ACCEPTABILITY OF BEST PRACTICE SCHOOL LUNCHES BY HIGH SCHOOL-AGED PARTICIPANTS IN AN OFFER SETTING: A RANDOMIZED CROSSOVER TRIAL

By

GABRIELA PAOLA PUCHE

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Thesis Approved:

Dr. Jillian Joyce

Thesis Adviser

Dr. Deana Hildebrand

Dr. Janice Hermann

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Name: GABRIELA PAOLA PUCHE

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Abstract: **BACKGROUND:** A barrier to improving school lunch dietary quality (DQ) is perceived low acceptability, as participation, selection, and plate waste, in school settings. The purpose of this study was to investigate differences in acceptability of National School Lunch Program (NSLP)-qualifying lunches of high [Healthy Eating Index (HEI)=90-95/100, best practice school lunch, BPSL] and moderate (HEI=75/100, typical school lunch, TSL) DQ in a controlled offer setting by high school-aged children. **METHODS:** This randomized crossover trial included convenience sample of 40 high school-aged students recruited from NSLP-participating schools. Instruments included hunger scale, selection record, taste test survey (TTS), and weighted plate waste assessment. Participants were randomized into three groups, attending three meal conditions (MC) in different order. Each MC had two options for each NSLP meal component: 1) BPSL/BPSL, 2) TSL/TSL, 3) BPSL/TSL. **RESULTS:** Before controlling for covariates, there were no significant differences among 14 acceptability measures when comparing all three MC. After controlling for BMI percentile, usual diet, and meal group, three significant differences in acceptability emerged, including texture TTS subscore, change in hunger score, and milk plate waste. Additionally, when looking at differences in acceptability in MC3 with increasing percentage of BPSL options chosen, there was only one significant difference, "serve at school" TTS subscore. With regression analysis, no significant relationship was detected between percentage of BPSL options chosen and "serve at school" subscore. **DISCUSSION:** Results suggest minimal differences in acceptability between BPSL and TSL, when served alone or in combination, among high school students in a controlled offer setting.

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CHAPTER I

INTRODUCTION

In the United States, we face a serious, prevalent, and costly issue, which is obesity. Nationwide, almost one-third of children are overweight or obese. Moreover, just about half of American adults have one or more preventable chronic diseases directly tied to obesity.[1] The state of Oklahoma has the sixth highest obesity rate for youth ages 10 to 17 years according to a 2017-2018 obesity report.[2] Estimates show that by 2030, almost half of Americans will be obese.[3]

The Centers for Disease Control and Prevention (CDC) state that childhood obesity puts children and adolescents at risk for serious diseases and health conditions, such as all causes of mortality, hypertension, dyslipidemia, type 2 diabetes, heart disease, gallbladder disease, osteoarthritis, sleep apnea, some cancers, low quality of life, mental illness, body pain, and difficulties with normal everyday physical functioning.[4] Children who are obese are more likely to become obese adults, and their obesity and disease risk is likely to be more severe.[5] The national estimated cost of obesity is $109.2 billion per year, and childhood obesity alone is responsible for $14 million in direct medical costs annually.[6] Thus, childhood obesity is a growing and costly issue that needs a high-impact solution.

The relationship between diet and health outcomes is inextricable, and dietary patterns have a central association in the development of obesity.[7] A poor dietary pattern includes the overconsumption of high-calorie, low nutrient-dense foods and beverages,[8] such as refined grains, added sugars, and added fats, and the under consumption of whole grains, fruits, and vegetables, and has been directly tied to obesity.[9] In contrast, a healthy eating pattern that follows the Dietary Guidelines for Americans (DGA) recommendations has been shown to support optimal health.[8]

Currently, the Healthy Eating Index (HEI), a tool that measures dietary compliance with DGA recommendations, shows that the dietary intake patterns of US children ages 6-17 years have a score of 53 out of 100.[41] According to the USDA Center for Nutrition Policy and Promotion, this score indicates that the dietary intake patterns of children do not conform to dietary recommendations and need improvement.[9] Based on the need for improvement in the diets of American children and its association with increased risk of obesity, a large-scale solution is needed that will tackle these connected issues.

The National School Lunch Program (NSLP) is one such solution. The purpose of the NSLP is to safeguard the health and well-being of children across the US by providing meals that are nutritious and inexpensive.[10] The CDC states that schools should model and reinforce healthy dietary behaviors by ensuring that nutritious and appealing foods and beverages are provided in all food venues in schools.[11] The DGA recommends that schools are an ideal setting in which to support healthy food choices.[12] Currently, school lunches meeting the minimum NSLP nutrition standards have a HEI score of 77.2 out 100,[13] which is significantly better than that of the average US child's diet (53/100), but still needs improvement.

There are several perceived barriers to improving dietary quality of school lunches, including concerns over lower acceptability. These perceptions cause several questions to arise: 1) what choices do children make when given the option between high and moderate dietary

quality food items in an offer setting, 2) what is the acceptability of a high dietary quality school lunch compared to a typical school lunch in an offer setting, and 3) how does increasing selection of higher dietary quality food items impact the acceptability of the resultant meal? This proposed study seeks to answer these practical questions. The purpose of this study is to investigate differences in acceptability of school lunches meeting NSLP nutrition standards of high (HEI score 90-95/100, best practice school lunch, BPSL) and moderate dietary quality (HEI score 75/100, typical school lunch, TSL) in an offer setting by high school-aged children.

Research Questions

1. What meal component choices do high-school children make in the lunchroom to build a reimbursable meal when given the option between BPSL and TSL meal components?

2. What are the differences in acceptability between BPSL meal components as the only options available and TSL meal components as the only options available by high-school children?

3. How does the presence of TSL meal component options impact the acceptability of BPSL meal component options compared to when BPSL meal component options are the only options available by high-school children?

4. What are the differences in acceptability of the complete meal with increasing selection of BPSL meal components when TSL meal components are also available by high-school students?

Purpose

1. To investigate differences in meal component choices high-school children make in the lunchroom to build a reimbursable meal when given the option between BPSL and TSL meal components.

2. To investigate the differences in acceptability between BPSL meal components served alone and TSL meal components served alone by high-school children.

3. To investigate differences in acceptability of the BPSL meal component options when they are served alone as compared to when they are served in the presence of TSL options by high-school children.

4. To investigate differences in acceptability of the complete meal with increasing selection of BPSL meal components when TSL meal components are also available by high-school students.

Hypotheses

1. When given the option between BPSL and TSL meal components, the participants will choose more TSL options.

2. When each are served alone, BPSL meal components will be equally acceptable to TSL meal components.

3. BPSL meal components served alone will be equally acceptable compared to BPSL meal components served alongside TSL meal components.

4. The acceptability of the complete meal will not differ with increasing selection of BPSL meal components when TSL meal components are also available by high-school students.

CHAPTER II

LITERATURE REVIEW

Definition of Dietary Quality

Dietary quality (DQ) defines how "healthy" a meal or diet is by comparing it to guidelines, or recommendations, for a healthy diet that are federally or scientifically established, such as the federally-established Dietary Guidelines for Americans (DGA) created by the United States Department of Agriculture (USDA) or the scientifically-established Dietary Approaches to Stop Hypertension (DASH) recommendations.[14] Dietary quality is a truer to life measure of nutrition, as it evaluates whole diets or dietary patterns as opposed to individual nutrient content. Dietary quality scoring systems are food- and/or nutrient-based and analyze adequacy, variety, moderation, and/or overall balance.

Measurement of Dietary Quality

Dietary quality can be measured by more than 80 different scoring systems.[15] One commonly used example is the Healthy Eating Index (HEI). The HEI measures how closely a diet follows the DGA and is applicable to anyone two years of age or older to whom US diet recommendations apply.[16] The HEI has 13 scoring components. These include total fruits, whole

fruits, total vegetables, greens and beans, whole grains, dairy, total protein foods, seafood and plant proteins, fatty acids, refined grains, sodium, added sugars, and saturated fats. Components are scored out of five or 10 points with a higher score indicating that a diet follows the DGA more closely and is of higher dietary quality. In addition to these components, the HEI also measures adequacy, variety, moderation, and overall balance. The score is standardized proportionally per 1,000 calories. The highest possible score for the HEI is 100 points.[17] According to the USDA Center for Nutrition Policy and Promotion (CNPP), an HEI score between 0-50 indicates a "poor diet," 51-80 "needs improvement," and 81-100 is "good." Some other examples of common DQ scoring systems include the Diet Quality Index (DQI), the Diet Quality Score (DQS), the Healthy Diet Indicator (HDI), and the Mediterranean Diet Score (MDS).[18]

Importance of Dietary Quality

The period between childhood and adolescence is believed to be a crucial period to encourage and establish dietary habits of high DQ,[19] due to its significant associations with health and academic outcomes.[15] In terms of health, a study by Perry et al. investigating the association between DQS overall and component scores and childhood obesity, showed that lower DQS was associated with higher risk of childhood obesity.[20] According to the CDC, young children with obesity tend to keep extra weight into adulthood.[21] Additionally, food habits and behaviors that develop in childhood track overtime and predict disease in adulthood.[22] In support of this notion, a study by Dahms et al. investigating the first development of >1 clinical risk factor, such as hypercholesterolemia, hypertension, type 2 diabetes, or cardiovascular disease (CVD), in relation to a high school dietary quality scoring system named the Alternative Healthy Eating Index (HS-AHEI) found that higher DQ in adolescence was associated with lower risk of developing CVD risk factors as an adult.[23]

Dietary quality is also associated with academic outcomes. In a study by Belot and James investigating the extent of the impact of healthy food in learning and educational outcomes, children that consumed meals of higher DQ had improved grades in English and science and decreased absenteeism.[24] Higher DQ of school lunches has also been associated with 3.4 times improved on-task time and increased alertness in the classroom[25] and higher reading and fluency scores.[26] Thus, higher DQ in childhood results in healthier, more successful lives.

As previously mentioned, the HEI score is a scoring system that assesses how closely dietary patterns align with DGA recommendations. A score between 0-50 indicates a "poor" diet, a score between 51-80 indicates that the diet "needs improvement", and a score between 81-100 indicates a "good diet".[27] According to the USDA CNPP, the diets of children ages 6-17 score 53 out of 100.[28] This score indicates that children are not meeting dietary recommendations and that their diets need improvement and are very close to being poor.

