The Flavor Station: A Pilot Salad Bar Trial to Increase Fruit and Vegetable Consumption in Elementary School Children

by

Cameron Scholtz

A Dissertation Presented in Partial Fulfillment
Of the Requirements for the Degree
Doctor of Philosophy

Approved February 2019 by the
Graduate Supervisory Committee:

Carol Johnston, Chair
Christy Alexon
Steven Hooker
David Schwake
Pamela Swan
Christopher Wharton

Arizona State University

May 2019

ABSTRACT

Most American children consume less than the recommend amount of fruits and vegetables (F&V), 74% and 84%, respectively. Eating too few F&V in childhood is associated with increased risk of cardiovascular disease, hypertension, respiratory symptoms, and some cancers later in life. Adequate F&V consumption favorably impacts antioxidant status, gut flora, mood, and cognitive functioning. Nutrients such as vitamin C and fiber are only naturally occurring in plant foods. For many children, school lunches are an important source of F&V. This pilot study assessed the feasibility of providing condiments to increase children's consumption of salad bar F&V in an elementary school cafeteria at lunchtime. The trial site was a single Title 1 elementary school in a large, urban district in the greater Phoenix metropolitan area. Taste tests were conducted on three convenience samples of children in grades 3 – 7, aged 8 – 12 years (n=57) to identify the most popular condiment flavors. The five highest rated flavors were made available daily at a "flavor station" in the school's lunchroom for three consecutive weeks during the Fall 2018 semester. Descriptive and inferential statistics were used to analyze data. A cost analysis was conducted for capital outlays related to the flavor station. School employee perceptions of F&V and the flavor station were assessed via posttest online surveys. Peanut butter was rated the best tasting condiment by children and was the only condiment that increased in popularity throughout the intervention. Overall, daily F&V consumption increased 17 g per child. There was a linear increase in F&V consumption during the study (r=0.986; P=0.014). As a proportion of the total F&V selected, F&V waste decreased by nearly 3%. The average daily cost of providing the flavor station was $0.09 per student. Sixty-five percent of school staff felt that the flavor station should continue at their school. Peanut butter is an affordable,

nutrient-dense food that accommodates the USDA Food and Nutrition Service meal patterns and nutrition standards, and thus, is a viable strategy for increasing F&V consumption and decreasing F&V waste. The results herein inform the development of future interventions to improve the palatability of F&V for children.

DEDICATION

I dedicate this with affection to my wonderful family. I am grateful for the love and support you gave me throughout my doctoral journey. To Dad, my biggest fan. To Mom, my sounding board. To Brendon, my inspiration.

ACKNOWLEDGEMENTS

I wish to express my deepest appreciation to my committee chair, Dr. Carol Johnston, whose expertise and patience ensured my doctoral journey was a rewarding adventure. Her enthusiasm and support for my projects are very much appreciated. It was an honor to have studied under her tutelage.

I am grateful to Dr. Christy Alexon for her interest in my dissertation project and for her talented contributions that improved the overall quality of my work. Her passion for nutrition as a practitioner and teacher has been an inspiration to me.

I would like to express my gratitude to Dr. Steven Hooker for his positive reinforcements during my doctoral journey. He is an avid wordsmith who helped me to improve my writing competence through practiced examples and valuable critiques.

I would like to thank Dr. Pamela Swan for her expert knowledge of the research process. Her feedback and suggestions were invaluable for elevating my work to a higher professional standard. For me, she is a skillful graduate school sorcerer.

I am indebted to David Schwake for mentoring me in school nutrition, and for his undying enthusiasm for my research ideas. His advocacy for my designs opened three years of fun and rewarding research projects at Litchfield Elementary School District.

I would like to thank Dr. Christopher Wharton for his thoughtful insights during the process of writing my dissertation. His critiques of my project data were invaluable.

I wish to thank the administration, teachers, and food service staff at Litchfield Elementary School District and Corte Sierra Elementary School. Your trust in me and your support of this nutrition research helped make my dissertation project a success.

TABLE OF CONTENTS

CHAPTER | Page

APPENDIX

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION / RATIONALE FOR THE STUDY

In many children's lunches, fruit and vegetables (F&V) are an endangered commodity. A majority of American children consume less than the recommend amount of F&V, 74% and 84%, respectively.[1] Eating too few F&V in childhood is associated with increased risk of cardiovascular disease (CVD),[2,3] hypertension,[4] respiratory symptoms,[5] and some cancers later in life.[3,6] Moreover, F&V consumption in children has been associated with lower energy intakes and decreased risk of overweight and obesity.[7-10] F&V are the only whole food sources of vitamin C and phytochemicals, nutrients that are not readily available in meats, fish, poultry, dairy, and refined grains. F&V, legumes, and whole grains are the only sources for dietary fiber (nondigestible carbohydrates and lignin). For some children, vitamin A, B6, and calcium may also be more readily available from plant sources. An estimated 12% - 24% of US children routinely skip breakfast,[11] a habit linked to reduced F&V consumption.[12,13] However, F&V availability at school is associated with an increased preference for vegetables outside of the school setting.[14] Evidence suggests that lifestyle and eating behaviors in childhood may persist into adulthood,[8,15,16] and since children spend a large portion of their time in school, these institutions are favorably positioned to influence healthy eating behaviors and improve diet quality.[17-19]

F&V consumption is linked to many health outcomes. Levels of oxidative stress may be higher in children exposed to secondhand smoke. Vitamin C is a powerful antioxidant and reduce oxidative stress that occurs from environmental exposures such as secondhand smoke. Soluble fiber is necessary to maintain optimal intestinal health. Gut microflora utilize soluble fiber to produce short chain fatty acids (SCFAs), ease bowl movements, and may improve mood and mental wellbeing. Vitamin B6 is necessary for biosynthesis of neurotransmitters, normal function of the immune system, and the production of hemoglobin.[20] Although readily available in animal products, the bioavailability of vitamin B6 can be diminished by cooking, freezing or other food processing, thus reaffirming the importance of including fresh vegetables in a balanced diet.[21-23] Although most children's diets provide adequate B6, a review of dietary recall data from the National Health and Nutrition Examination Survey (NHANES), 2003 – 2004 found that 24% of respondents who did not supplement B6 had low plasma levels (< 20 nmol/L) of pyridoxal 5'-phosphate (PLP), the active form of B6.[20]

The geographic location of a child's home may influence diet and health outcomes. Food deserts are residential areas without traditional grocery stores and represent neighborhoods where F&V are not easily accessible.[24] Food deserts have been associated with increased rates of asthma.[25] Increasing consumption of F&V in school may be especially important for children living in food deserts.

Research designs to promote children's F&V consumption are highly diverse. Many include some form of teacher training or additional nutrition-related curriculum. Others simply provide additional F&V to students. Some studies contain a single treatment, while others are multicomponent designs. Multicomponent interventions can be expensive and time consuming. Study durations also vary from several days or weeks to more than one year. The number of schools and students involved also differs between studies. Large studies have included 10 – 100+ schools.[26,27] Pilot studies typically evaluate one or several schools.[28-30] School food interventions typically do not report intervention costs or provide information regarding burden to school resources, making evaluations of sustainability more difficult.[31,32]

Most elementary school F&V studies collect consumption data through surveys or visual observation. Fewer of these studies obtain physical weights of F&V, though this method may provide more accuracy. Surveys are typically completed by parents, not students. The fallibility of using surveys to estimate dietary intake is well documented.[33] Additionally, there are four important quantities related to school salad bar F&V: total amount of F&V made available, total taken, total consumed, and total wasted. Most observational studies do not account for all four categories. F&V waste is not typically quantified, and it appears that no elementary school studies have quantified total available salad bar F&V.

Purpose of Study

Outside of the school setting, F&V are often consumed with condiments (flavorings such as dips, dressings, spreads, and other seasonings). Although some taste related studies have been conducted with school aged children,[34] there is a paucity of existing research to evaluate children's condiment taste preferences in an elementary school setting. Palatability of F&V is important because repeated tasting exposure is an effective strategy to increase children's liking of F&V.[34] This pilot study sought to inform the development of future interventions that seek to improve the palatability of F&V for children.

