitive development and children's perceptions of fruit and vegetables; a qualitative study. *Int J Behav Nutr Phys Act* [serial online] 2007;4:30. Available from: <http://www.ijbnpa.org/content/4/1/30> (cited 14 March 2013).
- Gibson EL, Wardle J. Energy density predicts preferences for fruit and vegetables in 4-year-old children. *Appetite* 2003;41:97–8.
- Anzman-Frasca S, Savage JS, Marini ME, Fisher JO, Birch LL. Repeated exposure and associative conditioning promote preschool children's liking of vegetables. *Appetite* 2012;58:543–53.
- Rolls BJ. Sensory-specific satiety and variety in the meal. In: Meiselman HL, ed. Dimensions of the meal: the science, culture, business and art of eating. Gaithersburg, MD: Aspen Publishers, Inc, 2000:107–16.