Factors Associated with Dietary Quality

Several factors may influence the DQ of children, such as socioeconomic status (SES), age, sex, and ethnic and/or racial background.[48-53] Dietary behaviors can also impact the DQ of children, such as beverage patterns, portion sizes, meal frequency and meal skipping.[54-56] Lastly, waist circumference is a predictive value for the development of chronic disease amongst children, and a higher waist circumference is associated with lower DQ.[57]

The National School Lunch Program Solution

The diets of US children need major improvement, and thus, a big impact solution is needed. In 2016, there were nearly 54 million school-aged children in the US[29]. During that time, the NSLP provided meals to more than 30 million, or almost 56% of, children in the US.[30] Participating children could eat lunch at school up to 5 days out of the 7-day week, making up

approximately 25% of their weekly meals. Opportunely, school meals can impact a large portion of US children's diets.

As previously mentioned, an average US child's diet has an HEI score of 53 out of 100.[31] Today, a typical school lunch, which meets minimum NSLP nutrition standards, has an HEI score of approximately 75 out of 100.[32] This score is much higher than that of the average US child's diet, but it technically needs improvement and has the potential to be even higher. A cross-sectional study by Joyce et al. investigating the impact on school lunch DQ of implementing child DQ best practices found that school lunch DQ could be as high as 92/100, with gold-standard meals.[32] Based on the importance of improving DQ mentioned above and the possibly major contribution of school lunches to a child's weekly nutrition, it could be of great benefit to US children to increase the DQ of school lunches even further.

Barriers to Improving Dietary Quality of School Lunches

Although the benefits of higher DQ are evident, there are numerous barriers to improving the DQ of school lunches. Perceptions of principals, food service directors, and food service workers are amongst, and shed light on, these barriers. For instance, according to a study by Nollen et al. investigating perceptions of the school heath and food environment, its impact on obesity, and the potential impact of school food legislation, principals and food service personnel don't feel as though schools play a major role in obesity or that it is the responsibility of the school to influence healthy eating habits.[33] Their primary goals related to school lunch are to ensure high participation rates and reduce plate waste.[33] Additionally, according to a study by Fulkerson et al., foodservice personnel feel that food offerings should be based largely on preparing students for the real world by providing choices between healthier and less healthful options.[34] In addition to the need to prepare students by offering choices within meals, a la carte items, sold separately from NSLP reimbursable meals, are reported to be a major source of

revenue for school cafeterias.[34] With this in mind, foodservice personnel feel as though healthy options are not the preferred option and that purchasing choices favor the unhealthier options,[34] hence, there is pressure to serve less healthful foods over healthier options, especially a la carte. To summarize, barriers to improving DQ of school lunches, according to school personnel, include their perceptions of obesity in schools, the need to prepare students for the real world, and financial pressures to serve less healthful options that students will like to increase revenue and NSLP participation while decreasing plate waste.

The barriers listed above are perceived barriers, so the question becomes whether these barriers actually exist. Some research has been done to investigate whether costs increase, participation and revenue decrease, and waste increases with higher DQ lunches, as staff perceive they will. Several studies suggest that some of these barriers may not exist. In a cross-sectional study by Cluss et al. when DQ of cafeteria options was improved, such that there was a greater number of healthier options and fewer less healthful options, purchase of foods with low or no nutritional value subsequently decreased and healthier option purchases equally increased resulting in no major decreases in overall purchases.[36] Another study by Cohen et al. evaluated the impact of updated school meal standards to the state of Massachusetts' competitive food standards (i.e., increasing DQ of foods) on both revenue and participation and found that when healthier foods were offered, there was no decline in participation rates.[36] Regarding plate waste, anecdotal reports of food waste under the 2010 Healthy, Hunger-free Kids Act were put to the test in a study by Schwarts et al. The study found that under these standards, in which fruits and vegetables were placed in individual categories with an increased serving size, fruit was consumed and was not thrown away.[37] These studies begin to dismantle the perceived barriers previously mentioned. However, these studies exclude certain aspects of acceptability and do not look at acceptability when numerous best practices are implemented to improve DQ of the overall

reimbursable meal. This is a critical gap in the literature that may prevent schools from further improving DQ of their meals.

Summary

Dietary quality evaluates dietary patterns by comparing them to established guidelines for a healthy diet. A commonly used measure is the HEI, which has 13 food and nutrient scoring components and evaluates for adequacy, variety, moderation, and overall balance on a 100-point scale. Currently, the HEI score of the average US child's diet is 53 out of 100, which needs improvement and bordering on poor DQ. This is problematic since DQ is positively associated with beneficial health and academic outcomes.

The NSLP impacts many children every day, making it an opportune tool to increase DQ and subsequently decrease risk of obesity and chronic disease, while increasing academic performance, in US children. However, there are numerous perceived barriers, including that when options are improved nutritionally, plate waste will increase, and participation will decrease. Several of these perceived barriers are unsupported by the literature. One of the most common concerns, in the literature and anecdotally, is poor acceptability of higher DQ lunch options. There remain several gaps in the literature when it comes to acceptability of improving DQ of lunch offerings, including lack of attention to certain aspects of acceptability and lack of investigation of acceptability when numerous DQ best practices are implemented. Since this area is a recurring and significant concern and there is limited research in this area, this proposed study aims to bridge that gap by investigating differences in acceptability of school lunches meeting NSLP nutrition standards of high (HEI score 90-95/100, best practice school lunch, BPSL) and moderate (HEI score 75/100, typical school lunch, TSL) DQ in an offer setting by high school-aged children, through the use of taste test surveys, monitoring meal component choices and selection rationale, plate waste assessment, and changes in satiety.

CHAPTER III

METHODOLOGY

Participants

Participants will consist of a convenience sample of 40 high school-aged students recruited from local NSLP-participating high schools. They will be recruited using flyers distributed through email blast at local high schools and through OSU, wellness committees associated with local school districts, social media, and other organized community groups. Incentives will include three free meals, $50, taste tester certificate, research experience, and a packet of recipes to take home.

The sample size was determined through power calculations[38] based on results from a previous and similar study on the acceptability of high DQ lunches in elementary-aged school children.[39] Power was set at 0.8 and alpha at 0.05. The calculations suggested that the sample size include two participants per group. The sample size will be set at 40 total participants (13-14 per group) to compensate for possible dropouts and to allow adequate power for sub-analyses.

Inclusion criteria will include being in grades 9-12, attending a school that participates in the NSLP, and being willing and able to come to all three meal sessions. Exclusion criteria

will include having food allergies and/or intolerances, having issues with chewing and swallowing, being on any medications with significant food/drug interactions, and having any medical conditions requiring a special diet.

Pre-screening will include questions that will be asked through email before coming in person for a full screening. These questions will be: 1) is your child in 9th-12th grade; 2) what school do they attend; 3) are you willing and able to bring them to all three meal sessions; 4) does your child have any food allergies, intolerances, or religious preferences; 5) does your child have any chewing or swallowing issues; and 6) has your child been put on a special diet or told to avoid certain foods by a physician or another licensed medical professional? The participants included after pre-screening will be randomly assigned to one of three groups using a random number generator.

The full, in-person screening will include a physical assessment in which height, weight, and waist circumference are measured. A demographic questionnaire will be administered in which ethnicity, age, grade level, gender, and parents' education level as socioeconomic status proxy will be obtained. Pre-screening questions will also be double-checked at this time. Usual diet will be assessed through use of the Automated Self-Administered 24-Hour Dietary Assessment Tool (ASA24, National Cancer Institute, 2018 version).[40]

Study Design

The study design will be a randomized cross-over trial. The participants will be randomized into three groups and will attend three meal conditions in a different order to control for an order effect. All three meal conditions will have meals presented with equal presentation style. The meal conditions will have two options for each NSLP school lunch meal component: fruit, vegetable, meat or meat alternative, grain, and milk. Participants will be instructed that they must take at least three components with at least one being a fruit or vegetable, to be consistent

with the offer service style in NSLP-participating high schools. A flow diagram of the study design can be found in figure 1. The options served for each meal component will vary based on two levels of the independent variable, dietary quality, including high DQ (best practice school lunch options, BPSL, HEI score of 90-95/100, implements best practices to greatly exceed NSLP nutrition standards) and moderate DQ (typical school lunch options, TSL, HEI score of 75-100, meets minimum NSLP nutrition standards). Meal conditions and the options offered for each meal component can be found in table 1.

Figure 1. Flow Diagram of Study Design

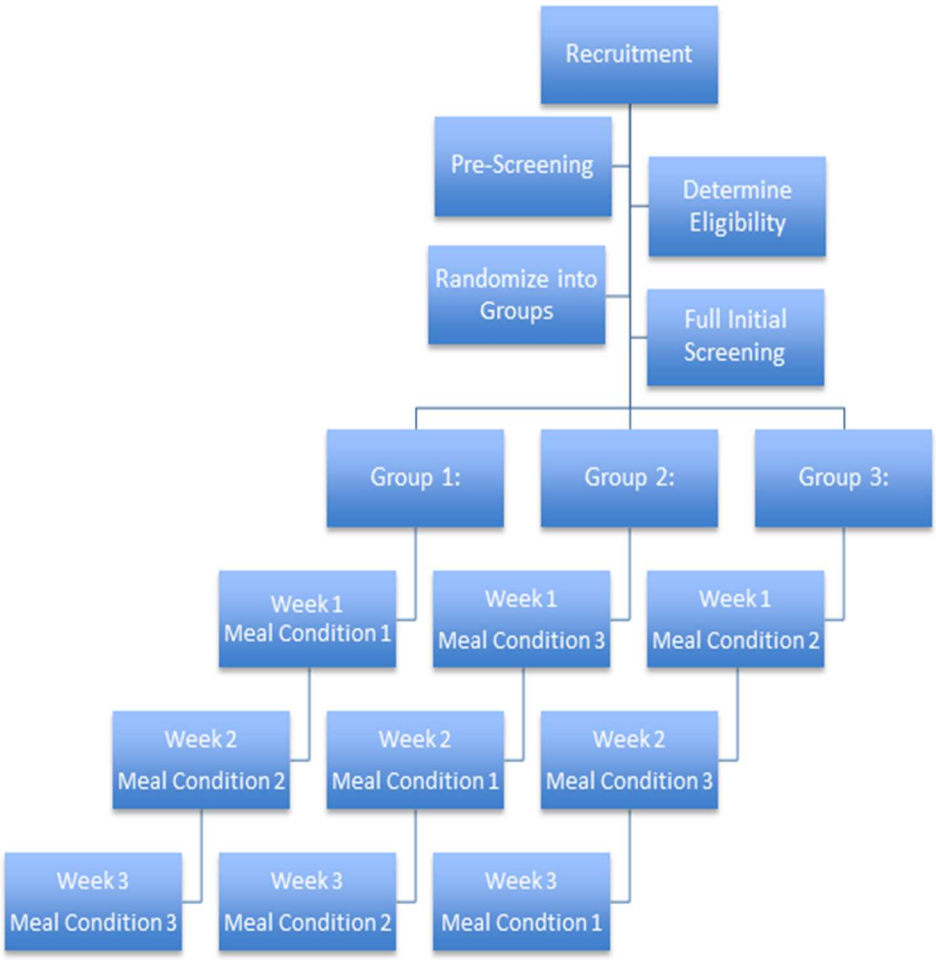


Table 1. Component Options for Each Meal Condition

Component	Meal Condition One Options	Meal Condition Two Options	Meal Condition Three Options
Fruit	BPSL1 – grapes BPSL2 – clementine	TSL1 – pineapple fruit cup in 100% fruit juice TSL2 – Mandarin orange fruit cup in 100% fruit juice	BPSL 3 – apple slices TSL 3 – peach fruit cup in 100% fruit juice
Vegetable	BPSL1 – broccoli salad BPSL2 – side salad w/ Italian dressing	TSL1 – broccoli w/ cheese sauce TSL2 – raw carrots w/ ranch	BPSL 3 – Asian coleslaw TSL 3 – French fries
Grain	BPSL1 – whole-grain cornbread BPSL2 – whole-grain cheese pizza	TSL1 – dinner roll TSL2 – cheese pizza	BPSL 3 – whole-grain slider bun TSL 3 – whole-grain rich hot dog bun
Meat/ Meat Alternate	BPSL1 – oven-baked chicken nuggets	TSL1 – chicken nuggets TSL2 – cheese pizza	BPSL 3 – BBQ pulled pork