To evaluate sustainability of this project, capital outlays related to the flavor station intervention were used to conduct a simple cost analysis. Staff perceptions related to the study design were assessed by post-test surveys. F&V were weighed directly prior to placing on the salad bar and at the end of the lunch period. Uneaten F&V waste from lunch trays returned by students was collected and weighed. It was hypothesized that the addition of condiments for F&V would increase the amount of F&V consumed by children at lunch.

Hypotheses

H1: Providing condiment flavorings for salad bar F&V in an elementary school cafeteria during a three-week intervention will significantly increase children's lunch-time consumption of these fruits and vegetables.

CHAPTER 2

REVIEW OF LITERATURE

Recommended Intakes of Fruits and Vegetables

Americans do not eat enough fruits and vegetables (F&V). Approximately 9% – 12% of adults aged ≥ 20 years meet federally established recommendations for F&V consumtpion.[35,36] Increased F&V consumption has been shown to decrease risk of chronic disease.[2-5] Higher F&V intake is associated with lower energy intake and decreased risk of overweight and obesity.[7-10] Prospective cohort studies indicate an inverse relationship between F&V consumption and cardiovascular (CV) mortality. In a meta-analysis by Want et al., risk of CV mortality was decreased by 4% for each additional daily serving of F&V consumed.[37] Another meta-analysis by Want et al. found that individuals who consumed 3 – 5 servings of F&V per day had an 11% lower risk of stroke; those consuming >5 servings had 26% lower risk.[38] Federal guidelines are 1.5 – 2 cups of fruits and 2 – 3 cups of vegetables per day, depending on gender and age.[39] The 5-a-Day for Better Health Program was established by the National Cancer Institute to boost F&V consumption for all Americans. As the name implies, this program seeks to encourage Americans to eat a diet that is rich in F&V.[40] Multiple factors influence children's F&V consumption, including age,[41] gender,[42] ethnicity,[12,41] socio-economic status,[42,43] taste preferences,[41,44] parental F&V habits,[45] and access to F&V at home.[45]

The Healthy Eating Index (HEI) is a standard measure of Americans' diet quality. Fruits and vegetables represent separate components of the index, which is comprised of a 100-point scale. Together, F&V make up 20% of the HEI 100-point scale. The HEI measures adherence to federal regulations published in the Dietary Guidelines for Americans (DGA).[39] The DGA recommends eating at least five servings of F&V per day.

However, diet quality is not only about obtaining five servings per day, but also including a variety of F&V. Groups of F&V such as citrus, cruciferous, leafy green, as well as colors (red, orange, yellow), each provide varying amounts of essential vitamins and minerals, plus antioxidants and phytochemicals.[46,47] Colors often indicate the presence of phytochemicals. For example, carotenoids are yellow or orange. Lycopene, a type of carotenoid, contributes to the red color of apricots, tomatoes, and watermelon. Lycopene possesses the chemical structure of a carotene and functions as an antioxidant, but it does not exhibit vitamin A activity. Green vegetables contain chlorophyll, a substance that has demonstrated an ability to inhibit heme-induced colonic cytotoxicity. The term "phytochemicals" encompasses a broad range of chemicals found only in plants (Figure 1). Many phytochemicals have been associated with beneficial health outcomes in humans, but the evidence for dose-response relationships has not been established, and there are no specific USDA dietary guidelines for these substances.

Flavonoids are a subclass of phytochemicals found in the peels and skins of F&V and are the most common type of polyphenols, a subclass of phytochemicals. Flavonoids can be further categorized into anthocyanins (blue, purple, or red pigments), and anthoxanthins, flavonols (yellow or blue pigments), flavanols, and flavones (white pigment). Fruits such as blackcurrant, blueberries, cranberries, and raspberries are rich in anthocyanins.[48] These compounds can react with several species of free radicals to mitigate their harmful effects. In vivo experiments, such as those conducted by Wang et al., have demonstrated strong antioxidant effects of anthocyanins.[49,50] Over 250 anthocyanins can be found in nature. It is estimated that a typical American diet contains 180 – 215 mg/d of anthocyanins.[49] Type 2 diabetes can be exacerbated by hyperlipidemia and hyperglycemia, which subject the body to oxidative stress.

Anthocyanins have been shown to inhibit the oxidation of LDL in vitro, and thus, may be beneficial in the treatment of type 2 diabetes.[50]

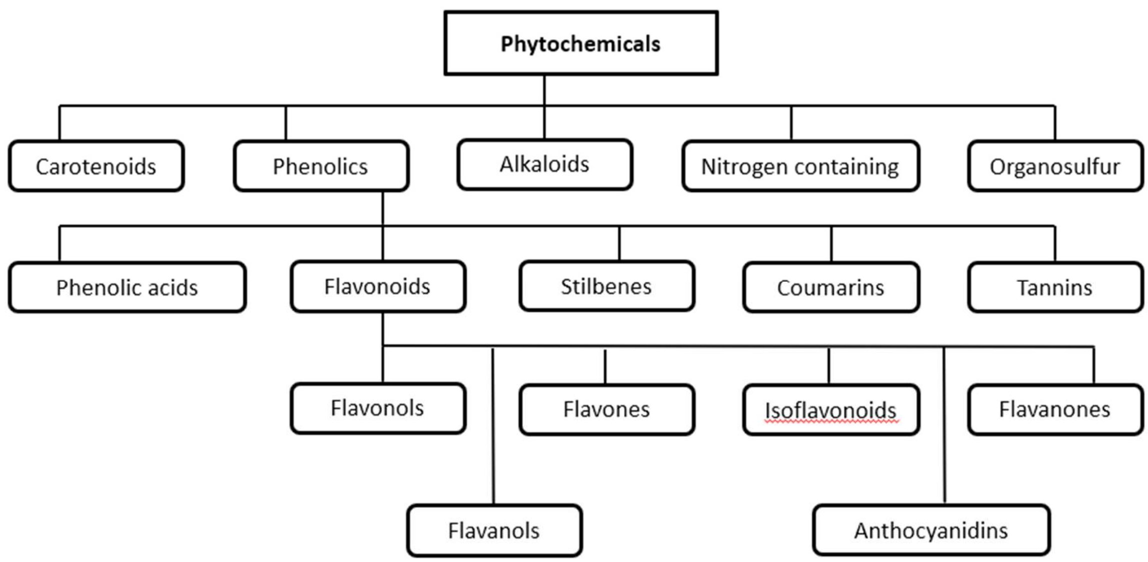

Figure 1. Classification of phytochemical constituents in fruits and vegetables. Adapted and modified from Nayak et al.[51]

The flavone content of a typical American diet is 1 g/d. In most F&V, flavone content varies slightly by season. However, a study of flavone chemistry conducted in the Netherlands found that green leafy vegetables contained five times more flavones in the summer, suggesting that flavone production may be stimulated by increased exposure to light.[52] Flavones may not play a significant role in human nutrition, however flavonols and flavanols are readily absorbed and metabolized. In several studies of diet content throughout the world, flavonol intake appears to vary by country, ranging from 6 g/d in Finland up to 64 g/d in Japan. Flavanols are found in fruits, tea, and wine.[53]

Energy dense food choices may be more affordable and easier to prepare than a meal prepared from fresh, whole foods. Quick-serve restaurants, convenience stores, and vending machines are often the most accessible sources of food. Food companies compete for consumer's attention by advertising products in print media, billboards, television, and social media. Under-consumption of F&V is not a simple matter of convenience and price.[45] Cooking skills, availability of F&V, and the ability to plan healthy meals must also be considered. During mealtimes, these factors converge to encourage less healthy options.[45,54] Convenience foods are typically processed, energy dense, and container higher amounts of saturated fat, added sugars, and sodium.[45,54,55] The term "Western diet" has been used to describe this pattern of eating. Conversely, a "healthy" diet is high in fruits, vegetables, and whole grains.[55] Moreover, adequate intake of F&V is relatively affordable. A recent USDA publication found that F&V recommendations can be met for $2.10 - $2.60 per day.[56] The Western dietary trend has been frequently observed in school-age children.

