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A Pilot Study to Compare a Mushroom-Soy-Beef Burger to an All-Beef Burger in School Meals

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ABSTRACT

Purpose/Objectives

The purpose of this study was to determine if mushroom blended recipes are an acceptable option for use in the school food program. The palatability and acceptance of mushroom-soy-beef blend burgers among school-aged children was tested.

Methods

Students in grades 2 through 8 were invited to participate in a taste test. Students who volunteered tasted two burger types: regular beef and mushroom-soy-beef "blend" burgers. Burgers were served in random order and were not labeled by type. An interviewer-administered survey included measures to assess palatability and acceptability and included closed and open-ended questions.

Results

Thirty-seven students participated in the taste test. The average age was 10.1 years (range: 7 – 13). Mean scores for acceptability and palatability were similar for both burger types. Students indicated taste as a key driver of burger preference.

Applications to Child Nutrition Professionals

This study demonstrated a comparable palatability and acceptance of the blended burger and the beef burger. These data can be utilized to demonstrate the advantages to schools considering adding mushroom-blend burgers to their menus as a lower calorie, lower fat burger option.

Keywords: taste test; energy density; palatability; food preference; school lunch program

INTRODUCTION

Over 30% of children and adolescents (ages 2 through 19) in the United States are overweight or obese (Ogden, Carroll, Kit, & Flegal, 2014). The rise in obesity prevalence in children over the past two decades in the U.S. has been accompanied by an increase in high energy density (ED in kcal/g) foods in the nation's food supply, and epidemiologic evidence suggests overconsumption of high ED foods is associated with higher daily energy intake, higher body mass index, and obesity risk (Drewnowski, 2004; Mendoza, Drewnowski, Cheadle, & Christakis, 2006). Research is needed to determine the most effective ways to reduce dietary ED, and schools provide an ideal setting to impact children and adolescents' dietary intake, as over 30 million students participate in the National School Lunch Program (NSLP) each day (U.S. Department of Agriculture [USDA], Food and Nutrition Service [FNS], 2013).

Dietary quality of school meals and students' nutritional intake have been highlighted as areas in need of improvement, particularly the excess of calories and saturated fat (Institute of Medicine, 2009; Clark & Fox, 2009; Gordon et al., 2009; USDA & U.S. Department of Health and Human Services [USDHHS], 2015). As part of the continued effort to combat childhood obesity in America and improve nutritional quality of school meals, new school meal standards were released in January 2012. These requirements include increasing servings of fruits, vegetables, and whole grains, higher levels of protein, vitamin A, vitamin C, calcium, and iron, while limiting saturated fat, *trans*-fat, cholesterol, added sugar, and sodium (USDA- FNS, 2012). Further, the Scientific Report of the 2015 Dietary Guidelines Advisory Committee identifies a healthy dietary pattern as lower in red and processed meat (USDA & USDHHS, 2015).

A potential strategy to improve school meal nutritional quality is to partially substitute higher ED meat with lower ED ingredients in recipes. Some, but not all, previous research has demonstrated that school lunch recipes made with partially substituted lower ED ingredients, such as soy-based ingredients, are accepted by students and improve nutritional quality (Ashraf, Schoeppel, & Nelson, 1990; Endres, Barter, Theodora, & Welch, 2003; Klein, 2006; Thomas & Lutz, 2001). Mushrooms as a substitution in meat-based recipes have the potential to be a viable option among students and help lower the fat and caloric composition of school meals while maintaining adherence to school meal regulations.

Mushrooms are a low ED food with the most common forms in the American diet providing 24 - 31 kcals and 0.2 - 0.34 grams of fat per 100 grams (Feeney et al., 2014). In addition to reducing energy intakes, the sensory qualities of mushrooms, including the texture and umami taste, may contribute to the utility of a meat-mushroom blend (Feeney, Myrdal Miller, & Roupas, 2014; Myrdal Miller et al., 2014). Previous studies investigated how substituting white button mushrooms for beef in a test lunch in the short-to-intermediate term affected energy intake, palatability, appetite, and satiety in normal weight, overweight, and obese adults. Energy intakes were significantly higher during meat lunches than mushroom lunches, and there was only partial energy compensation for this difference over four days. Total daily energy intake was also significantly greater on the meat days, while ratings of palatability, appetite, satiation, and satiety did not differ significantly (Cheskin et al., 2008). A more recent study found an advantage to mushroom substitutions on a longer-term basis in adults (Poddar et al., 2013). These results strongly suggest that the substitution of low ED mushrooms for high ED foods such as beef can be an effective method for reducing total daily energy intake.

Previous research suggests that the concept of blending higher ED ingredients with lower ED ingredients could be applied to a popular commercial item and tested in the school setting as a method to improve nutrient intake among children. This pilot study builds on the experimental results above to test the palatability and acceptance of mushroom-soy-beef blend burgers among school-aged children. Researchers sought to determine student acceptability of the blend burger for use in the school food program prior to developing a full scale operational intervention.