	BPSL2 – whole-grain cheese pizza		TSL 3 – hot dog
Milk	BPSL1 – plain low-fat milk BPSL2 – plain low-fat milk	TSL1 – low-fat chocolate milk TSL2 – low-fat chocolate milk	BPSL 3 – plain low-fat milk TSL 3 – low-fat chocolate milk

Acceptability

Currently, there is no consensus in the literature for a definition of acceptability or a single standardized measure of acceptability of school lunches. For the purpose of this study, acceptability will be measured through the recording of choices made and selection rationale; taste test surveys that include questions regarding appearance, taste, smell, texture and temperature; weighted plate waste assessment; and pre-and post-meal hunger and satiety survey. Choices made for each meal component will be recorded on a selection form. The taste test survey that will be used is a modified version of a taste test survey from the Ohio Action for Healthy Kids Website.[42] It will include several 5-point Likert scales to measure how much participants like the taste, appearance, smell, temperature and texture as well as how much the participants would like to see this item served at their school. The taste test survey will also include questions regarding selection rationale. Participants will complete this survey while eating. The weighted plate waste assessment method will be similar to methods previously used in studies by Cohn et al., Adams et al., and Nichols et al., and validated by Jacko et al. from Rutgers Department of Nutritional Sciences and Extension.[43-46] Individual food items will be weighed before service, and food remaining on trays (waste) will be weighed after consumption. A percentage will be calculated for waste from the pre-service weight of the food items. Pictures

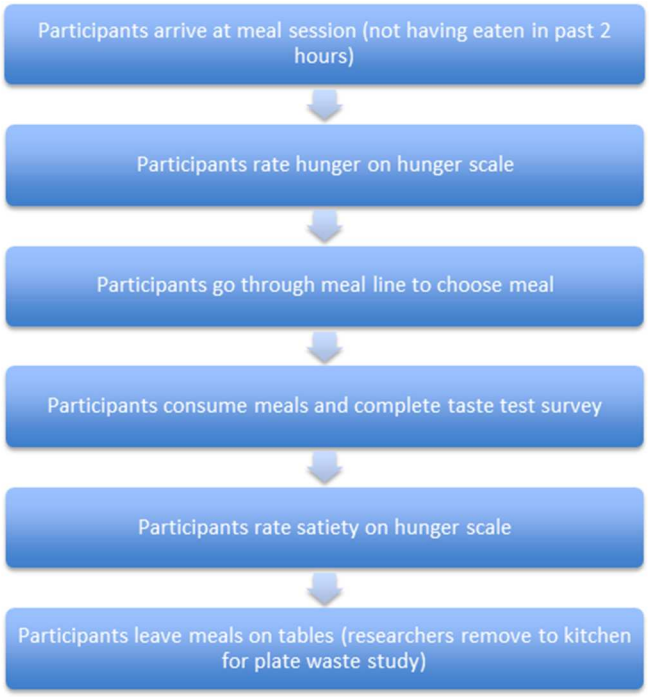
will be taken of all food items before and after service. Pre- and post-meal satiety, or hunger, will be evaluated using a 1-question, 5-point Likert scale commonly used in mindful eating and nutrition therapy for diabetes created by Harvard's Joslin Diabetes Center.[47] Pre-meal hunger score will be subtracted from post-meal hunger score to determine change in hunger.

Meal Session Flow

Each participant will check-in upon arrival and will receive a name tag with a tray ID number. Upon entering the eating area, participants will complete a pre-meal hunger scale. Then, participants will proceed to enter the service area and will build a lunch by selecting one option for each meal component. As this study is simulating an offer service style, participants will have to select at least three of the five meal components with at least one of those being a fruit or vegetable. Researchers will record the choices participants make as they go through the line, and trays will be marked with an ID number for each participant. While participants eat, they will fill out a taste test survey. After they are finished, participants will complete a post-meal hunger scale and leave with their guardian. Finally, researchers will weigh and record each tray's plate waste, along with a picture of each tray. A flow diagram of the meal sessions can be found in figure 2.

In order to keep the environment under control, participants will sit at individual tables to discourage sharing. Garbage cans will be removed from the eating and serving areas. Research assistants will also be monitoring participants to make sure they don't share or take any food with them when leaving.

Figure 2. Flow Diagram of Meal Session



Statistical Analysis

Descriptive statistics will be performed for group characteristics. Groups will be compared for differences in baseline characteristics by using one-way ANOVA and chi-squared. Cronbach's alpha will be used to check internal consistency of the taste test survey and plate waste assessment subcomponents (>0.6). Descriptive statistics will also be performed for all meal condition acceptability measures. A one-way ANOVA will be used to determine differences in acceptability (taste test scores, plate waste percentage, and change in hunger) between higher DQ meal components served alone (meal condition 1) and lower DQ meal components served alone (meal condition 2). A one-way ANOVA will also be used to determine differences in acceptability of the higher DQ meal component options when they are served alone (BPSL in

meal condition 1) as compared to when they are served in the presence of lower DQ options (BPSL in meal condition 3). A chi-squared test will be used to determine differences in meal component choices made to build a reimbursable meal when given the option between higher and lower DQ meal components (meal condition 3). A one-way ANOVA will be used to determine differences in acceptability of the complete meal built in meal condition 3 with increasing selection of higher DQ meal component options when lower DQ meal component options are also available. Regression analysis will be performed to determine how increasing selection of BPSL meal component options in meal condition 3 is related to acceptability. Secondary analysis will be performed using one-way ANCOVAs to control for covariates (gender, age, BMI percentile, waist circumference, ethnicity, socioeconomic status, and group) when investigating differences in acceptability in the scenarios mentioned.

Table 2. Diagram of statistical analyses performed

Statistical Test	**Variables Included**
One-way ANOVA and Bonferroni for multiple comparisons	Difference in age, BMI, BMI percentile, waist circumference, and usual diet HEI score by meal group
Chi-Squared	Differences in sex, weight category, ethnicity, and highest level of guardian education
Cronbach's alpha	Internal reliability or consistency of the taste test survey
One-way ANOVA	Differences in acceptability (taste, texture, temperature, appearance, smell, serve at school, and total taste test scores; change in hunger score; percent plate waste for fruit, vegetable, grains, protein, and milk meal components and average total plate waste) by

	demographics, weight status, level of guardian education, and usual diet HEI score
One-way ANOVA and Bonferroni for multiple comparisons	Differences in acceptability (taste, texture, temperature, appearance, smell, serve at school, and total taste test scores; change in hunger score; percent plate waste for fruit, vegetable, grains, protein, and milk meal components and average total plate waste) by meal condition
One-way ANCOVA	Differences in acceptability by meal condition controlling for meal group, BMI percentile, and usual diet HEI score
One-way ANOVA and Bonferroni for multiple comparisons	Differences in acceptability (taste, texture, temperature, appearance, smell, serve at school, and total taste test scores; change in hunger score; percent plate waste for fruit, vegetable, grains, protein, and milk meal components and average total plate waste) with increasing selection of BPSL options in MC3
One-way ANCOVA	Differences in acceptability with increasing selection of BPSL options in MC3 controlling for meal group, BMI percentile, and usual diet HEI score
Regression Analysis	Relationship between increasing selection of BPSL options in MC3 and significant outcomes from the corresponding one-way ANOVA

CHAPTER IV

MANUSCRIPT

Abstract

Gabriela P. Puche, BS, Kajal J. Patel, BS, Janice Hermann, PhD, RD, Deana A. Hildebrand, PhD, RD, LD, Jillian M. Joyce, PhD, RD

Department of Nutritional Sciences, Oklahoma State University, Stillwater, OK

BACKGROUND: A barrier to improving school lunch dietary quality (DQ) is perceived low acceptability, as participation, selection, and plate waste, in school settings. The purpose of this study was to investigate differences in acceptability of National School Lunch Program (NSLP)-qualifying lunches of high [Healthy Eating Index (HEI)=90-95/100, best practice school lunch, BPSL] and moderate (HEI=75/100, typical school lunch, TSL) DQ in a controlled offer setting by high school-aged children. **METHODS:** This randomized crossover trial included convenience sample of 40 high school-aged students recruited from NSLP-participating schools. Instruments included hunger scale, selection record, taste test survey (TTS), and weighted plate waste assessment. Participants were randomized into three groups, attending three meal conditions (MC) in different order. Each MC had two options for each NSLP meal component: 1) BPSL/BPSL, 2) TSL/TSL, 3) BPSL/TSL. **RESULTS:** Before controlling for covariates, there were no significant differences among 14 acceptability measures when comparing all three MC. After controlling for BMI percentile, usual diet, and meal group, three significant differences in acceptability emerged, including texture TTS subscore, change in hunger score, and milk plate waste. Additionally, when looking at differences in acceptability in MC3 with increasing percentage of BPSL

options chosen, there was only one significant difference, “serve at school” TTS subscore. With regression analysis, no significant relationship was detected between percentage of BPSL options chosen and “serve at school” subscore. **DISCUSSION:** Results suggest minimal differences in acceptability between BPSL and TSL, when served alone or in combination, among high school students in a controlled offer setting.