Food processing, commonly observed within Western diets, can alter the content of vital nutrients, phytochemicals, and fiber.[23,48,52,53] While some nutrients and dietary fiber may be reincorporated later in the manufacturing process through enrichment, other beneficial substances are often not replaced. Enrichment is the process of replacing nutrients, while "fortification" describes the practice of adding nutrients that were not originally contained in the food.[57] However, these practices typically do not replace other beneficial compounds found in F&V such as phytochemicals, which are only naturally occurring in plants.[47] Research into phytochemicals is a relatively new field.[47] The exact photochemical makeup of most F&V is not well understood. What is known is that phytochemicals function as antioxidants and have exhibited cancer-preventing benefits.

The recommend daily amount of F&V for boys and girls aged 6-11 is 1.5 cups and 1.5 – 2. 5 cups, respectively.[39] Eating breakfast is an important step toward meeting these daily guidelines as research has shown that children who eat breakfast are more likely to eat F&V than children who regularly skip breakfast.[58] Children who consume breakfast may perform better academically in school and have higher overall diet quality.[12,13] Unfortunately, breakfast consumption has declined over the past 25 years. An estimated 12% - 24% of US children may frequently begin the school day having skipped breakfast.[12,13] Children living in food deserts or whose parents/guardians do not provide F&V are at risk of low diet quality.[59] Exposure to F&V at an early age helps form healthy eating habits that can carry forward into adulthood.[8] School lunch provides a critical opportunity to increase their intake of F&V.[17,18]

In the US, all elementary school children attend lunch. Schools that participate in the US Department of Agriculture (USDA), National School Lunch Program (NSLP) are required to provide pupils with F&V at every lunch. The NSLP ensures that K - 5th grade students receive 1/2 cup of fruits and 3/4 cup of vegetables at lunch, per day, although the intake of these servings is not guaranteed.

Health Benefits of Fruit and Vegetable Consumption

There are many benefits to children consuming adequate daily amounts of F&V. Respiratory diseases may be exacerbated by poor F&V consumption.[60] In a study of Swedish children aged 8 years there was an inverse relationship between total fruit consumption and rhinitis (adjusted odds ratio (aOR) = 0.62; 95% CI = 0.45-0.86). When individual F&V were analyzed, consumption of apples, pears, and carrots was also inversely correlated with IgE-mediated asthma.[61] A cross-sectional study of Mexican children (6 to 7 years; n=1486) found that adherence to the Mediterranean diet was protective against upper respiratory allergic symptoms including rhinitis, wheezing, sneezing, and asthma.[62] Another project evaluating the Mediterranean diet is the International Study of Asthma and Allergies in Childhood (ISAAC) , a large cross-sectional study of children aged 9 to 11 years encompassing 155 study locations across 22 countries.[63] Phase II of this study included 50,004 children aged 8 to 12 years from 20 countries. Total intakes of fruits and cooked green vegetables were each inversely correlated with current complaints of wheezing. Consuming fruits and vegetables at least once per day was correlated with lower lifetime prevalence of asthma. Conversely, consumption of a Western diet pattern ≥ 3 times per week was correlated with a higher lifetime prevalence of asthma.[64]

A key component of the Mediterranean diet pattern is a high intake of plant-based foods including F&V, grains, legumes, nuts, and seeds.[65,66] This diet has been evaluated for its ability to mitigate respiratory allergies. There is evidence that following the Mediterranean diet pattern may help prevent atopic disease symptoms in children.[62,67] A cross-sectional study by De-Batlle, et al. analyzed a random sample of Mexican children aged 6 to 7 years in Mexicali, Mexico. ISAAC food frequency questionnaires (FFQs) were completed by the children's parents. For each child, a Mediterranean diet score was computed based on self-reported 12-month dietary intake.[62] The diet score was originally developed by Trichopoulou, et al. to measure the Mediterranean diet's impact on all-cause mortality. The scale ranges from 0 to 9, with higher numbers indicating greater adherence to the Mediterranean diet.[68] In the De-Batlle study, the mean Mediterranean score was 3.7 (SD=1.3). The score was inversely correlated with a child child's odds of ever having asthma. Interestingly, junk food and fat consumption were positively correlated with the odds of ever having asthma, rhinitis, sneezing, itchy/watery eyes.[62] Studies have also shown that consuming a Mediterranean diet is inversely associated with current symptoms of wheezing in children.[64,69] The 10-year ISAAC Phase Two study was setup to evaluate whether poor antioxidant and n-3 polyunsaturated fatty acids (PUFA) status combined with a Western diet pattern is associated with complaints of allergies and asthma during the previous 12 months. Children aged 8 to 12 years were randomly selected from centers located in 20 countries. The analysis found that the Mediterranean diet was protective against current symptoms of wheezing and asthma.[64] Castro et al. also tested the hypothesis that the Mediterranean diet (low intake of antioxidants and PUFA and high intake of n-6 PUFA [e.g. margarine or vegetable oil]) might be associated with wheezing in Spanish preschool-age children (n=2922). Parents of the children completed ISAAC Phase III core and environmental questionnaires. Non-wheezing children consumed significantly more vegetables and cereals during the preceding 12 months. The benefits of consuming a Mediterranean diet were independent of obesity and physical activity.[69]

Evidence suggests that a deficiency of dietary antioxidants including vitamins C and E, and beta-carotene may be associated with asthma. Eosinophils, t-lymphocytes and macrophages are important in the body's immune response. Unfortunately, when acting in the respiratory airways these cells are known to create an abundance of oxidants. Bronchial epithelial cells are damaged or destroyed by unmitigated exposure to oxidants.[70] However, some studies examining dietary intake and asthma have not supported the association with antioxidants. For example, a 2005 case-control analysis by Nagel et al. found that antioxidant status did not play a significant role in asthma risk of 105 newly diagnosed cases of asthma compared with 405 controls.[71]

F&V may be the ideal sources of several nutrients including, including vitamin C, vitamin A, antioxidants, and phytochemicals. Dietary fiber is found in the cell walls and intracellular matrix of plants.[47] Consuming whole F&V may confer greater health benefits than taking the concomitant vitamins, minerals, and phytochemicals in supplement form.[72,73] In a 25-day randomized controlled trial of healthy adult males (n=43), Dragsted et al compared six servings/day of F&V against supplementation with similar amounts of vitamins and minerals (V&Ms). F&V consumption, but not V&M supplementation, increased the activity of erythrocyte glutathione peroxidase, a defensive antioxidant enzyme. The amount of time before lipids are oxidized in plasma is termed the oxidation "lag time". In the Dragsted study, plasma lipid oxidation lag times was increased in both groups, but it was significantly greater in the F&V group.[72] Unlike consuming the recommended amount of F&V, supplementation of V&M has potential to cause more harm than benefit. A radical (sometimes referred to as "free radical") is a molecule with an unpaired electron, making it highly reactive (and damaging) to other molecules. Antioxidants work by donating an electron to a radical, which stabilizes the molecule. However, antioxidants are also able to gain an election, which can create a new radical.[73] A dose-response relationship may exist between F&V consumption and lifespan. In a study of Swedish adults aged 45 to 83 years (n=71,706), consumption of >5 servings of F&V were positively correlated with longer lifespan and decrease rate of all-cause mortality. For individuals consuming <5 servings of F&V, there was a linear relationship between servings and decreased lifespan with zero servings associated with a lifespan reduction of three years.[74] However, determining specific dose-response relationships for F&V has proven difficult. Although many cohort studies have collected data regarding the relationship between F&V intake and risk of mortality or disease, many were not sufficiently powered to achieve statistical significance.[75] Then there are the categories of F&V dose-response relationship to all-cause mortality, cardiovascular disease, stroke, and cancer; each likely having its own thresholds. Further complicating matters are the various categories of F&V (e.g. citrus, cruciferous, leafy green, legumes).