METHODOLOGY

Sample and Procedures

The study procedures consisted of a taste test comparing two burger versions (traditional beef burger (JTM Food Group, n.d.- a) versus a mushroom-soy-beef "blend" burger (JTM Food Group, n.d.- b) (Table 1). While the beef burger's primary ingredient is ground beef, the blend burger's primary ingredients are ground beef, mushrooms, and textured vegetable protein. A Baltimore City Public School System Registered Dietitian provided input into the study design and was on site during test testing, ensuring that the burger products and preparation methods were consistent with the school district's existing product availability and protocols.

One Baltimore City elementary/middle (Pre-K - 8th grade) public charter school participated in this study and was recruited based on a prior relationship with a study team member. The school administrators provided assistance in scheduling and recruitment and access to their kitchen and cafeteria facilities. All children in grades 2-8 who participated in the after-school program were invited to participate.

Table 1. ***Nutrient Comparison Between Blend Burger and Beef Burger***

	Blend Burger	**Beef Burger**
Serving Size (ounces)	2.46	2.45
Calories	129	176
Protein (grams)	12	12
Carbohydrates (grams)	2	3
Total Fat (grams)	8	12
Saturated Fat (grams)	3.1	4.8
Trans Fat (grams)	0	0.8
Cholesterol (milligrams)	32	49
Sodium (milligrams)	215	279
Fiber (grams)	1	0
Iron (milligrams)	1	1

A double-blinded taste test was performed in randomized order of presenting the two burger types, labeled as "Burger A" and "Burger B." The school's cafeteria manager prepared both burger types, following the school's nutrition service standard procedures and as recommended by the manufacturer (cooked in steamer to preserve moisture). Interviewers administered the

taste test to each student individually. One half of a 2.45 ounce burger of each variety was served, each on one half of a hamburger roll. Condiments (ketchup and mustard) were offered. In order to cleanse the palate, the student was asked to drink a little water and then wait approximately two minutes, timed by the interviewer (Skokan, Junkins, Corneli, & Schunk, 2001). Burger 1 ("A" or "B" depending on order of randomization) was then placed before the child with instructions to eat as much as desired, but at least one bite. After the student tasted Burger 1, the interviewer administered survey questions to assess acceptability of Burger 1. The student was then asked to drink water and then taste Burger 2, given the same instructions as for Burger 1. After the student tasted Burger 2, the interviewer administered survey questions to assess acceptability of Burger 2, followed by survey questions to assess preference for Burger 1 or Burger 2.

Data collection was completed on a single day in November 2014. Parents provided written consent, and students volunteered and provided oral assent to participate. Students received a $10 gift card for their participation. The study procedures were reviewed and approved by the Johns Hopkins Bloomberg School of Public Health Institutional Review Board, and the Baltimore City Public Schools System Office of Research and Accountability.

Outcome measures

Demographic variables including age, gender, and grade level were collected. The survey also consisted of questions on palatability, acceptability, and preference.

Palatability and Acceptability. Students completed a 7- point Hedonic Facial Scale (grades 2- 5) or a 7-point Likert scale (grades 6- 8) to assess acceptability, including flavor, appearance, texture/consistency, tenderness/juiciness, smell/aroma, and overall satisfaction with the burger.

The Food Action Rating Scale (FACT) is a 9-point rating scale which has been used in multiple consumer preference studies (Aliani, Ryland, & Pierce, 2012; Jones et al., 2014; Ludy & Mattes, 2012; Schutz, 1965). A modified version of the FACT, using a 5-point rating scale, was administered to determine the children's perceptions of acceptability. The modified FACT scale values were as follows: 1= "I would eat this only if I were forced to"; 2= "I would hardly ever eat this"; 3= "I would eat this if available but would not go out of my way"; 4= "I would eat this very often"; 5= "I would eat this food every opportunity I had."

Preference. To determine burger preference the following question was asked: "If each of the burgers you just ate was offered next week in your school cafeteria, and you had to choose one, which one would it be?" Open-ended questions were as follows: "What about your first choice of burger did you like?" and "What about your second choice did you dislike?"

Data Analyses

Using Stata Version 11, mean scores on the Hedonic Facial Scale or Likert scale and FACT ratings were compared for significant statistical differences between the two burgers.

RESULTS AND DISCUSSION

Thirty-seven students (20 girls, 16 boys, 1 gender not recorded) with an average age of 10.1 years (range: 7 -13 years) participated in the taste test. Two students declined participation.

Outcome Measures

Palatability and Acceptability. There were no differences in mean acceptability scores for flavor, appearance, texture/consistency, tenderness/juiciness, smell/aroma, and overall satisfaction between the beef burger and blend burger (Figure 1). Beef burger and blend burger FACT ratings were also not significantly different (3.8 vs. 3.6, p-value: 0.80).