KEY WORDS: National School Lunch Program, acceptability, dietary quality

Introduction

The period between childhood and adolescence is believed to be a crucial time to encourage and establish high dietary quality (DQ) eating habits,[1] due to its significant associations with health and academic outcomes.[2] In terms of health, a diet of high DQ is associated with a lower risk of childhood and adult obesity,[3,4] as well as with lower risk of developing cardiovascular disease (CVD) risk factors as an adult.[5] Additionally, food habits and behaviors that develop in childhood track overtime and predict disease in adulthood.[6] In terms of academic outcomes, a diet of high DQ is associated with improved grades in English and science and decreased absenteeism.[7] Higher DQ of school lunches has also been associated with 3.4 times improved on-task time and increased alertness in the classroom[8] and higher reading and fluency scores.[9] Thus, higher DQ in childhood results in healthier, more successful lives.

The average US child's diet has a Healthy Eating Index (HEI) score, for DQ, of 53 out of 100,[10] which needs improvement.[11] Considering this need for improvement and the impact of high DQ on health and academic outcomes, a large-scale public health intervention could be beneficial. The National School Lunch Program (NSLP) offers a big opportunity to impact a large portion of children. If a child eats lunch from school five days per week and consumes three meals per day seven days per week, school lunches are providing one quarter of that child's weekly meals and thus is a major contributor to their overall DQ.

A typical school lunch, which meets minimum NSLP nutrition standards, has an HEI score of approximately 75 out of 100.[12] This score is 42% higher than that of the average US child's diet, but also needs improvement and has the potential to be higher.[12] Based on the importance of improving DQ and the possibly major contribution of school lunches to a child's weekly nutrition, it could be of great benefit to US children to increase the DQ of school lunches even further.

There are numerous barriers to improving the DQ of school lunches even further. According to school personnel, these barriers include that schools are not perceived to play a major role in obesity or that it is the responsibility of the school to influence healthy eating habits,[13] the need to prepare students

for the real world, and financial pressures to serve less healthful options that students will like to increase revenue and NSLP participation, while decreasing plate waste.[14] One of the most common concerns, in the literature and anecdotally, is poor acceptability of higher DQ lunch options. This research on these barriers looks at perceptions and not whether they truly exist.

Some research has been done to investigate whether costs increase, participation and revenue decrease, and waste increases with higher DQ lunches, as staff perceive they will. Several studies suggest that some of these barriers may not exist. In a cross-sectional study by Cluss et al. (2014) when DQ of cafeteria options was improved, such that there was a greater number of healthier options and fewer less healthful options, purchase of foods with low or no nutritional value subsequently decreased and healthier option purchases equally increased resulting in no major decreases in overall purchases.[15] Another study by Cohen et al. (2016) evaluated the impact of updated school meal standards to the state of Massachusetts' competitive food standards (i.e., increasing DQ of foods) on both revenue and participation and found that when healthier foods were offered, there was no decline in participation rates.[16] Regarding plate waste, anecdotal reports of food waste under the 2010 Healthy, Hunger-free Kids Act were put to the test in a study by Schwarts et al. (2015). The study found that under these standards, in which fruits and vegetables were placed in individual categories with an increased serving size, fruit was consumed and was not thrown away.[17]

These studies begin to dismantle the perceived barriers previously mentioned. However, these studies exclude certain aspects of acceptability and do not look at acceptability when numerous best practices are implemented to improve DQ of the overall reimbursable meal. This is a critical gap in the literature that may prevent schools from further improving DQ of their meals. Since this area is a recurring and significant concern and there is limited research in this area, this study aimed to bridge that gap by investigating differences in acceptability of school lunches meeting NSLP nutrition standards of high (HEI score 90-95/100, best practice school lunch, BPSL) and moderate (HEI score 75/100, typical

school lunch, TSL) DQ in a controlled offer setting by high school-aged children, through the use of taste test surveys, monitoring meal component choices, plate waste assessment, and changes in hunger.

Methodology

Participants

Participants consisted of a convenience sample of 40 high school-aged students recruited from local NSLP-participating high schools. They were recruited using flyers distributed through email blast at local high schools and through Oklahoma State University (OSU), wellness committees associated with local school districts, social media, and other organized community groups. Incentives included three free meals, $50, taste tester certificate, research experience, and a packet of recipes to take home.

The sample size was determined through power calculations[18] based on results from a previous and similar study on the acceptability of high DQ lunches in elementary-aged school children.[19] Power was set at 0.8 and alpha at 0.05. The calculations suggested that the sample size include two participants per group. The sample size was set at 40 total participants (13-14 per group) to compensate for possible dropouts and to allow adequate power for sub-analyses.

Inclusion criteria included being in grades 9-12, attending a school that participates in the NSLP, and being willing and able to come to all three meal sessions. Exclusion criteria included having food allergies and/or intolerances, having issues with chewing and swallowing, being on any medications with significant food/drug interactions, and having any medical conditions requiring a special diet, all impacting child safety and limiting choices, a measure of acceptability, within the meals.

Pre-screening included questions that were asked through email before coming in person for a full screening. These questions were: 1) is your child in 9th-12th grade; 2) what school do they attend; 3) are you willing and able to bring them to all three meal sessions; 4) does your child have any food allergies,

intolerances, or religious preferences; 5) does your child have any chewing or swallowing issues; and 6) has your child been put on a special diet or told to avoid certain foods by a physician or another licensed medical professional? The participants included after pre-screening were randomly assigned to one of three groups using a random number generator. Groups can be visualized in supplemental figure 1.

The full, in-person screening included a physical assessment in which height, weight, and waist circumference were measured. A demographic questionnaire was administered in which ethnicity, age, grade level, gender, and parents' education level as socioeconomic status proxy were obtained. Pre-screening questions were also double-checked at this time. Usual diet was assessed through use of the Automated Self-Administered 24-Hour Dietary Assessment Tool (ASA24, National Cancer Institute, 2018 version).[20]

Study Design

The study design was a randomized cross-over trial. A flow diagram of the study design can be found in supplemental figure 1. The participants were randomized into three groups and attended three meal conditions in a different order to control for an order effect. All three meal conditions had meals presented with equal presentation style. The meal conditions had two options for each NSLP school lunch meal component: fruit, vegetable, meat or meat alternate, grain, and milk. Participants were instructed to take at least three components with at least one being a fruit or vegetable, to be consistent with the offer service style in NSLP-participating high schools. The options served for each meal component varied based on two levels of the independent variable, dietary quality, including high DQ (best practice school lunch options, BPSL, HEI score of 90-95/100, implements best practices to exceed NSLP nutrition standards) and moderate DQ (typical school lunch options, TSL, HEI score of 75-100, meets minimum NSLP nutrition standards). Meal conditions and the options offered for each meal component can be found in table 1.

Acceptability

Currently, there is no consensus in the literature for a definition of or way to best measure acceptability of school lunches. For the purpose of this study, acceptability was measured through the recording of choices made; taste test surveys that included questions regarding appearance, taste, smell, texture, temperature, and whether to serve at school; weighted plate waste assessment; and pre-and post-meal hunger survey. Choices made for each meal component were recorded on a selection form. The taste test survey that was used was a modified version of a taste test survey from the Ohio Action for Healthy Kids Website.[21] It included several 5-point Likert scales to measure how much participants liked the taste, appearance, smell, temperature and texture, as well as how much the participants wanted to see this item served at their school. The taste test survey also included questions regarding selection rationale. Participants completed this survey while eating. The weighted plate waste assessment method was similar to methods previously used in studies by Cohn et al. (2013), Adams et al. (2005), and Nichols et al. (2002) and validated by Jacko et al. (2007) from Rutgers Department of Nutritional Sciences and Extension.[22-25] Individual food items were weighed before service, and food remaining on trays (waste) was weighed after consumption. A percentage was calculated for waste from the pre-service weight of the food items. Pictures were taken of all food items before and after service. Pre- and post-meal hunger was evaluated using a 1-question, 5-point Likert scale commonly used in mindful eating and nutrition therapy for diabetes created by Harvard's Joslin Diabetes Center.[26] Pre-meal hunger score was subtracted from post-meal hunger score to determine change in hunger, as an indication of satiety.

Meal Session Flow

A flow diagram of the meal sessions can be found in supplemental figure 2. Each participant checked-in upon arrival and received a name tag with a tray ID number. Upon entering the eating area, participants completed a pre-meal hunger scale. Then, participants proceeded to enter the service area and built a lunch by selecting from two options for each meal component. As this study was simulating an offer service style, participants selected at least three of the five meal components with at least one of those being a fruit or vegetable. Researchers recorded the choices participants made as they went through

the line, and trays were marked with an ID number for each participant. While participants ate, they filled out a taste test survey. After they were finished, participants completed a post-meal hunger scale and left with their guardian. Finally, researchers weighed and recorded each tray's plate waste, along with a picture of each tray.

In order to keep the environment under control, participants sat at their own individual tables to discourage sharing. Garbage cans were removed from the eating and serving areas. Research assistants also monitored the participants to make sure they did not share or take any food with them when they left.

Statistical Analysis

Descriptive statistics were performed for group characteristics. Assumptions of normality and equality of variance were evaluated using Kolmogorov-Smirnoff test and Levene's or Brown-Forsythe tests. Groups were compared for differences in baseline characteristics by using one-way ANOVA and chi-squared. Bonferroni was used for multiple comparisons to be conservative and due to there being unequal sample sizes for subgroup comparisons. Cronbach's alpha was used to check internal consistency of the taste test survey and plate waste assessment subcomponents (>0.6). Internal consistency was high with a Cronbach's alpha of 0.761. Thus, all survey subcomponents were included in analysis.

Descriptive statistics were also performed for all meal condition acceptability measures. Assumptions of normality and equality of variance were evaluated using Kolmogorov-Smirnoff test and Levene's or Brown-Forsythe tests. The assumption for normality was not met for grain and protein plate waste percentage. Inverse transformation was used and normality was achieved for these variables. A one-way ANOVA was used to determine differences in acceptability (taste test scores, plate waste percentage, and change in hunger) between higher DQ meal components served alone (meal condition 1), lower DQ meal components served alone (meal condition 2), and when both are served together (meal condition 3). A chi-squared test was used to determine differences in meal component choices made to build a reimbursable meal when given the option between higher and lower DQ meal components (meal

condition 3). A one-way ANOVA was used to determine differences in acceptability of the complete meal built in meal condition 3 with increasing selection of higher DQ meal component options when lower DQ meal component options were also available. Regression analysis was performed to determine how increasing selection of BPSL meal component options in meal condition 3 was related to acceptability. Bonferroni was again used for multiple comparisons. Secondary analysis was performed using one-way ANCOVAs to control for significant covariates, possibly consisting of gender, age, BMI percentile, waist circumference, ethnicity, socioeconomic status, and group, when investigating differences in acceptability in the scenarios mentioned.