A systematic review and dose-response meta-analysis by Aune et al. analyzed 95 unique cohort studies encompassing Asia (n=20), Australia (n=5) Europe (n=26), and the United States (n=20). A 200 g/day incremental intake of F&V was associated with reductions in relative risk (RR) of coronary heart disease (8 – 16%), stroke (13 – 18%), cardiovascular disease (8 – 13%), total cancer (3 – 4%), and all-cause mortality (10 – 15%). The findings by Aune et al. were similar to previous meta-analyses but additionally included more studies and data for F&V subgroups. The incremental decreases in RR were significant up to 800 g/day (10 servings/day) of F&V.[75]

Oxidative Stress

Reactive oxygen species (ROS) are a byproduct of the body's metabolism of molecular oxygen (O_2). These radicals are often produced mitochondrial energy production. Oxidative stress occurs when the body's production of ROS exceeds its antioxidant capabilities. This is a problem because ROS can damage DNA, lipids, proteins, and other cellular structures.[76] Children exposed to environmental insults such as second-hand smoke experience increased oxidative stress. Oxidative stress and poor F&V intake have been associated with increased risk of atopic diseases such as asthma.[5,60,77]

To reduce oxidative stress the body must either avoid creation of free radicals or mitigate their damaging effects. Free radicals introduced through the environment (smoking, air pollution, etc.) might be lessened through behavioral changes, but oxidants created through the body's normal metabolism will still exist. A diet rich in F&V may offer increased protection against damage from environmental pollutants. In a cross-sectional study of coke oven workers (COW), Xie et al. found this population was exposed to high levels of toxic chemicals, including polycyclic aromatic hydrocarbons.

However, the COWs who consumed a plant-based diet tended to have higher levels of antioxidants and lower levels of oxidative stress (serum malondialdehyde) and genetic damage (micronucleus MN frequency & 8-oxo-2'-deoxyguanosine).[76]

A cross-sectional study by Holt et al. examined food frequency questionnaires for 285 boys and girls aged 13-17 years at baseline and 2-year follow up. After adjusting for age, sex, and race, F&V consumption was significantly correlated with oxidative stress. Adolescents with higher intakes of F&V had higher serum levels of vitamin C and lower levels of inflammatory biomarkers (C-reactive protein, interleukin-6, and urinary F2-isoprostane). This study was one of the first to show a potential correlation between high flavonoid intake and low inflammation in an adolescent population.[78] In addition to vitamins and minerals, plants produce other substances collectively known as phytochemicals.[79] These non-nutrient, yet beneficial compounds include carotenoids, polyphenols, and phytoestrogens.

Carotenoids are found in F&V that are red, orange, or yellow in color.[78] Of the approximately 50 carotenoids found in the human, beta-carotene is perhaps the most well-known. Although not considered an essential nutrient, a beta-carotene molecule is a provitamin and can be split to form vitamin A. Beta-carotene is fat soluble and has moderate antioxidative characteristics. Its protective functions are seen in cell membranes and low-density lipoproteins. Beta-carotene is not considered a nutrient, thus no dietary reference intake (DRI) has been establised.[78] Lycopene is carotenoid with stronger antioxidant effects than beta-carotene. Lycopene is found in tomatoes and may reduce the risk for CVD and some types of cancer.[80]

Taking antioxidants as supplements may not be as effective as eating whole F&V. The combination of vitamins, minerals, and phytochemicals contained in F&V appears to have an additive effect toward disease prevention.[78] For example, Liu et al. demonstrated that the combinations of vitamin C and phytochemicals from apples was more effective at killing cancer cells than vitamin C alone. The antioxidant capacity of 100 g of apples with skin is equivalent to 1500 mg of vitamin C. Thus, vitamin C accounted for <4% of the total antioxidant effect. Apples with skin had a higher total oxyradical scavenging capacity than apples without skin and phytochemicals account for most antioxidant activity of apples. It has been hypothesized that an individual phytochemical may not possess the same bioactive (beneficial) effects outside its constituent fruit or vegetable.[81,82]

Issues with lung function may increase oxidative stress. Children exposed to secondhand smoke experience higher amounts of oxidative stress.[83,84] Kahraman et al identified children and adolescents aged 5 – 17 years (n=40) who had been exposed to passive smoke from ≥ 5 cigarettes/day during the preceding six weeks. Forty age- and gender-matched subjects with no previous passive smoke exposure served as the control. Serum analysis indicated that the exposures group had significantly higher total oxidative stress than the control group. The exposure group also displayed lower levels of paraoxonase-1, a lipoprotein that supports the function of high-density lipoprotein (HDL). Asthmas sufferers with poor antioxidant status may experience more frequent and severe symptoms. Exacerbations of the disease may cause a further reduction in plasma antioxidants.[70] Some evidence suggests that vitamins C and E may lessen the detrimental effects of ozone on the small airways in the lungs of children.[70,85]

Consumption of fresh F&V is important because processed F&V may contain lower quantities of vitamins and phytochemicals. During processing, food may undergo heating, water soaking, drying/dehydration, oiling, and other production methods that change a food's natural properties. Processing also transforms polyphenolic molecules (e.g. anthocyanins, proanthocyanins), which may diminish their antioxidant capacity. Irradiation is used to destroy harmful microorganisms, but it may also damage phytochemicals and reduced antioxidant capacity.[51]

Beta-carotene supplementation has never been conclusively shown to be protective against cancer or cardiovascular disease.[86] The effectiveness of supplementing individual or combinations of vitamins and minerals in healthy populations is inconclusive. A recent review and meta-analysis by Schwingshackl et al. found that vitamin E supplementation was associated with a reduced risk of cardiovascular mortality, while supplementing folic acid was associated with lower risk of CVD. However, vitamins C, D, and K, and selenium, magnesium, and eicosatetraenoic acid where found to have no effect on any measured health outcomes. Moreover, beta-carotene combined with other supplements showed no effect.

Beyond having no effect, supplementing vitamins and minerals may be harmful. Singular supplementation of beta-carotene or vitamin A may increase the risk of all-cause mortality. The risk of cancer mortality was also increased from singular vitamin A supplemention.[87,88] Singular vitamin E may also increase the risk of all-cause mortality.[88] The US Preventative Task Force also specifically recommends against supplementing beta-carotene and vitamin E. A systematic review of primary prevention interventions conducted on healthy adults and published between 2005 – 2013 found null or weak evidence to support singular or combined multivitamin and mineral supplements in the prevention of CVD and cancer.[89] [See page 2 of Schwingshackl article]

Polyphenols are chemicals abundant in natural plant foods that possess potent antioxidant properties. Sources of polyphenols include coffee, tea, red wine, and oregano. Polyphenols may be protective against some forms of cancer and may help regulate immune cell function. There is evidence suggesting these chemicals can reduce inflammation and decrease risk of inflammatory diseases such as arthritis, macular degeneration, and dementia.[78] Polyphenols in the human diet consist primarily of flavonoids. Flavonoids are found in the skins of F&V and imbue these plants with vibrant colors. In adult populations, previous studies have shown that a high flavonoid intake was associated with lower amounts of oxidative stress and inflammation.[90,91] Although the impact of flavonoids in children's diets has not yet been well established, children who consume F&V are at lower risk of high cholesterol and hypertension later in life.[78] Thus, children may benefit from consumption of flavonoid-rich fruits and vegetables. Phenolic acids protect plants from ultraviolet radiation and environmental stress and are thought to provide similar antioxidant benefits in the human diet.[78]

Improvements to individual health can be seen by adding one F&V serving per day. By contrast, consuming additional animal-based foods does not equate to similar benefits. Consumption of dairy products does not appear to either diminish or increase risk of all-cause mortality or cardiovascular disease.[92] There is a dose-response relationship between increased servings of unprocessed red meat and increased risk of all-cause mortality. Consuming up to 1 serving/d of processed meat is associated with increased all-cause and cancer mortality.[93]