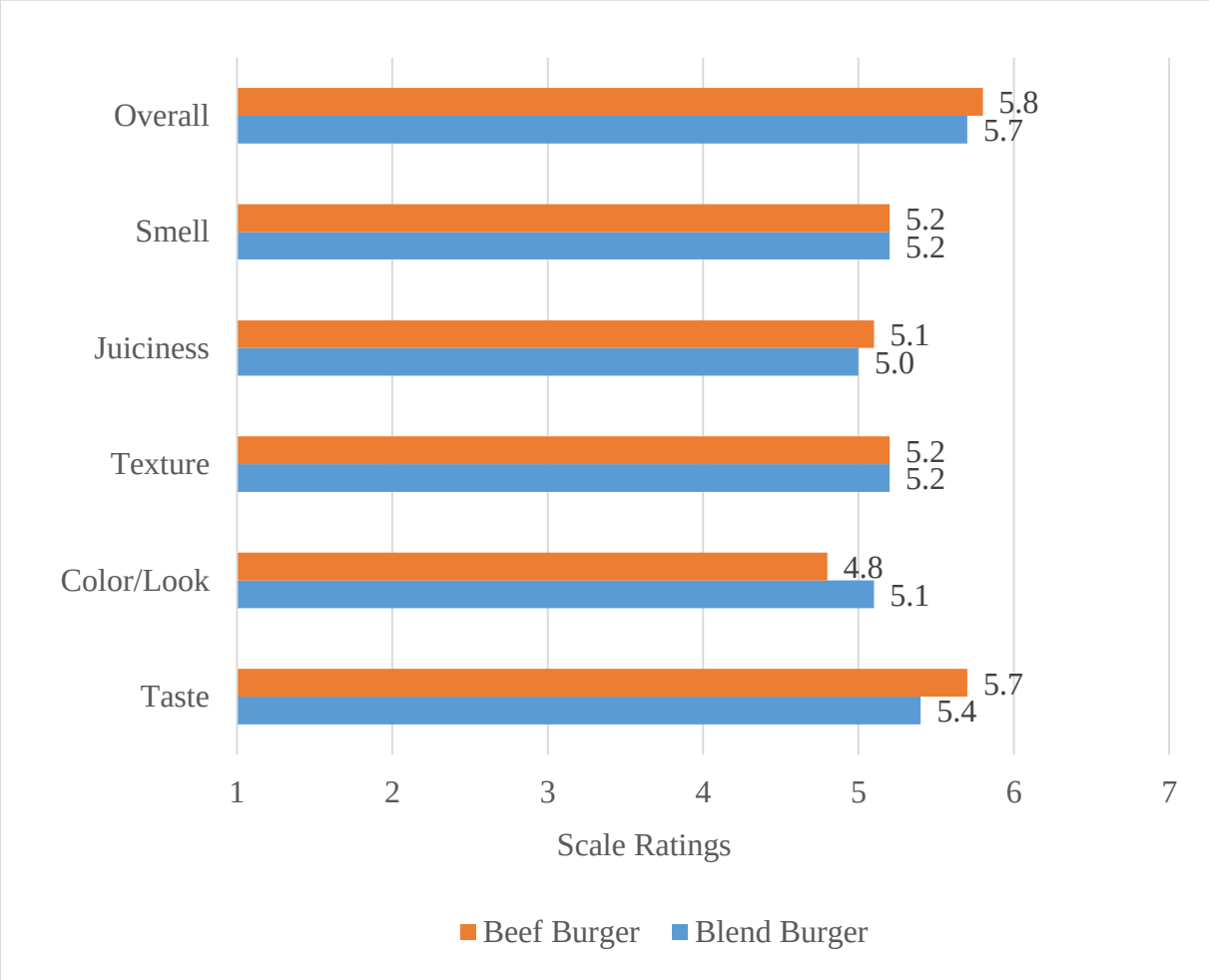

Figure 1. ***Burger Acceptance Ratings Among Students Participating in a Taste Test of Blend burgers and Beef Burgers (n= 37)***

Preference. When asked which burger they would choose if it were offered next week in the school cafeteria, 14 (37.8%) students chose the blend burger and 23 (62.2%) chose the beef burger (Table 2). The blend burger was preferred over the beef burger by 35.0% (n= 7) of girls and 43.7% (n= 7) of boys; however, there were no statistically significant differences in burger preference observed based on gender (p= 0.593). The majority (75.0%, n= 12) of students aged

10 and older preferred the beef burger over the blend burger (Table 2). No statistically significant differences in burger preference were observed based on age (p= 0.160).

Table 2. ***Burger Preference Among Students Participating in a Taste Test of the Blend Burger and Beef Burger by Age and Gender*** *(n= 37)*

	n	Blend Burger	Beef Burger	*p*-value
All	37	14 (37.8%)	23 (62.2%)	
Gender [a]				0.593
Female	20	7 (35.0%)	13 (65.0%)	
Male	16	7 (43.8%)	9 (56.3%)	
Age				0.160
≤ 10 years	21	10 (47.6%)	11 (52.4%)	
≥ 10 years	16	4 (25.0%)	12 (75.0%)	

[a] One student with no response to gender: preference response was beef burger

Among the 14 students who choose the blend burger as their first choice, 11 student responses were related to taste when asked, "What about your first choice of burger did you like?" For instance, *"Tastes good, didn't taste nasty."* Other common answers were related to texture. For instance, *"[It had] more flavor and it had a soft texture when I chewed it."*

When 14 students who preferred the blend burger were asked what they did not like about their second choice, the majority (n= 8) of students' responses were related to poor taste. For example, *"Tastes not as good"* and *"It doesn't taste sweet"*.