Results

The goal for participant recruitment was 13 per group to allow adequate power with attrition. Initially, 30 participants were recruited and completed the initial assessment (MG1 n=10, MG2 n=10, MG3 n=10). In the end, 25 participants completed at least one meal session (16.7% overall attrition, MG1 n=9, MG2 n=8, MG3 n=8). Additionally, one participant completed two sessions, and 20 participants completed all three sessions. Twenty-two participants completed MC1, 21 completed MC2, and 23 completed MC3.

Table 2 provides a summary of the baseline characteristics of participants who completed at least one meal session overall and by meal group. Overall, participants were mostly 9th graders (54.2%). The remainder of participants were in 10th (20.8%) and 11th (25.0%) grade. There were no significant differences in grade distribution between the meal groups (p=0.167). The average age for all participants was 15.4 years, with no significant differences in age between meal groups (p=0.193). Regarding sex distribution, 45.8% were female, and 54.2% were male overall. There were no significant differences in sex distribution between the meal groups (p=0.392). The majority of participants were Caucasian (79.2%). There was no significant difference in ethnicity among meal groups (p=0.031). Related to weight status, the average BMI percentile and waist circumference for all participants were 70.4 and 79.8

cm, respectively. According to BMI percentile, 54.2% of participants had a healthy weight status (<85th percentile), 16.7% had an overweight status (85th-95th percentile), 29.2% had an obese weight status (>95th percentile). There were no significant differences in BMI percentile (p=0.839), BMI percentile category (p=0.395), or waist circumference between meal groups (p=0.822). The average dietary quality for all participants as measured by the Healthy Eating Index 2015 was 41.7, with no significant differences between meal groups (p=0.115).

Covariates

There were no significant differences in acceptability results by grade level (ps>0.017) and sex (ps>0.05). There were however significant differences in acceptability by meal group for taste test survey subcomponents including appearance (p=0.009, MG2 0.68 points higher than MG3), texture (p<0.001, MG3 0.82 points lower than MG1 and 0.86 points lower than MG2), and serve at school (p=0.002, MG2 0.82 points higher than MG3), as well as total taste test score (p=0.002, MG2 3.55 points higher than MG3), vegetable percent plate waste (p=0.016, no longer significant with multiple comparisons), and average total plate waste (p=0.016, MG2 15.3% less than MG3). There were significant differences in acceptability by age for milk percent plate waste (p=0.017). There were also significant differences in acceptability by BMI percentile for taste test survey subcomponents including smell (p=0.036), texture (p=0.008), temperature (p=0.029), and serve at school (p=0.024), as well as total taste test score (p=0.003), change in hunger (p=0.016), milk percent plate waste (p=0.006), grain percent plate waste (p=0.030), protein percent plate waste (p=0.001), and average total plate waste (p=0.012). Similar differences in acceptability were seen by waist circumference. There were additional significant differences in acceptability by weight status category for taste test survey subcomponent texture (p=0.004, normal weight category 0.84 points lower than overweight category), change in hunger (p=0.005, normal weight category 0.74 points lesser drop in hunger than obese category), and average

total plate waste (p=0.002, normal weight category 17.0% greater than obese category). There were significant differences in acceptability by ethnicity for taste test survey subcomponent texture (p=0.004, no longer significant with multiple comparisons) and SES for milk percent plate waste (p=0.006, subgroup sample sizes too small for multiple comparisons). Finally, there were significant differences in acceptability by usual diet as measured by HEI score for taste test survey subcomponents including appearance (p=0.037), smell (p=015), texture (p=0.011), temperature (p=0.023), and serve at school (p=0.001), as well as total taste test score (p<0.001), change in hunger (p=0.007), vegetable percent plate waste (p=0.027), grain percent plate waste (p=0.060), protein percent plate waste (p=0.001), milk percent plate waste (p=0.006), and average total plate waste (p=0.025). Based on these results, secondary analysis with ANCOVA included BMI percentile, meal group, and HEI score to control for significant confounding variables.

Comparison of Acceptability by Meal Condition

Meal conditions were compared for acceptability, such that scenarios including when BPSL are served alone (MC1), when TSL are served along (MC2), and when a combination of BPSL and TSL are served (MC3) were compared. Supplemental tables 1, 2, 3, and 4 and figures 1 and 2 provide a summary of acceptability of each meal condition by meal component option chosen, taste test score, plate waste percentage, and change in hunger. To summarize overall acceptability of the meal conditions, average (standard deviation) total taste test scores were 22.5 (4.4), 24.3 (3.3), and 23 (2.7), for MC1, MC2, and MC3 respectively. Additionally, average (standard deviation) total plate waste percentages were 26.6% (23.1%), 17.5% (15.6%), and 16.3% (13.6%), for MC1, MC2, and MC3 respectively. Finally, average (standard deviation) change in hunger scores were -1.7 (0.9), -1.6 (0.9), and -1.7 (0.8), for MC1, MC2, and MC3 respectively, from pre- to post-meal. Before controlling for confounding variables, there were no significant differences in taste test survey subscores or total taste test score, meal component plate waste percentages or average total plate waste percentage, or change in hunger score from pre- to post-meal (ps>0.017) between meal conditions. Significant differences emerged after controlling for

confounding variables, including BMI percentile, meal group, and HEI score. There was a significant difference between meal conditions in texture after controlling for meal group ($p<0.001$) and for all three variables ($p=0.001$), in change in hunger after controlling for BMI percentile ($p=0.004$), and in milk plate waste after controlling for BMI percentile ($p=0.002$) and all three variables ($p=0.008$).

Acceptability in Meal Condition 3 with Increasing Proportional Selection of BPSL Options

In MC3, where there were both BPSL and TSL options available for each meal component, participants' meals could vary in their composition, including proportion of components (%) as BPSL options. There were significant differences in frequency of BPSL as compared to TSL options chosen for each meal component. The BPSL option was chosen significantly more often for fruit (mean difference = 60%, $p=0.0002$), grain (mean difference = 48%, $p=0.0013$), and meat/ meat alternate (mean difference = 48%, $p=0.0013$) components, while the TSL option was chosen significantly more often for vegetable (mean difference = 90%, $p<0.0001$) and milk (mean difference = 72%, $p=0.0094$) components. Researchers investigated differences in acceptability with increasing proportional selection of BPSL options, as a percentage of BPSL component options taken out of total meal components selected. Before controlling for confounding variables, as participants selected more BPSL options to build their meals, there was one significant difference in acceptability for "serve at school" taste test survey subscore ($p=0.023$). After controlling for confounding variables, including BMI percentile, meal group, and HEI score, no additional significant differences in acceptability emerged, and the difference in taste test survey subscore for serve at school was no longer significant ($ps>0.05$). Regression analysis was performed looking at the relationship between "serve at school" subscore and percentage of BPSL options chosen in MC3. There was a very weak (beta = -0.090), non-significant ($p=0.682$) relationship between the two variables.

Discussion

The purpose of this cross-over study was to investigate differences in acceptability of school lunches chosen by high school-aged children in an offer setting when all BPSL options (MC1, HEI score 90-95/100), all TSL options (MC2, HEI score 75/100), and a combination of BPSL and TSL options (MC3) were served. Before controlling for confounding variables, there were no significant differences in any of the 14 acceptability measures when comparing all three meal conditions. Significant confounding variables included weight status, meal group, and usual diet, as HEI score. After controlling for confounding variables, three significant differences in acceptability emerged from the 14 total measures of acceptability, including texture taste test subscore, change in hunger score, and milk percent plate waste. Additionally, when looking at MC3 and differences in acceptability as percentage of BPSL options chosen in a meal increases, there was only one significant difference in acceptability ("serve at school" taste test survey subscore) out of the 14 measures. With regression analysis, no significant relationship was detected between percentage of BPSL options chosen in a meal and "serve at school" subscore. These results indicate minimal difference in acceptability of school lunches chosen by high school-aged children in a controlled offer setting when all BPSL options, all TSL options, and a combination of BPSL and TSL options were served

Existing literature has to some extent previously investigated whether the introduction of higher dietary quality items would negatively impact foodservice settings through decreased acceptability. None of these studies showed a negative impact on revenue, participation, or plate waste.[35-37] However, there was a gap in the literature since none of these studies looked at acceptability more directly and broadly, such as using a taste test survey, when numerous best practice options are implemented to increase the dietary quality of meals. This study bridges the gap by investigating acceptability in more direct ways. This study found no difference in acceptability in the presence of higher dietary quality food items either in combination with typical options or by themselves, further supporting that providing those items in a cafeteria would not harm school foodservice establishments in operational aspects related to student acceptability. A similar unpublished study involving elementary school students performed by researchers

in our lab also found minimal significant differences in acceptability between BPSL and TSL options, alone or in combination, in a controlled serve setting.

Strengths

The study design of this project involved a randomized cross-over trial with a large enough sample size for broad statistical analysis. Additionally, the study was conducted in a controlled environment to eliminate acceptability confounding variables, including environmental cues, marketing, and peer pressure. This study also used a variety of acceptability measures beyond plate waste and participation by including a taste test survey with six subscores and change in hunger, or satiety. The plate waste methodology and change in hunger methodology used for this study were previously established and validated. Additionally, all recipes were standardized, tested recipes developed by state and national child nutrition program leaders.

Limitations

The convenience sample was gathered from a Midwestern US town with an academic institution, which limits generalizability due to lack of socioeconomic and ethnic diversity among the participants. Even though a strength of the study is that it took place in a controlled setting, it does not reflect a real-world setting. As such, results may differ in a real school cafeteria. The taste test survey, although extensive and typical, was not validated or established in previous literature. However, it was gathered from a USDA Action for Healthy Kids toolkit for schools. Lastly, the sample size was too small for some sub-analyses.

Implications for Practice and Future Research

When looking at practical implications for schools, if a school would like to change what is offered in their cafeteria to best practice options either fully or partially, there may not be a decrease in acceptability by high school-aged children. Additionally, progressive school wellness policies are

supported in the inclusion and encouragement of increasing best practice meal options in school cafeterias. At the federal level, changes to NSLP policy should continue to improve the DQ of nutrition standards, as this is supported by research showing improved academic performance and health outcomes of higher DQ lunches and, based on the current as well as numerous previous studies, will likely not result in decreased participation or acceptability by students. Future studies should focus on testing BPSL acceptability and feasibility in a real-world setting, such as an actual school cafeteria, and on using validated, more consistent methods for measuring acceptability beyond just participation and plate waste.