Intestinal Health

The average human body plays host for up to 100 trillion (10^{14}) microbes consisting of 500 – 1000 different species. To illustrate this magnitude, for every human cell there are 10 bacteria.[94,95] Collectively, these microbes are termed the "microbiota", and their genes the "microbiome".[96] The enormity of the microbial population might be thought of as "organ" unto itself. Composition of the microbiome varies greatly from person to person and is significantly impacted by an individual's diet.[94,97]

Prebiotics are plant-derived carbohydrate compounds such as fructans and galacto-oligosaccharides that are found in some vegetables and which promote the growth of beneficial bacteria in the gut. Examples of vegetables with prebiotic activity include artichokes, asparagus, leeks, garlic, and onions. In context of the human diet, prebiotics exhibit three key characteristics: acid resistance, fermentability, and microflora selectivity. In humans, prebiotics demonstrate a characteristic resistance to stomach acidity and digestive enzymes which allows them to survive the gastric environment during transit into the intestinal tract. Once in the intestine, prebiotics are fermented by gut microflora. Composition and/or activity of beneficial bacteria (i.e. probiotics) are stimulated in the presence of prebiotics. Examples of these helpful bacteria are *Lactobacillus* and *Bifidobacterium*.[98] Prebiotic F&V provide nutrients to beneficial microbes, which promote their colonization of the intestine. This is important because these microorganisms appear to impart many health benefits. Gut microflora may be protective against atopic diseases (asthma). Zuccoti et al. reviewed 17 randomized controlled trials and found that probiotic treatment for infants significantly decreased RR for eczema compared with control subjects; no similar benefits were found for decreasing asthma RR. Still, the results reinforce the notion of consuming adequate dietary fiber to support healthy gut microflora.[99]

The building blocks of F&V are simple and complex carbohydrates. The human body produces enzymes that break down simple carbohydrates (e.g. sugars), which are then readily absorbed in the stomach and small intestine. Starches are long strands of linked sugars that are found in abundance in vegetables and legumes such as potatoes, brown rice, and kidney beans. Dietary fibers are carbohydrates that cannot be digested by humans. While all plants contain fiber, some of the best sources include bran, dried peas and beans, F&V, whole grains, and nuts.[39] These fibers may be water soluble or insoluble. When dispersed in water, soluble fibers form gels and slow the passage of digested food through the gastrointestinal tract. Insoluble fibers increase bulk and enhance gut motility.[100] The soluble fibers are fermented by microflora in the large intestine (e.g. β-glucans, gums, pectin). Byproducts of their fermentation include vitamin K and the SCFAs propionate, acetate, and butyrate. Low soluble fiber intake and decreased production of SCFAs may be associated with higher risk of colon cancer.[101] SCFAs are an energy source in human metabolism.[97,100] SCFAs may also confer anti-inflammatory benefits. Species of bacteria that produce SCFAs include *Bacteroides* and *Faecalibacterium*. The presence of these beneficial microbes may inhibit gut colonization of pathogenic species.[97] The phytochemicals contained in soluble fiber are freed during fermentation in the gut and may provide anticarcinogenic and antioxidative benefits.[94] Furthermore, the intestinal absorption of other nutrients is impacted by the products of fermentation. Consumption of soluble fiber also supports healthy gut functioning through microbial diversity and preservation of the microbiome,[39,97,100] though a diet low in fiber will result in less beneficial species of gut microbes.[97]

The soluble fibers (e.g. cellulose, lignin) absorb water in the colon, which creates bulk and increases viscosity, and thereby eases defecation. This bulking effect also helps trigger satiety by providing a feeling of fulness. In sufficient quantities, fiber bulk can sequester potential carcinogens.[101] Resistant starch is another type of fiber that may protect colonocytes against the genotoxic effects of high protein and high fat diets. Functional fiber is synthetically produced from starchy foods. It can be added to foods during the manufacturing process and may confer similarly beneficial properties as naturally-occurring fibers. Overall, the consumption of adequate dietary fiber is associated with decreased risk of colon cancer, CVD, obesity, type 2 diabetes, and enhanced functioning of the immune system.[94,97]

Although US government guidelines count 1 cup of fruit juice as 1 fruit serving, the dietary fiber has been removed from these products and sugars may be added. Thus, fruit juices should be consumed in moderation. The 2015 DGA recommends that individuals consume at least half of fruit servings as whole fruits.[39] The DGA 2015-2020 set nutritional goals for daily fiber intake for children aged 4 – 8 years of 16.8 g and 19.8 g, and adolescents aged 9 – 13 years of 22.4 g and 25.2 g, respectively for females and males.[39] A recommend daily allowance (RDA) has not been established for fiber. The current daily adequate intake (AI) of fiber for children aged 4 – 8 years is 25 g. For children and adolescents age 9 – 13 years, the recommended fiber intake is 14 g per 1000 calories, or 31 g/day for boys and 26 g/d for girls.[39]

One study of preschoolers aged 2 – 5 years revealed a positive association between fiber consumption and diet quality.[102] Ma et al. conducted a meta-analysis of 11 prospective studies of dietary fiber and found a significant association between low fiber consumption and increased risk of proximal and distal colon cancers, +21% and +14%, respectively.[103] A meta-analysis of 17 prospective cohort studies by Yao et al. detected an inverse association between dietary fiber intake and risk of type 2 diabetes, and calculated a dose-response relationship in which each additional 2 g of dietary fiber intake lowered the risk of type 2 diabetes by 6%.[104] Kim et al. demonstrated a dose-response relationship of soluble fiber (β-glucan) and insulin sensitivity in a randomized crossover study of adult obese women (n=17). Experimental meals contained either 0, 2.5, 5, 7.5 or 10 g of β-glucan. Peak glucose levels were significantly lower for a meal containing 10 g versus 0, 2.5, and 5 g of β-glucan, though total area under the curve (TAU) at 2-hour follow up was not significant. Insulin sensitivity was significantly lower at 30 and 60 minutes for the 10 g meal compared with 0, 2.5, 5, and 7.5 g meals. There was an inverse linear relationship between increased β-glucan and decreased insulin response.[105] A review of literature suggests that no studies have evaluated a dose-response relationship for fiber in children.[106]

Intestinal health includes a genetic component. Children may inherit some of the gut microbiome characteristics of their parents.[107] Although an individual's genes cannot be modified, a recent statistical analysis 1,046 adults by Rothschild et al. suggests that only a 1.9% – 8.1% of bacteria taxa are highly inheritable, and that diet and lifestyle may account for >20% of the diversity in the gut microbiome.[108] The inclusion of a plant-based diet may be one of the most important lifestyle modifications that an individual can make. Carcinogenic compounds can be formed during various preparation techniques. Cooking meat at high temperatures creates heterocyclic aromatic amines (HACs). Some of these HACs are believed to be positively correlated with increased risk of some cancers. N-nitroso-compounds (NOC) and polycyclic aromatic hydrocarbons (PAH) are carcinogens that can be introduced into meats such as bacon, ham, and sausage through the process of curing or smoking.[109] Increased risk of colorectal cancer from consumption of meat recently led the World Health Organization (WHO), International Agency for Research on Cancer (IARC) to designate red meat as "probably carcinogenic".[110]

Cognitive Function

In school-aged children, F&V consumption is associated with better academic performance.[65,111,112] Consumption of fruits increases blood glucose levels which, in turn, may improve attention span. The mechanism for this is acetyl CoA, the byproduct of glycolysis. Acetyl CoA is a precursor to the neurotransmitter acetylcholine, an organic chemical necessary for neural function and cognitive performance.[113] A study by MacLellan et al. found that students with high academic performance were more likely to be daily F&V consumers.[111]