Among the 23 students who choose the beef burger as their first choice, 17 students also referred to taste. Other common responses were related to texture and juiciness. For example, *"It was more juicier and tasted better"; "Really good flavor like one you'd buy at a restaurant."*

When students who preferred the beef burger were asked what they did not like about their second choice, most students responded with poor taste (n= 12) or poor texture (n=9). For instance *"Really hard to swallow, doesn't have much flavor"* and *"Hard, didn't have much taste."*

Discussion

This study demonstrated a comparable level of acceptance, palatability profile, and satiety value of the two burger types. These data, along with nutritional data on the lower fat and calories of the blended burger, suggest potential advantages to schools considering adding mushroom-blend burgers to their menus.

Through plate waste studies, children in school settings have previously been shown to demonstrate acceptance of recipes partially substituted with lower ED ingredients, specifically soy (Ashraf, et al., 1990; Endres, et al., 2003; Klein, 2006). For example, plate waste data was used to measure the acceptability of both soy-substituted and soy-enhanced products during a four-week period among over 1,000 elementary school students (1^{st} to 6^{th} grade). The researchers found that the percentage of foods consumed was similar for soy-based and traditional entrées, with the exception of "chicken-like" nuggets (Klein, 2006).

In the current study, 62% of students preferred beef burger over the blend burger. Although multiple characteristics, such as texture, juiciness, and appearance were also described as reasons for liking or disliking burger choices, qualitative data indicated that taste is a primary sensory characteristic driving preference, which is consistent with the literature (Glanz, Basil, Maibach, Goldberg, & Snyder, 1998).

Taste preference is influenced by multiple factors, including genetics, social determinants, parental influence, the home food environment, and exposure (Adair & Popkin, 2005; Drewnowski, 1997). Experience with the taste of foods and repeated exposure increases acceptance and preference for selected foods, highlighting the importance of exposure frequency (Cooke, 2007; Lakkakula, Geaghan, Zanovec, Pierce, & Tuuri, 2010; Sullivan & Birch, 1990; Wardle & Cooke, 2008; Wardle et al., 2003). Repeated exposure to beef burgers and the higher fat content could potentially lead to some students preferring the beef flavor over the blended flavor (Birch, 1992).

This study had some limitations. First, a relatively small sample size limited the power to test differences between subgroups, such as age and gender. Second, the study was completed at one school with students who participated in the after school program; therefore, the findings may not be generalizable to students outside of this school program. The participating school also has a consistent history of health promotion. Students are exposed to various foods and nutrition education opportunities through their full-time, on-site food educator, which also limits the generalizability of the study. Third, study participants were self-selected. It is unknown whether the students who participated were more open to new recipes than students who did not participate, or if they had different levels of exposure to mushrooms or soy.

A key strength of the study was the randomized, controlled and blinded taste-testing procedures utilized, which would reduce any bias resulting from knowing which burger contained the mushroom and soy ingredients. Further, the equipment used to prepare the burgers for taste testing was the same that would be used in standard school operating procedures, and was overseen by the school's cafeteria manager.

CONCLUSIONS AND APPLICATIONS

Multiple barriers exist to serving more healthful food options in school settings, including taste and quality of the foods served (Brouse, Wolf, & Basch, 2009; Cho & Nadow, 2004; Gordon et al., 2007; Meyer et al., 2001; Nollen et al., 2007). This research provides support for student acceptability of a burger that is lower in fat and energy density (kcal/gram). While the beef burger provided 2.39 calories per gram, the blend burger provided 1.85 calories per gram. The blended burger tested in this pilot study would allow school nutrition programs to serve a burger

that is a similar portion size, while adhering to school meal guidelines. In addition to increasing exposure to new ingredients, taste tests with students provide the opportunity for students to provide feedback on potential new recipes, and can help increase engagement in school nutrition and the menu planning process.

Future research should include a larger sample size so that differences in preference based on age can be better understood. Studies on cost effectiveness and impact on dietary intake when using mushroom-blended recipes in schools are also needed. Further research is needed to determine the feasibility, acceptance, and satiety when served in the normal school lunch setting, and is the next step in this research.

Based on our findings, mushroom-soy-beef blended burgers have the potential to be an accepted alternative to higher energy density beef burgers among school-aged children. Additional blended recipes for commonly served school menu items, such as meatloaf, meatballs, and meat-based spaghetti sauce should also be considered and explored.