Conclusions

As availability and selection of best practice (high DQ) school lunch options increase, students may like it just as much as when mostly typical (moderate DQ) school lunch options are available. This maintained high level of acceptability appears to be possible in scenarios in which schools transition to having best practice options as half or all of available school lunch options. Overall, this study supports school cafeterias in moving towards providing higher DQ school lunches by implementing more best practices.

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Figure S1. Flow diagram of study design

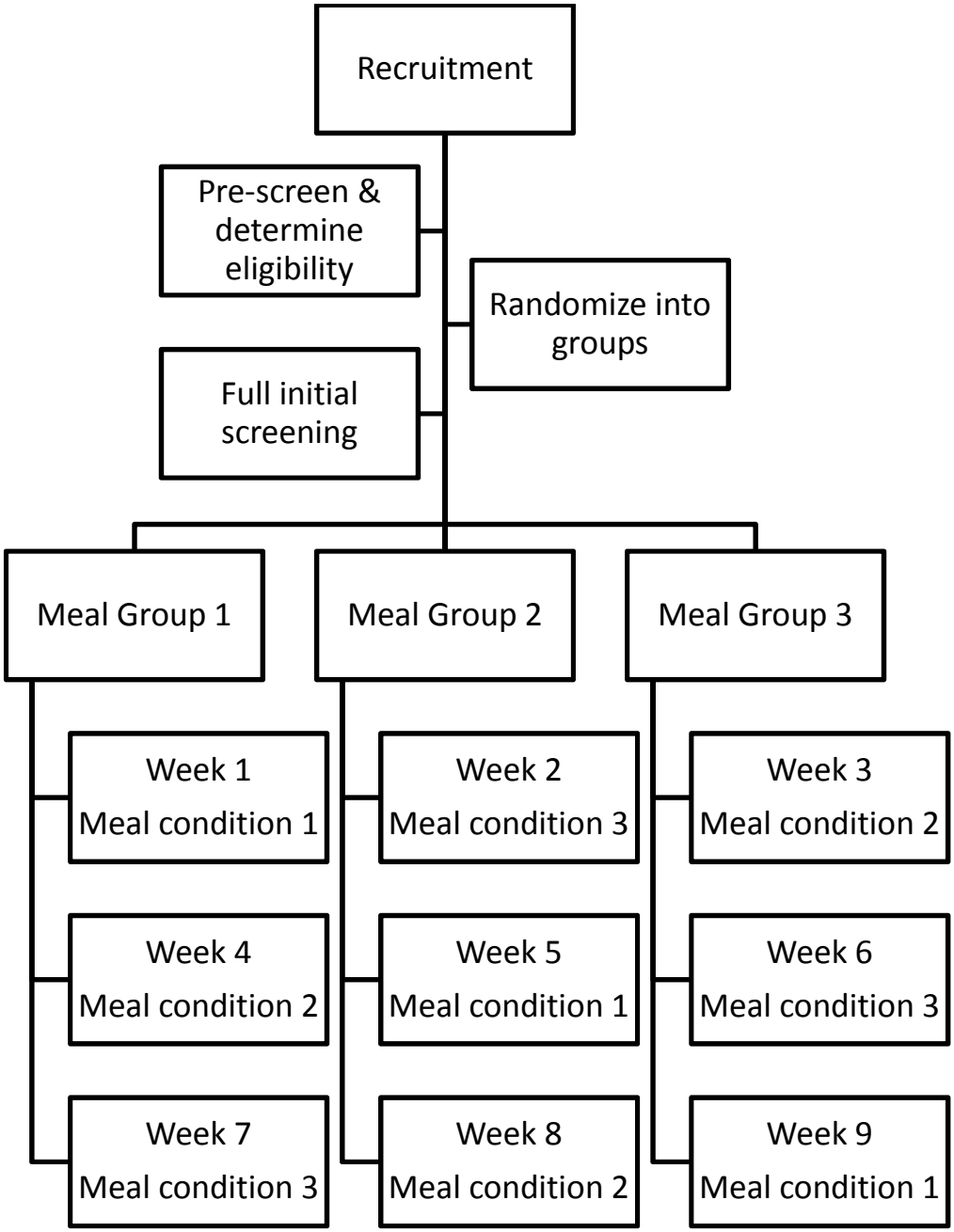


Table M1. NSLP meal component options for each meal condition

NSLP Meal Component	Meal Condition One Options	Meal Condition Two Options	Meal Condition Three Options
Fruit	BPSL1 – grapes BPSL2 – clementine	TSL1 – pineapple fruit cup in 100% fruit juice TSL2 – Mandarin orange fruit cup in 100% fruit juice	BPSL 3 – apple slices TSL 3 – peach fruit cup in 100% fruit juice
Vegetable	BPSL1 – broccoli salad BPSL2 – side salad w/ Italian dressing	TSL1 – broccoli w/ cheese sauce TSL2 – carrots w/ ranch	BPSL 3 – Asian coleslaw TSL 3 – French fries
Grain	BPSL1 – whole-grain cornbread BPSL2 – whole-grain cheese pizza	TSL1 – dinner roll TSL2 – cheese pizza	BPSL 3 – whole-grain slider bun TSL 3 – whole-grain rich hot dog bun
Meat/ Meat Alternate	BPSL1 – oven-baked, whole -rain chicken nuggets BPSL2 – cheese pizza	TSL1 – chicken nuggets TSL2 – cheese pizza	BPSL 3 – BBQ pulled pork TSL 3 – hot dog

Milk	BPSL1 – plain low-fat milk BPSL2 – plain low-fat milk	TSL1 – low-fat chocolate milk TSL2 – low-fat chocolate milk	BPSL 3 – plain low-fat milk TSL 3 – low-fat chocolate milk

Figure S2. Flow diagram of meal sessions

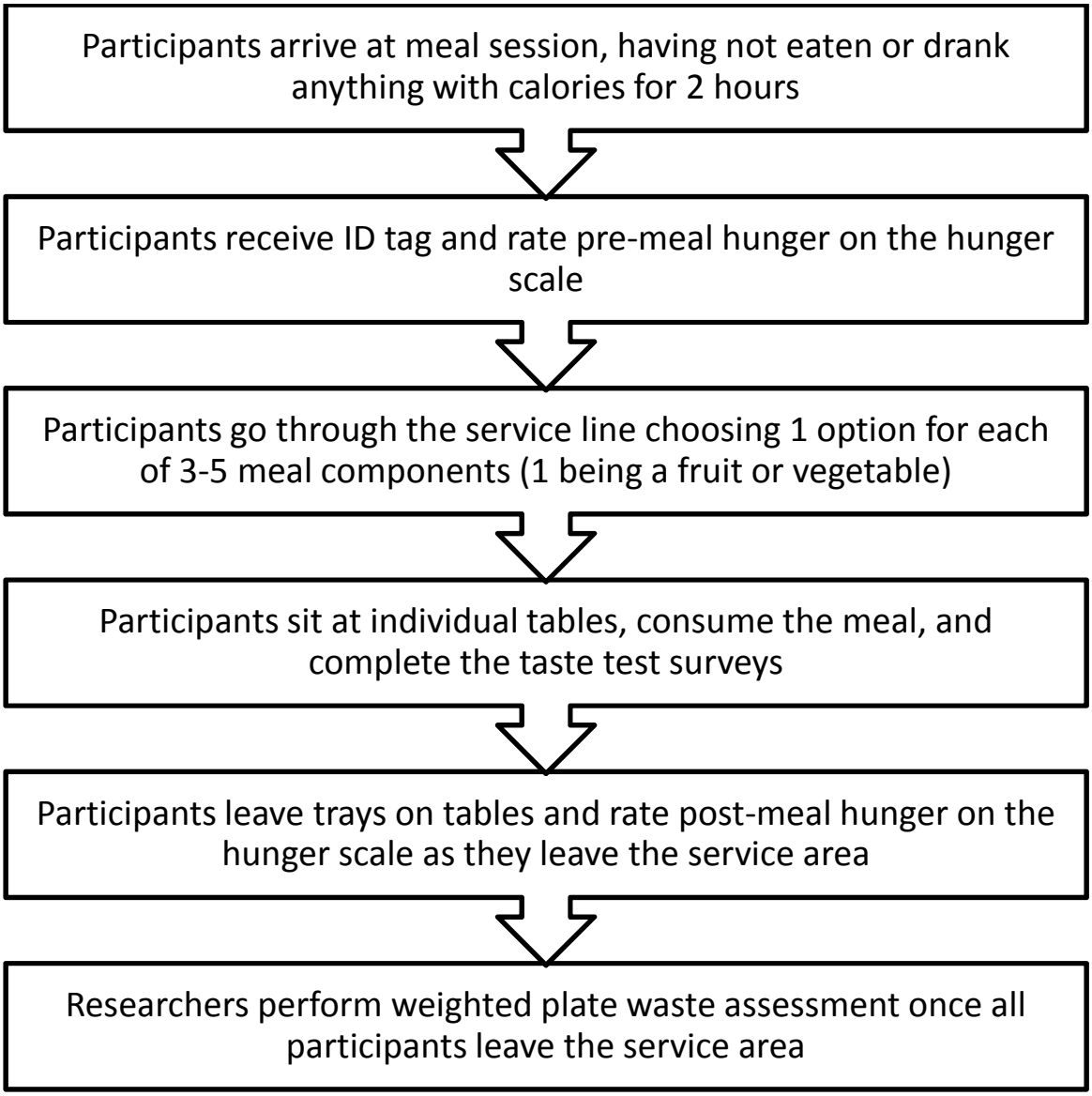


Table M2. Baseline characteristics of participants who completed at least one meal session

Characteristic		All Participants (n=25)	Group 1 (n=9)	Group 2 (n=8)	Group 3 (n=8)
Count, Proportion (%)					
Grade Level	**9th grade**	14, 56.0%	5, 55.6%	2, 25%	7, 87.5%
	10th grade	5, 20.0%	1, 11.1%	3, 37.5%	1, 12.7%
	11th grade	6, 24.0%	3, 33.3%	3, 37.5%	0%
	12th grade	0%	0%	0%	0%
Sex	**Female**	12, 48.0%	2, 22.2%	6, 75%	4, 50%
	Male	13, 52.0%	7, 77.8%	2, 25%	4, 50%
Ethnicity*	**Caucasian**	18, 72.0 %	8, 88.9%	7, 87.5%	3, 37.5%
	Hispanic	3, 12.0 %	0%	0%	3, 37.5%
	African American	0%	0%	0%	0%
	Native American	3, 12.0 %	1, 11.1%	0	2, 25 %
	Asian/ Pacific Islander	1, 4.0 %	0%	1, 12.5%	0%
	Other	0%	0%	0%	0%
	<85th, Healthy	14, 56.0%	4, 44.4%	5, 62.5%	5, 62.5%