The Glycemic Index (GI) is a measure of the extent to which a food increases blood glucose concentration.[114,115] Foods are compared to a reference value (glucose or white bread), and ranked accordingly. A high GI food will raise blood glucose concentration more than a low or medium GI food. Fruits and non-starchy vegetables typically have low GIs because their fiber content has a blunting effect on intestinal glucose uptake. In the presence of fiber, carbohydrate absorption is more gradual, thus helping to prevent a spike in blood glucose concentration. This more stable availability of energy may improve brain function.[114,115]

A "junk food" diet pattern is one that includes processed foods, snack foods, added sugars, high sodium, saturated fats, and carbonated drinks.[66,116] Decreased consumption of junk foods and increased consumption of F&V has been positively correlated with specific academic outcomes. Surveys conducted by Øverbya et al. of 9th and 10th grade students (n=482) found those who reported frequent consumption of junk food had more difficulties with math. Conversely, there was an inverse relationship between regular fruit consumption and problems with mathmatics.[112] In one study, poor adherence to the Mediterranean diet pattern was correlated with lower academic performance.[65] Adequate and good adherence to a Mediterranean diet has been associated with improved math and language scores, and overall grade point average (GPA).[66]

Mood

Mood is a subject of interest related to child wellbeing. An unsuitable balance of macronutrients and micronutrients can affect a child's mood. Evidence from previous studies suggests that the etiology of depression may be influenced by diet and nutritional status. Low consumption of nutrient dense foods and high consumption of energy dense foods appear to increase the odds of finding depression and other mood related problems in children and adolescents. For instance, a Western diet pattern containing high levels of fat and sugar may be associated with higher incidence of depression.[116-118]

Chronic inflammation may contribute to depression [Jacka 2007]. Colloquially, unhappy (overworked) macrophages are implicated in the development of negative feelings or depressed moods. Macrophages secrete monokines (e.g. IL-1, interferon alpha, and tumor necrosis factor), a category of cell mediators. In the 1991 paper "The Macrophage Theory of Depression", Smith proposed that excessive macrophage monokine secretion can lead to symptoms of depression. Under a typical Western diet pattern, the ratio of omega-6 to omega-3 fatty acids is increased. Omega-6 fatty acids trigger increased macrophage activity. Omega-3 do not have this effect and eicosapentanoic acid (EPA) is an antagonist of arachidonic acid, a metabolite produced by macrophages. A diet that decreases the omega-6:omega-3 ratio will lessen macrophage activity and ease symptoms of chronic depression.[119] Since the time of the Smith paper, numerous studies have echoed a strong association between chronic depression and diet.[120-122]

The impact of dietary habits on mood is important because depressive symptoms in adolescence may persist into adulthood. Oddy et al. found that increased consumption of F&V, fish, and whole-grains was inversely correlated with inflammation and depressive symptoms in adolescents. Consuming a Western diet at 14 years of age was associated with increased inflammatory markers at 17 years.[123]

Subpar levels of some micronutrients may present as psychological disturbances prior to any physical symptoms [Benton].[124] This phenomena has been observed with thiamine,[125] riboflavin,[126] and vitamin C.[127] Deficiencies in folate[128] or B-vitamins have also been associated with depression.[118,129] Vitamins B6, B12, and folate are necessary for normal functioning of the brain and central nervous system. Furthermore, metabolism characteristics of b-vitamins make them prone to high turnover and body stores can fluctuate day-to-day. Herbison et al. used the Commonwealth Scientific and Industrial Research Organization FFQ to analyze the eating patterns of adolescents aged 17 years(n=709). Data were collected for the prior 12 months of eating. Youth with higher intakes of B6 and folate had lower rates of internalizing behaviors (depression and anxiety). Overall, poor status of b-vitamins and folate was associated with higher frequency of externalizing (aggressive/delinquent) behaviors. The association between b-vitamin status and folate was stronger for externalizing than internalizing behaviors. Externalizing behaviors increase risk of substance abuse in adulthood.[118]

The Strengths and Difficulties Questionnaire (SDQ; Goodman, 1997) is a validated measurement of children's level of hyperactivity, conduct problems, emotional symptoms, peer problems, and pro-social behavior. These sub-scales are measured from 0 – 10, and the first four comprise a total difficulties score (0 - 40); a higher score signifying more behavior problems. The fifth pro-social scale is a reverse score of total difficulties.[130] A longitudinal study by Wiles et al. found that a pattern of poor diet quality between the ages of 4.5 to 7 years was a positively associated with an increased SDQ score.[116] Eating a variety of F&V may also improve mood and quality of sleep.[120]

Vitamin B6 is implicated in depression and sleep quality due to its involvement in the synthesis of serotonin, a neurotransmitter. Vitamin B6 is also involved in amino acid metabolism and hemoglobin synthesis and PLP is involved in dozens of enzyme functions. The best sources of vitamin B6 are beef, poultry, and fish. However, the molecule can be destroyed by freezing or cooking. Thus, F&V are important alternative sources of vitamin B6. Dark leafy green vegetables, avocados, papayas, oranges, cantaloupe, and bananas are good sources of B6 that can be served raw at a salad bar. In a cross-sectional study of Japanese adolescents, increased vitamin B6 intake was negatively correlated with depressive symptoms.[131]

Poor nutrition potentially enables a cascade of unwanted behaviors and events. A child with poor F&V intake is more likely to be deficient in some nutrients, which affects behavior and mood, and may lead to aggressiveness. The Health Behaviour in School-Aged Children study (HBSC) is a worldwide collaboration with the WHO. Jackson et al. analyzed data from HBSC for U.S. children aged 10- 17 years. Children who reported the lowest F&V intake had 46% increased odds of displaying bullying behavior. Moreover, poor nutrition was more influential in causing non-deviant youth to become bullies.

Non-deviant youth with the poorest nutrition (highest junk food intake scores) had 171% higher odds of externalizing bulling behavior compared with deviant youth who had the lowest junk food intake. Non-deviant youth with the lowest F&V consumption had 108% increase odds of bullying compared to non-deviant youth with the highest F&V intake.[132]

Food Deserts

There is no scientific consensus as to the definition of food deserts. The US Department of Agriculture defines a food desert as a census tract that has low income (poverty rate ≥ 20% or median family income is ≤ 80% of the State-wide median family income) and ≥ 33% of live more than 1 mile away (or 20 miles away in the case of rural areas) from the nearest supermarket, supercenter, or large grocery store.[133] Typically, the term refers to some degree of reduced availability of F&V, whole grains, low-fat milk, and other foods that comprise a healthy diet.[24,134] Food deserts are areas where nutritious foods are less accessible due to inconvenience, geographic distance, economic factors, and/or a paucity of F&V variety. Absence of a supermarket is typical of a food desert setting.[24,39] Living in a food desert may increase risk of diet-related diseases including atopic diseases, diabetes, cancer, cardiovascular disease, and obesity.[24,25,134]

Easy access to foods that are less nutrient dense may negatively impact children's F&V consumption.[59,135] Timperio et al. examined associations between types of food stores and children's F&V intake. Surveys were conducted with Australian parents of 340 children aged 5 – 6 and 461 aged 10 – 12 years. The influence of family socioeconomic status was partially controlled by randomly sampling parents from low, medium, and high socioeconomic areas. The parents ranked their children's frequency of consuming 14 types of fruits and 13 types of vegetables. Availability of five types of food sellers (e.g. greengrocer, supermarket, convenience store, fast food store, and café/restaurant) were determined by using a geographic information system (GIS). Seventy percent of the children had none of these food store types within 0.5 miles from their home. For most subjects, the closest type of food store was either a convenience store (58.2%) or café/restaurant (54.2%). Children who lived within ≤ 0.5 miles of a convenience store were 38% less likely to consume fruit ≥ times/day and 25% less likely to consume vegetables ≥ 3 times/day than children who lived further from these types of stores.[59]