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BIOGRAPHY

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Acceptance of a Mushroom-soy-beef Blended Burger among School-aged Children

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***Objective*: We tested children's acceptance and the satiety value of a mushroom-soy-beef blended burger versus an all-beef burger in the school cafeteria setting. *Methods*: Students in 3rd to 8th grade completed self-administered surveys to measure choice (blended vs all-beef burger), acceptance, and satiety during normal school lunch hours. *Results*: Ninety-two students (47.6%) and 101 (52.3%) students chose the blended and all-beef burger, respectively. Only 24 (24.7%) students who choose the blended burger and 23 (25.0%) students who choose the all-beef burger would not choose that burger again. Mean satiety score was similar for the 2 burger types (p = .243). *Conclusion*: Acceptance and satiety of a blended and an all-beef burger are comparable among children in the school cafeteria setting.**

***Key words*: child; school; food preferences; satiety**
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As part of the effort to combat childhood obesity in the United States (US), there have been notable changes in school lunches. In 2010, Congress passed legislation to improve child nutrition and decrease hunger across the US. The *Healthy, Hunger-Free Kids Act of 2010* (S.3307) helps ensure children have access to healthful food options in school by requiring the US Department of Agriculture (USDA) to establish nutrition standards for all foods sold in schools, beginning in 2012.[1,2] Requirements include increasing consumption of fruits, vegetables, and whole grains, while limiting saturated fat, trans-fat, cholesterol, added sugar and sodium. Portion sizes also are reduced for some age groups to align better with caloric needs.[3] School nutrition professionals are challenged to provide foods that meet these new standards, and that are also acceptable among students in both taste and satiety.

Incorporating mushrooms into school meals has the potential to be a viable option to help adhere to school meal regulations by lowering the fat and caloric composition of meals, in addition to exposing students to a greater diversity of foods. Mushrooms are a low energy density [ED, in kcal/g] food and a source of fiber, selenium, vitamin B12 and several

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other vitamins and minerals.[4] Consumption of high ED foods are associated with higher daily energy intake and risk for obesity among US children.[5] Mushrooms also have sensory qualities such as meat-like texture and umami taste that may contribute to the utility of a meat-mushroom blend. Thus, they can be incorporated into familiar meat-based recipes.[4,6]

We previously conducted a series of studies to explore the short, intermediate, and long-term effects of substituting white button mushrooms for beef in a test lunch on energy intake, palatability, appetite, and satiety (general fullness) in normal weight, overweight, and obese adults. Energy intake was significantly higher during meat lunches and total daily energy intake also was significantly greater on the meat days, while ratings of palatability, appetite, satiation, and satiety did not differ significantly.[7,8] These results suggested that the substitution of low ED mushroom foods for high ED foods, such as beef, can be an effective method for reducing total daily energy intake without sacrificing taste and satiety. Thus, mushroom-blend alternatives may have utility in settings, which require innovative ways to meet nutrition requirements.

In the school setting, blending higher ED ingredients with lower ED ingredients, such as meat-mushroom blended recipes, can offer children exposure to diverse ingredients and help achieve a diet lower in red and processed meat, as recommended by the Scientific Report of the 2015 Dietary Guidelines Advisory Committee.[9] We have tested this technique by applying it to a popular item among children in the school meal setting. We examined the palatability and acceptance of mushroom-soy-beef blend burgers in comparison to the traditional beef burger to explore the feasibility of utilizing mushroom-blended recipes for school-age children. In a pilot study, 37 children in grades 2 through 8 participated in a randomized, blinded taste test.[10] Students tasted 2 burger types, regular beef and a mushroom-soy-beef blended burger, and completed an interviewer-administered survey after tasting each burger. Mean scores for acceptability and palatability were similar for both burger types. This study demonstrated a comparable palatability and acceptance of the blend burger and the beef burger, and suggested that there may be advantages to schools considering adding mushroom-soy-beef blended burgers to their menus as a lower-calorie, lower-fat burger option.

The current pilot study builds on the series of experimental results above to test the acceptance and satiety of mushroom-soy-beef blend burgers among school-aged children, and to determine feasibility for expanded use in school food programs. It was hypothesized that acceptance and satiety ratings would be similar between the 2 burger types.

METHODS

Participants

We recruited one elementary/middle public charter school in the city of Baltimore, Maryland to complete this pilot study. The participating school was recruited based on existing relationships with the research team and due to the diverse student demographics. For example, a considerably high percentage (76.8%) of students received meal benefits through the Free and Reduced Price Meals (FARMs) government program at the time this study was performed. Enrollment and demographic reports by the Baltimore City Public School System indicated that this school's student body was comprised by white (37%), Hispanic (37%), African-American (19%), Asian/Pacific Islander (1%), Native Hawaiian (<1%), American Indian (<1%) and multiracial (6%) children. Approximately 24% of the students did not speak English as their primary language.

The school food environment included cafeteria volunteers (typically parents), a food education class, and a full-time on-site food educator. The school administrators provided a letter of support for the study agreeing to arrange assistance in scheduling the pilot study, and allowed access to their kitchen and cafeteria facilities.

Procedures

All students in grades 3 to 8, who participated in the school lunch program on study days, were invited to participate. Students were given a description of the study to take home; parents were asked to contact the school administrators or the principal investigator if they did not want their child to participate. Parents also were given pertinent information including a consent form and letter stating the study rationale in both English and Spanish.