BMI Percentile Category	**85th-95th, Overweight**	4, 16.0%	3, 33.3%	1,12.5%	0%
	>95th, Obese	7, 28%	2, 22.2	2, 25.0%	3, 37.5%
Mean ± Standard Deviation					
Age (years)		15.4±1.2	15.2±1.2	15.9±0.9	15±1.3
Height (cm)		168.2±8.0	169.1±6.0	169.9±9.5	165.6±8.2
Weight (kg)		69.4±18.8	72.2±23.3	68.7±15.7	67.3±18.5
BMI Percentile		70.4±26.0	73.3±25.0	66.4±29.0	71.4±26.3
Waist Circumference (cm)		79.8±14.3	77.8±13.7	81.9±14.5	79.6±14.3
Dietary Quality (Total HEI score, out of 100)		41.7±10.8	40.5±12.7	45.5±8.5	39.1±10.1

*Significant difference between groups, $p<0.017$

Table S1. Frequency and proportion of meal component options chosen for each meal condition

Meal Condition (Option 1, Option 2)	Fruit		Vegetable		Grain		Meat/ Meat Alternate		Dairy	
	Option 1	Option 2	Option 1	Option 2	Option 1	Option 2	Option 1	Option 2	Option 1	Option 2
	(frequency item was chosen) / (total number of children participating), % of time chosen									
1 (BPSL 1, BPSL 2)	16/20, 80.0%	4/20, 20.0%	3/11, 27.3%	8/11, 72.3%	8/21, 38.1%	13/21, 61.9%	8/22, 36.4%	14/22, 63.6%	2/2, 100%[+]	
2 (TSL 1, TSL 2)	6/12, 50.0%	6/12, 50.0%	5/19, 26.3%	14/19, 73.7	10/21, 47.6%	11/21, 52.4%	10/21, 47.6%	11/21, 52.4%	8/8, 100%[+]	
3 (BPSL, TSL)	16/20, 80.0%*	4/20, 20.0%	1/19, 5.3%	18/19, 94.7%*	17/23, 73.9%*	6/23, 26.1%	17/23, 73.9%*	6/23, 26.1%	1/7, 14.3%	6/7, 85.7%*

[+]Plain milk was the only BPSL option and chocolate milk was the only TSL option

*Significant difference in frequency of option chosen $p<0.05$

Table S2. Summary of Acceptability as Average Taste Test Scores by Meal Condition

Meal Condition	Appearance	Taste	Smell	Texture	Temperature	Serve at School	Total Taste Test Score
			Mean ± Standard Deviation				
1 (BPSL 1, BPSL 2)	3.7 ± 0.9	3.7±1.1	3.7±1.0	3.6±0.9*	3.5±0.7	4.3±0.9	22.5±4.4
2 (TSL 1, TSL 2)	4.1±0.6	4.4±0.7	3.9±0.8	4.1±0.7*	3.5±1.1	4.4±0.8	24.3±3.3
3 (BPSL, TSL)	3.9±0.7	4.0±0.6	3.7±0.6	3.6±0.6*	3.3±0.8	4.4±0.8	23±2.7

*Significant difference between meal conditions (p<0.017) after controlling for meal group alone and all confounding variables (meal group, BMI percentile, usual diet HEI score)

Table S3. Summary of Acceptability as Average Plate Waste Percentage of Meal Components by Meal Condition and Meal Component Option

Meal Condition	Meal Component Option	Fruit Plate Waste Percentage	Vegetable Plate Waste Percentage	Grain Plate Waste Percentage	Meat/ Alternate Plate Waste Percentage	Milk Plate Waste Percentage	Average Total Plate Waste Percentage
			Mean ± Standard Deviation				
1	**BPSL 1**	16.5±26.4	78.3±27.5	49.5±32.8	22.2±38.8	19.3±27.2*[#]	26.6±23.1[+]
	BPSL 2	23.8±20.6	19.6±18.3	21.0±27.0	21.0±27.1		
2	**TSL 1**	24.7±21.6	28.2±35.6	0.2±0.8	3.3±10.4	10.7±17.1*[#]	17.5±15.6[+]
	TSL 2	41.5±31.3	43.2±22.3	9.0±24.8	9.0±24.8		
3	**BPSL**	20.8±28.6	91.8±0	1.8±3.8	3.9±9.6	0±0*	16.3±13.6[+]
	TSL	38.6±12.3	27.6±34.0	7.6±12.8	0±0	10.7±9.1*	

*Significant difference between meal conditions (p<0.017) after controlling for BMI percentile alone and all confounding variables (meal group, BMI percentile, usual diet HEI score)

[#] Plain milk was the only BPSL option and chocolate milk was the only TSL option

[+] Meals could be a mix of the two options so it cannot be designated as option 1 or option 2

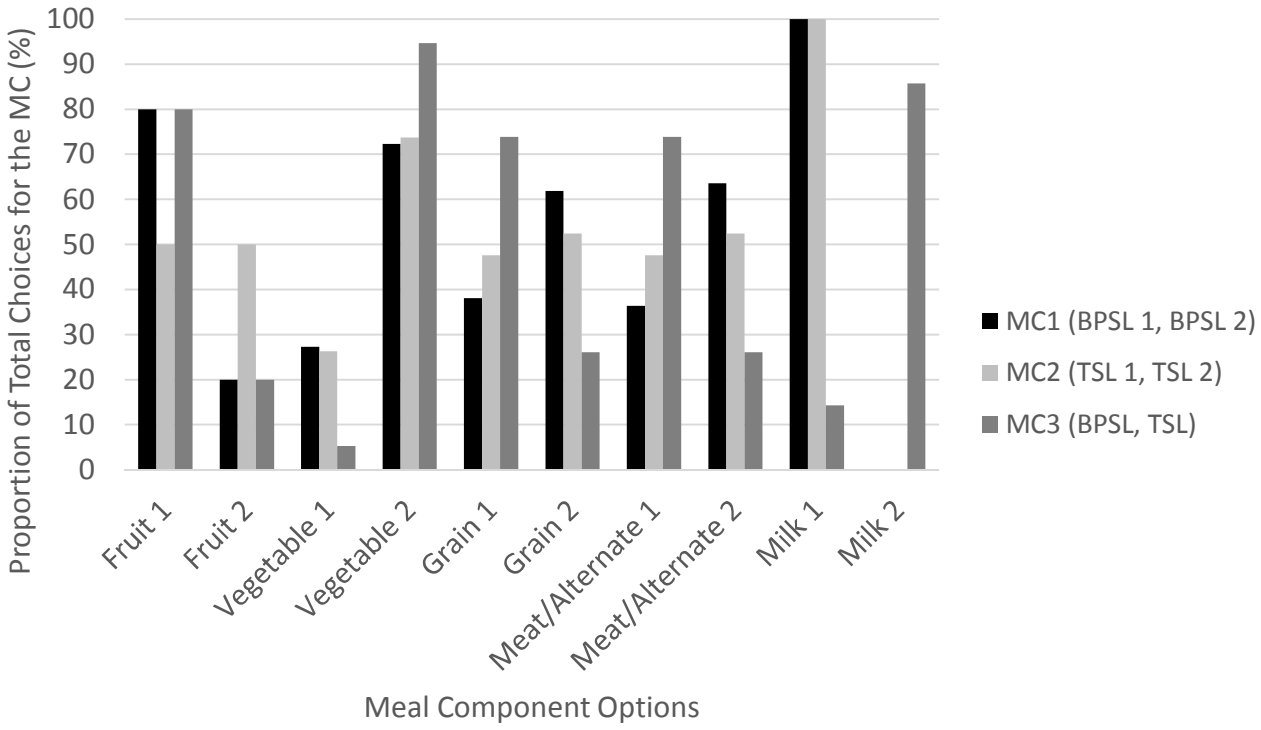
Table S4. Summary of Change in Hunger by Meal Condition

Meal Condition	Change in Hunger (Post-Pre)
	Mean ± Standard Deviation
1 (BPSL 1, BPSL 2)	-1.7 ± 0.9*
2 (TSL 1, TSL 2)	-1.6±0.9*
3 (BPSL, TSL)	-1.7±0.8*

*Significant difference between meal conditions (p<0.017) after controlling for BMI percentile