Children living in food deserts may be especially dependent on F&V served in school. Minority children and those from families living at or below the poverty threshold may be disproportionately affected.[24,136] Beydoun et al. analyzed data from the USDA Continuing Survey of Food Intakes by Individuals (CSFII) for years 1994 – 1996 (n=3,051), and 1998 (n=3819) for children aged 2 – 9 years. The dietary intake data consisted of two complete days of 24-hour dietary recalls. For each subject, a household-level poverty income ratio (PIR) was computed as total family income divided by the poverty threshold and children were categorized into either a low or high-income group. Children from the low-income group (PIR 0 – 185%) consumed less fast food and less F&V than children in the high-income group. High F&V prices were associated with lower fiber intake. Increased BMI was also associated with higher F&V prices, especially in the low-income group.[136]

Improved access to a greater variety of F&V may also increase consumption. Caldwell et al. used the Youth Risk Behavior Survey to survey adults and children in northern Colorado. These individuals were subjects in various community-based interventions with the goal of disseminating health and nutritional information. The respondents were asked about their prior 7 days of fruit and vegetable consumption. This survey was repeated at 1-year follow up and the respondents were asked about their perceived access to fresh F&V. Both greater perceived access to F&V and greater availability of F&V were significantly associated with higher F&V consumption.[137]

Children living in areas with decreased access to fresh F&V may miss out on positive role modeling, have fewer opportunities to view positive eating behaviors, and have less frequent exposure to healthy foods.[24,138] French et al. conducted a 2-year intervention involving 20 secondary schools. The intervention combined greater access to low-fat foods with positive peer role modeling of health food choices. At two-year follow up, although student's perceived purchases of low-fat foods did not increase, cafeteria cash register sales data revealed a significantly higher amount of purchases of low-fat foods.[138] Developing positive F&V preferences may help children gravitate toward healthy food choices. Self-efficacy also plays a role in a child's ability to make healthy food choices. Jago et al. used FFQs to evaluate how behavioral and environmental variables affect children's (n=204) consumption of F&V. Children who lived nearer to convenience stores had lower F&V consumption. The regression model predicting fruit consumption revealed that fruit and fruit juices were partial mediators (34%; p=0.071) for consumption; however, this mediation was not statistically significant. The association with vegetable consumption was partially (26%; p=0.032) mediated by preferences for vegetables and was statistically significant.[135]

Although living in or near a food desert will present hurdles to healthy eating, parents may be well suited to help their children overcome these disadvantages. Parents can model healthy F&V eating behaviors. There may exist a relationship between parental (especially maternal) education and children's consumption of F&V. Education level is often an indicator of socioeconomic status. Cooke et al. survived 564 parents of children aged 24 to 72 months. A dichotomous variable was used to categorize parents who left full-time education before or after the age of 21. Children ate more vegetables, but not fruit, when the parent had more education. No difference was seen in F&V consumption related to socioeconomic status. Positive parental role modeling related to dietary behaviors was also a powerful predictor of children's fruit ($r=0.39$; <0.004) and vegetable ($r=0.49$; $p<0.001$) intake. Breastfeeding, and introducing F&V to children at an early age (e.g. during family mealtime) were also correlated with higher child consumption of F&V.[42] Other studies have found contrasting results regarding socioeconomic status. Rasmussen et al. reviewed some the determinants of F&V consumption and found that higher socioeconomic status was associated with children's increased intake of F&V.[43] Parents can also limit their children's consumption of sugary snacks which compete with nutrient dense foods. Limiting empty calories can increase diet quality and may have the side effect of decreasing behavioral problems such as attention deficit hyperactivity disorder.[139]

Food deserts have also been associated with increased risk of asthma. In one chart review study, 57% of children lived >0.5 miles from a store selling F&V, and children who lived >1 mile from a grocery store had 53% higher odds of having asthma.[25] Low antioxidant status might partially explain this increase. Having food insecurity and living in an impoverished neighborhood by also increase perceived stress, which in turn, causes increased amounts of stress hormones to circulate throughout the body. This may increase anxiety and cause shortness of breath.

Dietary antioxidants may help reduce exercised-induced asthma.[140,141] Tecklenburg et al. evaluated a high-dose ascorbic acid (1,500 mg) supplement in a double-blind, cross-over, placebo-controlled trial. Subjects with exercised-induced asthma experienced significantly less asthma during the intervention than the control period.[141] Trenca et al. evaluated young adults (aged 18 - 39) with asthma during an ozone O^3 challenge. O^3 is an environmental air pollutant that causes oxidative damage in the human body. While the toxic effects of O^3 have not been well-studied in conjunction with diet, evidence suggests that a diet rich in F&V may help quench free radicals created from O^3 exposure. An intervention group received doses of 400 IU of vitamin E and 500 mg of vitamin C. These subjects experienced less acute bronchial responses at 35 minutes follow up.[140] A typical meal containing F&V does not provide these amounts of vitamins, but consuming the recommended daily amount of F&V will aid in replenishing the body's antioxidant stores.

Individuals with asthma have been shown to have suboptimal levels of circulating Glutathione peroxidase (GPx), an antioxidant that contains selenium.[142,143] Selenium content of foods is highly variable. Beets, cabbage, and mushrooms are sources of inorganic selenium, although the organic selenium found in animal sources is more bioavailable. The bioavailability of selenium can be affected by an individual's genotype and is also affected by the presence of other nutrients including vitamin E.[144]

School Interventions

From a public health perspective, changes in physical activity and diet are measured at population levels. The community environment is a popular area of study. Within communities, children spend a large portion of time in schools. Evidence suggests that school meals may be more nutritious than off-campus alternatives.[12,145] More than 30 million children eat lunch in school every day in the United States, making these institutions ideal locations to modify food attitudes and behaviors.[146] Consequently, many studies have investigated nutrition interventions in schools.[147,148] Interventions may be single component or multicomponent, but most have more than one component. Multicomponent interventions differ greatly but may include teacher training, nutrition curriculums, food distribution, marketing campaigns, and parental involvement. Within a multicomponent project, the individual treatments may show varying levels of interaction. Multicomponent interventions may realize greater overall effect than single-component interventions,[31,147] However, a recent review by Appleton et al. suggests the existence of publication bias toward multicomponent designs because the increased costs and resources that are required by more complicated study designs are rarely put into context. Multicomponent interventions tend to be more complex, have higher costs, require additional school resources, and long-term sustainability is not often explored. The heterogenetic nature of multicomponent designs makes comparisons between these studies more difficult. School staff may also perceive multicomponent interventions to be more burdensome. Due to their high degree of variability and overhead, multicomponent interventions are not as easily repeatable.[31,147]

Taste Preferences

Children are innately wary of new foods and may avoid opportunities to interact with and taste unfamiliar foods. This avoidance behavior, "neophobia", is an evolutionary response meant to protect against the ingestion of harmful substances. The effect can be exacerbated by ethnic traditions and cultural norms. In the school setting, a fear of new foods may prevent children from developing healthy preferences. Evidence suggests that repeated exposure to a food can reduce neophobia.[34,41,149]

Children form attitudes and behaviors about food through several mechanisms. Preferences are shaped by simple exposure, social context, and a reduction in neophobia. Associative learning refers to the context in which foods are presented, consumed, and the resulting outcomes; positive or negative experiences. Evidence suggests that children's repeated exposure to flavors may improve children's liking of specific foods. The impact of repeated taste exposure is powerful enough to reverse an existing dislike for a food.[149] The number of exposures necessary to improve liking (or decrease disliking) is not well established. It has been estimated that as many as 8 – 15 tastings may be necessary in elementary school aged children.[34]

The power of repeated tastings to influence children's vegetable liking was demonstrated by Lakkukula et al. during a 10-week study of fourth- and fifth-grade students (n=360). A baseline taste test established a child's like or dislike for four different vegetables (bell pepper, carrots, peas, tomatoes). Children recorded their feelings about the vegetable on written surveys. Following the baseline tasting results, the children were separated into groups based on whether they had or had not tasted the vegetables. Ten subsequent tasting sessions (1 per week) were held. Over 10 tastings, children's mean liking for carrots, peas, and tomatoes improved. Overall, there was no significant improvement for peppers. However, children who began the intervention as "dislikers", and who participated in at least 8 tastings, increased their liking of all four vegetables.[34]