A burger preference and satiety test was con-

Table 1
Nutrient Comparison between Blend Burger and Beef Burger

	Blend Burger	Beef Burger
Serving Size (ounces)	2.46	2.45
Calories	129	166
Protein (grams)	12	12
Carbohydrates (grams)	2	0
Total Fat (grams)	8	12
Saturated Fat (grams)	3.1	4.8
Trans-fat (grams)	0	0.8
Cholesterol (milligrams)	32	49
Sodium (milligrams)	215	254
Fiber (grams)	1	1
Iron (milligrams)	1	1

ducted in the school cafeteria during normal lunch procedures comparing the same 2 burger products previously tested (traditional beef burger versus a mushroom-soy-beef "blend" burger) (Table 1).[10-12] The Baltimore City Public School System's registered dietitian provided input during the development of the research plan and study procedures, ensuring that the burger products and preparation methods were consistent with the school district's existing product availability and protocol. The purchase of additional kitchen equipment was not necessary to participate in this pilot study, and the preparation of both burger types was similar. The beef burgers were already part of the school menu, and both burgers were available from the same vendor. The cafeteria manager required minimal training regarding how to prepare the blended burgers, and other cafeteria staff were not involved in the preparation process, only the serving process.

Data collection took place on 3 separate school days, spaced approximately 3 weeks apart, in December 2014 and January 2015 during the same lunch periods on each day. The first 2 days of data collection established a baseline preference for each of the 2 burger types on separate days versus a non-burger choice (Day 1: Beef Burger vs Chicken Sandwich; Day 2: Blend Burger vs Meatball Sub). The third day of testing included a head-to-head comparison of the blend burger versus the beef burger. Students in grades 3- 8 who participated in the school lunch program (including free, reduced-price, and paying students), were offered 2 main entrées using normal school lunch procedures, along with their usual choice of side dishes.

Instrumentation and Measures

Paper surveys were administered on all 3 data collection days. Students were given instructions to complete the surveys on their own at the lunch table immediately after they consumed their lunch. During the completion of these surveys, the on-site food educator was not present. The study staff members and the usual school cafeteria volunteers helped make sure students completed the entire survey on their own. The blend burger was referred to as the "power burger" in the paper surveys and during verbal instructions for completing the survey. Upon returning their completed survey on each study day, each student was offered a bookmark or ruler.

Demographic variables, including age, sex, and grade level, were collected to describe the sample. The survey also consisted of questions on food choice, acceptability, and satiety.

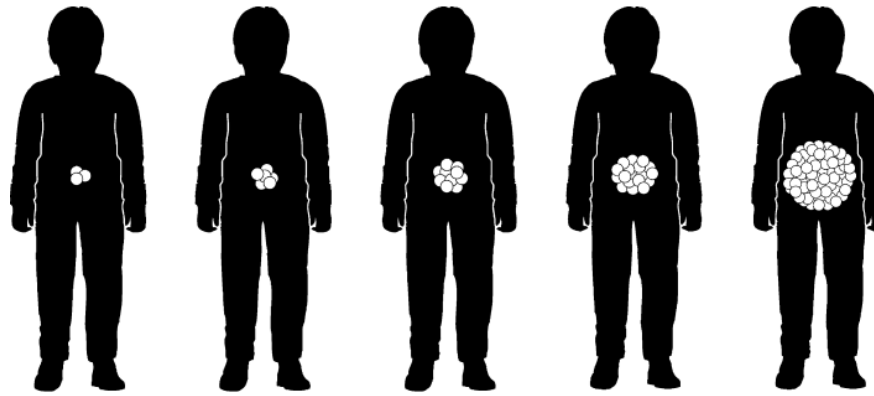
Food choice and acceptability. To determine food choice and acceptability the following questions were asked: "Which did you eat today [entrée 1] or [entrée 2]?" and, "If the item you just ate was offered next week in your school cafeteria, would you choose it again?" Response choices were, "Yes," "No" and "Maybe."

Satiety. To determine satiety, the following question was asked: "How full are you after the lunch you had today?" Students in grades 2 to 5 rated satiety using a validated, sex-specific silhouette satiety scale with 5 profiles, assigned scores 0 to 4 (Figure 1).[13,14] Students in grades 6 to 8 completed a visual analog scale (VAS), anchored by extremes of hunger and fullness.

Data Analysis

The goal of data analysis was to determine the proportion of students choosing each entrée and to evaluate the acceptability and satiety of the

Figure 1
Satiety Silhouette for Males



Note.
Validated, satiety silhouette used to measure satiety among students in grades 2 to 5. Male and female silhouettes were provided. Reprinted with permission from Elsevier.
Faith MS, Kermanshah M, Kissileff HR, Development and preliminary validation of a silhouette satiety scale for children. *Physiol Behav*. 2002;76(2):173-178.

mushroom-soy-beef blend burger compared to the traditional beef burger, in the school cafeteria setting. Survey responses were tallied to determine the number and percentage of students choosing the blend burger and beef burger from the cafeteria line in comparison to the non-burger alternative and each other. Survey responses also were tallied to determine the proportion of students who suggest they would choose each entrée again in the future. Satiety score for grades 6 to 8 were calculated by measuring the distance in millimeters from 0, and was re-coded into categories (0, 1, 2, 3, 4) with 0 indicating "extremely hungry" and 4 "not at all hungry," so that satiety ratings for all ages could be merged. We calculated mean satiety scores by entrée and significant differences in mean scores between entrées using STATA Version 11 (StataCorp, College Station, TX).