Figure M1. Meal component option choices by meal condition

A. All meal conditions



B. Meal condition 3 only

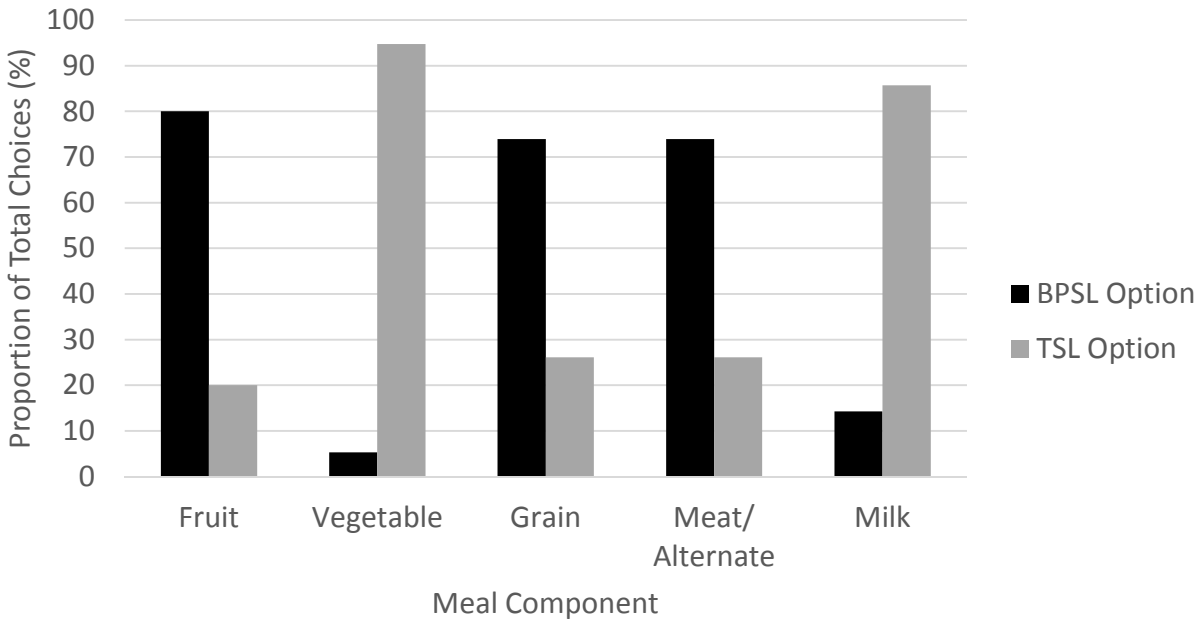
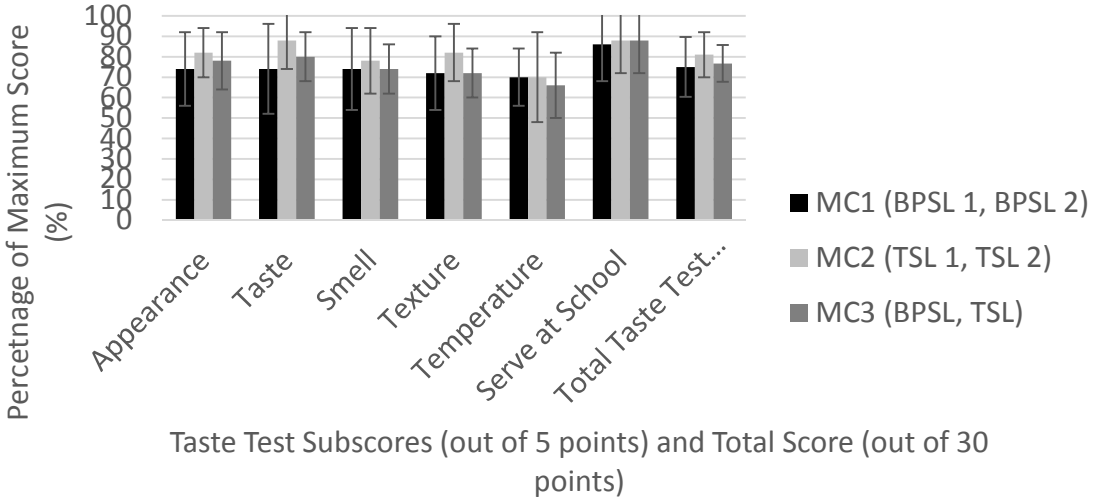
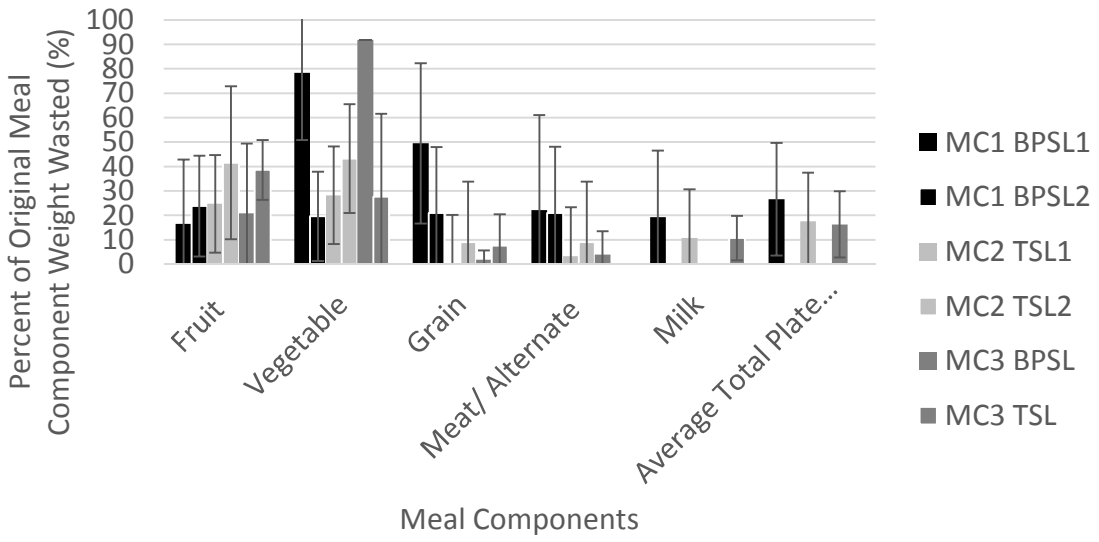


Figure M2. Comparison of Acceptability by Taste Test Scores and Plate Waste Percentages between Meal Conditions

A. Taste test survey subscores and total score



B. Plate Waste Percentage for Meal Components and Average of Total Meal



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APPENDICES

APPENDIX A
Assessment Form

Basic Medical History

Participant's Name _____ Date _____/_____/_____

Parent/ Guardian's (for emergency contact only) Cell # _____-_____-_____

Enrolled in a public school offering NSLP? Y N Grade level _____
* If no, participant is not eligible to participate in study.

Able to speak English? Y N
* If no, participant is not eligible to participate in study.

Able to safely consume, chew, and swallow solid and liquid food items without modification of texture or thickness? Y N
* If no, participant is not eligible to participate in study.

Any food allergies or intolerances? Y N
* If yes, participant is not eligible to participate in study.

Medical Conditions: _____
* If any medical conditions would be adversely affected by the food items served in any study meals (as decided by the responsible graduate student, a Registered Dietitian), participant is not eligible to participate in study.

Medications:
_____
* If any medications would adversely interact with the food items served in any study meals (as decided by the responsible graduate student, a Registered Dietitian), child is not eligible to participate in study.

DoB Sex: M F Height _____ cm Weight _____ kg Waist Circ. _____ cm
___/___/___ _____ cm _____ kg _____ cm

Ethnicity:
Caucasian, Hispanic, African American, Native American, Asian/ Pacific Islander
Other: _____

Highest level of parent/guardian education:
____ Some high school
____ Completed high school
____ Some college
____ Completed college (graduated with a degree)

To be completed following screening by responsible graduate student:

BMI _____

Coded Tray ID _____

APPENDIX B

Hunger Scale

Date ____/____/____
Pre-meal / Post-meal

The Hunger Scale

Tray ID _____

1	2	3	4	5
Stuffed	Full	Comfortable	Hungry	Ravenous

The Hunger Scale

Tray ID _____

1	2	3	4	5
Stuffed	Full	Comfortable	Hungry	Ravenous

The Hunger Scale

Tray ID _____

1	2	3	4	5
Stuffed	Full	Comfortable	Hungry	Ravenous

The Hunger Scale

Tray ID _____

1	2	3	4	5
Stuffed	Full	Comfortable	Hungry	Ravenous

APPENDIX C

Meal Component Selection Form

Date ____/____/____

Selection Question Responses

Tray ID _____

Meal Component Options Chosen:

Fruit	1	2
Vegetable	1	2
Grain	1	2
Meat/MA	1	2
Milk	1	2

Tray ID _____

Meal Component Options Chosen:

Fruit	1	2
Vegetable	1	2
Grain	1	2
Meat/MA	1	2
Milk	1	2

Tray ID _____

Meal Component Options Chosen:

Fruit	1	2
Vegetable	1	2
Grain	1	2
Meat/MA	1	2
Milk	1	2

Tray ID _____

Meal Component Options Chosen:

Fruit	1	2
Vegetable	1	2
Grain	1	2
Meat/MA	1	2
Milk	1	2

APPENDIX D

Taste Test Survey

Tray ID _____
Date ____/____/____

Taste Test Survey

Circle the number that best describes how you feel about the meal that you are tasting!

What do you think of the **color/look** of this meal?

1	2	3	4	5
Very Bad	Bad	Just Okay	Good	Very Good

What do you think of the **taste/ flavor** of this meal?

1	2	3	4	5
Very Bad	Bad	Just Okay	Good	Very Good

What do you think of the **smell** of this meal?

1	2	3	4	5
Very Bad	Bad	Just Okay	Good	Very Good

What do you think of the **texture** of this meal?

1	2	3	4	5
Very Bad	Bad	Just Okay	Good	Very Good

What do you think of the **temperature** of this meal?

1	2	3	4	5
Very Bad	Bad	Just Okay	Good	Very Good

Modified from: Taste testing in schools: resource guide page. Ohio Action for Healthy Kids website. Available at: http://www.ohioactionforhealthykids.org/wp-content/uploads/2012/01/OAFHK-2012-Taste-Testing-Toolkit-WEB.pdf Updated: no date. Accessed: March 24, 2017.

Tray ID _____
Date ____/____/____

Do you think we **should serve this meal** on the lunch menu?

1	2	3	4	5
Completely Disagree	Somewhat disagree	Unsure	Somewhat agree	Completely agree

Please explain the reason you chose the option that you did for each lunch component.

Vegetable _____

Fruit _____

Grain _____

Meat/ Protein _____

Milk _____

_____

Thank you for tasting!

APPENDIX E

Plate Waste Assessment Form

Date: ____/____/____

Meal options offered _____ & _____

Tray ID	Picture taken of tray? Yes or No	Was any food thrown away? Yes or No	Was any food traded while eating? Yes or No	Was any food taken out of the kitchen area? Yes or No	Which fruit option was chosen? If chosen.	Weight of remaining fruit (g, to nearest 0.1)	Which vegetable option was chosen? If chosen.	Weight of remaining vegetable (g, to nearest 0.1)	Which grain option was chosen? If chosen.	Weight of remaining grain (g, to nearest 0.1)	Which protein option was chosen? If chosen.	Weight of remaining protein (g, to nearest 0.1)	Which milk option was chosen? If chosen.	Weight of remaining milk (g, to nearest 0.1)
Full ____ Meal		X	X	X	X		X		X		X		X	
Full ____ Meal		X	X	X	X		X		X		X		X	

VITA

Gabriela Paola Puche

Candidate for the Degree of

Master of Science

Thesis: ACCEPTABILITY OF BEST PRACTICE SCHOOL LUNCHES BY HIGH SCHOOL-AGED PARTICIPANTS IN AN OFFER SETTING: A RANDOMIZED CROSSOVER TRIAL

Major Field: Nutritional Sciences

Biographical:

Education:

Completed the requirements for the Master of Science in Nutritional Sciences at Oklahoma State University, Stillwater, Oklahoma in December, 2020.

Completed the requirements for the Bachelor of Science in Nutrition at Texas Woman's University, Denton, Texas in 2018.

Experience:

Graduate Research Assistant & Graduate Teaching Assistant for the Department of Nutritional Sciences August 2019-Present

Graduate Teaching Assistant for the College of Human Sciences – August 2018- May 2019

Professional Memberships:

American Society for Nutrition, Student Member- 2020 Present
Academy of Nutrition & Dietetics, Student Member- 2014- Present
Oklahoma Academy of Nutrition & Dietetics, Student Member- 2018- Present