Table 2
Student Acceptance of the Beef Burger, Blend burger and Non-burger Alternatives

	Day 1		Day 2		Day 3	
	Beef Burger	Chicken Sandwich	Blend Burger	Meatball Sub	Blend Burger	Beef Burger
	(N = 28)	(N = 199)	(N = 115)	(N = 68)	(N = 97)	(N = 92)
No	2 (7.1%)	24 (12.1%)	26 (22.6%)	22 (32.4%)	24 (24.7%)	23 (25.0%)
Yes	13 (46.4%)	99 (49.8%)	28 (24.4%)	10 (14.7%)	15 (15.5%)	18 (19.6%)
Maybe	13 (46.4%)	76 (38.2%)	61 (53.0%)	36 (52.9%)	58 (59.8%)	51 (55.4%)

Note.
Student responses to "If the item you just ate was offered next week in your school cafeteria, would you choose it again?"

Table 3
Day 3-Beef Burger versus Blend Burger, Entrée Choice by Sex and Age

		N	Beef Burger	Blend Burger	p
Sex					
	Girls	100	51 (51.0%)	49 (49.0%)	.701
	Boys	93	50 (53.8%)	43 (46.2%)	
Age					
	≤10 years old	92	54 (58.7%)	38 (41.3%)	.090
	≥10 years old	101	47 (46.5%)	54 (53.5%)	

RESULTS

Surveys were completed during the same 3 lunch times on each of the 3 data collection days. For all 3 study days, the mean age of survey participants was 10.7 years old (range: 8-15).

Day 1: Beef Burger vs. Chicken Sandwich

On Day 1 of testing, 228 students (110 girls, 117 boys, 1 missing) chose one of the 2 featured entrées from the cafeteria line and completed the survey. The chicken sandwich was chosen by 200 students (87.7%), and the beef burger was chosen by 28 students (12.2%). When asked if they would choose their selected entrée again next week if offered for lunch, 46.4% (N = 13) of students who chose the beef burger said "yes," and 49.8% (N = 99) of students who chose the chicken sandwich said "yes" (Table 2). Mean satiety score was similar for the beef burger and the chicken sandwich (2.3 versus 2.4, p = .884).

Day 2: Blend Burger vs. Meatball Sub

On Day 2 of testing, 184 students (81 girls, 103 boys) chose an entrée from the cafeteria line and completed the survey. The blend burger was chosen by 117 (63.2%) students, and the meatball sub was chosen by 68 (36.8%) students. When asked if they would choose their entrée again next week if offered at lunch, 24.4% (N = 28) of students who chose the blend burger said "yes," and 14.7% (N = 10) of students who chose the meatball sub said "yes" (Table 2). Most responses were "maybe" for the blend burger (N = 61, 53.0%) and meatball sub (N = 36, 52.9%), respectively (Table 2). Mean satiety score was similar for the blend burger and the meatball sub (2.3 vs 2.4, p = .7431).

Day 3: Blend Burger vs. Beef Burger

On Day 3 of testing, 193 students (100 girls, 93 boys) chose an entrée from the cafeteria line and completed the survey. The blend burger was chosen by 92 students (47.6%) and the beef burger was chosen by 101 students (52.3%). No significant differences were observed based on sex or age for burger choice (Table 3). When asked if they would choose their entrée again next week for lunch, 19.6% (N = 18) of students who choose the blend burger said "yes," and 15.5% (N = 15) students who choose the beef burger said "yes." Most responses were "maybe" for the blend burger (N = 58; 59.8%) and beef burger (N =51; 55.4%), respectively (Table 2). Mean satiety score was similar for the blend burger and the beef burger (2.2 vs 2.0, p = .243).

DISCUSSION

We demonstrated a comparable acceptance and satiety value of the blend burger compared with the beef burger, while maintaining strict adherence to federal school lunch guidelines. When asked if they would choose their entrée again the following week, 77.4% and 79.4% of students who choose the blend burger said "yes" or "maybe" on Day 2 and Day 3, respectively. On Day 3, head-to-head comparison of the burgers, only 24.7% (N = 24) of students who chose the blend burger would not

choose that burger again next week, compared to 25.0% (N = 23) of students who chose the beef burger.

All entrées except the blend burger were on the usual menu rotation at the school. Test days 1 and 2 provided a baseline for each burger option, but also exposed most students to the blend burger as an entrée option for the first time (however, not all students tried the blend burger). The chicken sandwich was a clear favorite when offered with the beef burger and was chosen by the highest proportion of students in comparison to all other options.

Previous studies have found that blended recipes (such as soy-enhanced ground beef) were acceptable to students through measuring plate waste or purchase data.[15-17] For example, plate waste data was used to measure the acceptability of both soy-substituted and soy-enhanced products during a 4-week period among >1000 elementary school students (grades 1-6). The researchers found that the percentage of foods consumed was similar for soy-based and traditional entrées, except for "chicken-like" nuggets.[17] In another study, Maryland middle school students were served 4 soy-based products. Three of the 4 soy-based products were selected at a similar frequency to the traditional versions at lunch time. No significant differences were observed in amounts consumed of macaroni and cheese with soy pasta (Midland Harvest Pasta), a "hybrid" patty with half ground beef and half soy (Healthy Grillers Beef Patties), and soy-based nuggets (Morningstar Farms Veggie Chick'n Nuggets) compared to traditional versions based on plate waste; however, significantly fewer of the soy-based "chicken-less" slices (Garden Veggie Chick'n) were consumed compared to traditional chicken in Caesar salad.[18]

Satiety values were similar for both entrées served on each of the 3 study days. Although the blend burger provides 27% fewer calories and 33% fewer fat grams per serving than the beef burger, both are the same portion size (2.45 ounces), which may have contributed to the similar satiety ratings of the 2 burgers. These data, along with nutritional data on the lower fat and calorie content of the blend burger, and the previous experimental studies on palatability and acceptance, demonstrate that there are potential advantages for schools considering adding mushroom-blend burgers to their menus.

Strengths and Limitations

Our study has several strengths. The emphasis on mushrooms as the primary blending ingredient makes this pilot study both unique and innovative, in addition to examining differences in satiety. If this pilot study were to be implemented on a larger scale, additional training and kitchen equipment should not represent a significant challenge as the preparation process was similar for the blended and beef burgers. Based on personal communication with the JTM Food Group regional sales manager, the blended burger is approximately 14¢ less expensive than the all-beef burger. This cost difference is based on the "commercial" cost that includes the full value of the ingredients, which does not include USDA donated foods to reduce the cost of the beef or mushrooms (Personal communication, Lisa Pline, JTM Food Group Regional Sales Manager, July 15, 2016). Because the blended burger had a comparable acceptance and satiety response when compared to other choices already included in the school menu, our study might suggest a potentially cost-effective strategy aiming to lower, or at least maintain, preparation costs while reducing energy density.

We also call to attention several limitations of this study. First, the study was conducted in a single public charter school with an existing emphasis on nutrition and health promotion, exposing their students to various foods and nutrition education opportunities. This may limit the generalizability of the findings to schools and school districts without these resources. We recommend additional testing in schools with a varying level of exposure to alternative menu items and food education opportunities as a next step. Second, whereas there was no evidence of this, as the survey was self- administered, there is the potential for misinterpretation of instructions. Third, although age-appropriate rating scales and a validated satiety scale were used, future studies should examine the reliability and validity of the food acceptance measure used in this study. Finally, traditional beef and blend burgers were not compared against the same non-burger alternative.

Despite these limitations, this pilot study demonstrated a practical method for serving a lower energy density entrée following standard school operating procedures, which was also accepted

by students. Incorporating a mushroom-blended recipe into school menus is only one of the many components that may improve the school food environment, and has the potential to help achieve school nutrition quality standards and introduce students to a lower fat, lower calorie option. An examination of the strengths and limitations of this pilot study can inform efforts to design future studies in additional school settings to assess the feasibility of a large-scale expansion.

IMPLICATIONS FOR HEALTH BEHAVIOR OR POLICY

Although testing in additional schools with a broader range of student demographics in various settings is warranted, school nutrition professionals may wish to consider mushroom-blended recipes for helping meet school nutrition guidelines and as a nutrition education opportunity. This will expose students to more diverse ingredients and offer the potential to provide a new way to incorporate delicious, low energy density foods into their diets. Incorporating mushrooms into traditionally-offered recipes or commercial products, such as burgers, spaghetti, lasagna, and meatloaf, may be most feasible. This can be combined with other strategies suggested to increase acceptance of lower-fat options, such as having school personnel encourage students to try new foods when served, providing education about food origin when serving novel foods in the classroom and cafeteria setting, and having an appealing presentation.[19,20] One large school food service provider, Sodexo, has reported its plans to incorporate blended burgers into school meals nationwide through their 250 K-12 school district accounts, further indicating the potential feasibility of this practice.[21]

In addition to student preferences and federal school nutrition standards, multiple factors influence the feasibility of incorporating new options into school meals, such as a school environment supportive of the change, adequate labor and training, and food costs.[22] A supportive school environment can be fostered by involving the entire school community in menu planning decisions (such as through school health councils, focus groups, and surveys). We suggest conducting taste tests or otherwise exposing students to the new option prior to serving it on the cafeteria line; this increases familiarity and exposure. We further suggest that menu changes be communicated with personnel, students, and parents, and that such communications include the rationale for considering menu changes and the potential benefits to student nutrition and health of new types of offerings.

In our pilot study, minimal training for the cafeteria manager was needed to prepare the blended burgers. Whereas the cost of blended and all-beef burgers was comparable in this pilot study, an exploration of cost effectiveness for school lunch operations is valuable. Future research could explore the quantitative impact substituting the lower ED mushroom-soy-beef blend burger and other mushroom-blended recipes for traditional school meals has on students' overall dietary intake, as well as explore the impact of marketing strategies in schools on choice and acceptance of such new food options.

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Human Subjects Approval Statement

The Johns Hopkins Bloomberg School of Public Health Institutional Review Board reviewed and approved study procedures (IRB# 00005591), as did the Office of Research and Accountability Institutional Review Board of the Baltimore City Public Schools System (IRB# 0000114).

Conflict of Interest Disclosure Statement

All authors of this article declare they have no conflicts of interest.

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