Bere et al. found that children's F&V intake could be increased by having greater access to F&V at home and school. However, accessibility is not always enough to improve consumption. Preferences for F&V are a critical determinant of children's consumption patterns. Children are often focus solely on taste.[150] Fortunately, with repeated taste exposure, an existing taste aversion can be changed into a positive preference.[41,150] A large survey of Minnesota middle school students (n=3957) by Neumark et al. lends credence to the importance of providing children with pleasurable tastes of F&V. Although home availability of F&V was the strongest predictor of consumption, their model found that taste preferences were correlated with positive attitudes about health and nutrition (0.58) and self-efficacy for making healthy food choices (0.38).[151]

A randomized controlled trial conducted by Wardle et al. found that children's neophobia for certain vegetables could be overcome through repeated tastings. Improvement in liking was stronger in the taste exposure group than in the information-only or passive control groups at 14-day follow up. Longer-term effects of the exposure were not measured. A potential confounder in the study was that parents conducted the tastings in absence of the investigators. It is unknown whether parents were permitted to modify vegetable flavors with condiments or other seasonings.[41]

Methods of Assessing Consumption and Waste

School food interventions measure consumption through surveys, visual observation, and direct weights. Participant surveys are often used as the sole method of quantifying changes in F&V intake.[26,152,153] Dietary recall surveys have been used for decades to assess diet quality of individuals and populations. The memory-based nature of dietary recall surveys has been highlighted as a potential flaw in this measurement technique. NHANES is an ongoing, multi-decade project that attempts to track the health and nutritional status of Americans through annual, cross-sectional studies. A recent statistical analysis of NHANES dietary recall surveys from 1971 – 2010 found that mean reported intakes were prone to underreporting and "not physiologically plausible".[33] Another problem with questionnaires may be the subject's desire to omit details or please the investigator.[33] Surveying and interviewing protocols may induce false memories. When a subject is presented with a set of words that reflect a central theme, recall may be shape toward that theme.[154,155] Even when dietary recall surveys are well-designed, their use in assessing intakes of young children (7 – 11 y) may be problematic.[156]

Visual observations are conducted by investigative staff using grading scales.[157] Some studies have employed digital photography.[158] There is a tendency for visual observation to overestimate actual weights of F&V and small portions may also be prone to inaccurate estimation. Accurate observation of plate waste is predicated on knowing the initial amount of F&V place on the tray.[159]

Unlike surveys and visual observation, the weighing of foods provides a direct measurement of quantity.[157] Foods can be weighed on a participant level or in aggregate. Obtaining food weights has been shown to be significantly more accurate than visual observation.[157] Most observational F&V interventions have not quantified waste. Thus, very few elementary school studies exist which have combined measurements of F&V taking, consumption, and waste. A review of literature did not reveal any elementary school studies that have measured the total quantity of F&V made available at a salad bar during lunch. Previous studies that have aggregated F&V weights have done so based on a representative sample, or after a subject placed the F&V on the tray.[160-162]

Individual tray weighing is an alternative to visual observation. Under this scheme, subjects are randomly invited to receive a marked lunch tray when paying for their lunch. The students then make their food selections, after which the designated trays are intercepted and directed to a measurement table to facilitate weighing of the F&V. Student cooperation in the process is incentivized by research staff through the provision of small gifts. The strengths of such a design are the ability to measure student consumption at the individual level and the additional demographic data that may be collected.[160]

Changes in Fruit and Vegetable Consumption

Many school F&V interventions result in only small improvements, or null findings.[147,152,163-165] A meta-analysis by Evans et al. evaluated 27 studies and found a mean daily F&V increase of 1/3 - 1/2 servings (20 – 30 g). However, most of the included studies realized no significant improvement in vegetable consumption. Interestingly, any improvements in vegetable intake (0.07 servings) were voided by the exclusion of fruit juice.[147] A multicomponent intervention by Ransley et al. included free daily F&V, teacher training, marketing, cooking activities, and games in a cohort of 3703 children aged 4 – 6 years, in 92 schools. For students aged 6 years, the intervention group's mean serving intake was 0.5 servings higher at 3 months compared with the control's intake, but at 7 months there was no difference between the groups (0.00 servings).[152]

Extrication of single effects in multicomponent designs can be difficult. A mitigating strategy is to include a control group that receives only one of the interventions. A two-year study in The Netherlands at primary schools compared a single-component F&V intervention with a multicomponent nutrition intervention. Six schools were randomly assigned to receive either one extra serving of F&V, or a program that included classroom nutrition lessons and parental involvement. Six other schools served as controls. At the 20-month follow up, children in single intervention had a 7.2 g/day increase in fruit consumption, while those in the multicomponent increased intake to 15.2 g/day. No significant changes were detected in vegetable intake. These intakes were measured indirectly by surveying parents. Fruit juice was included in the intake calculations.[163]

Some multicomponent interventions include a physical activity (PA) component. The Active Programme Promoting Lifestyle in Schools (APPLES) is a school-based obesity prevention program that incorporates PA and nutrition. APPLES provides teacher training and assistance with modifying school lunch menus. The program was implemented over the course of one academic year. A participating school must submit a formal action plan outlying the specific PA and nutritional changes it will make. The APPLES program was evaluated in a 12-month randomized controlled trial. At 12-month follow up, there were no significant changes seen in children's PA or dietary behavior scores. There were slight improvements in children's mean daily F&V intake as measured by 24-hour recall.[164]

Active for Life Year 5 (AFLY5) was 2-year study design that combined PA and dietary interventions. Subjects were children aged 9 – 10 years during the intervention period and 10-11 years at follow up. One strength of this study was its 12- and 24-month measurements. The intervention ended after 12 months, so the 24-month follow up provided a glimpse of the program's long-term impact. AFLY5 was a large multicomponent design that tested a combination of five treatments at 60 primary schools in England. Teacher training, multi-media curriculum materials, additional homework, marketing, and parental involvement were the primary treatments, all of which ended after the first year. Dietary recall data was obtained through interviews with children conducted by trained field workers. No significant changes in F&V consumption were observed at 12 or 24 months. At 12 months, students in the intervention schools increased their daily F&V intake by only 0.02 servings more than the control.[165]

Some school F&V study designs may impart a higher degree of subject burden or necessitate greater investigator interaction. Digital photography has been used to estimate plate waste at the individual student level. Subject selection is typically randomized, and trays are colored coded to alert investigative staff about which students are being followed. To obtain a photograph of the tray, the student may be intercepted by an investigator before proceeding to eat lunch. Students are made aware that participation is optional. Although the photographs are taken after the child has made their F&V selections, the direct interaction likely increases a child's awareness that the tray contents are a focus of the intervention'.[158] It is unknown what amount of subject bias may be introduced through the additional student interaction required by an individual tray evaluation method.

Conclusion

This pilot study tested the feasibility of condiment taste tests and the subsequent effects on a salad bar F&V intervention. Few school studies have measured total available salad bar F&V, amount taken, amount consumed, and amount wasted. Upon review of the existing literature, it appears that no study has evaluated the impact of offering student-chosen condiments at an elementary school salad bar to increase F&V consumption at lunch. The taste tests provided detailed information on condiment taste preferences for 30 individual children. Taste test data included the children's favorite condiment flavors, gender, and grade level. The salad bar intervention collected total F&V available, as well as the amount of F&V taken, consumed, and wasted. Descriptive statistics and qualitative analysis were used to analyze taste test surveys and F&V data. To evaluate sustainability, capital outlays related to the flavor station were used to conduct a simple cost analysis. Staff perceptions related to the present study design were assessed by post-test surveys.

CHAPTER 3

METHODS

The current pilot study tested the feasibility of using a flavor station in conjunction with salad bars to promote fruit and vegetable (F&V) consumption. Sample size did not reflect statistical considerations.[166] Pilot studies conducted in 1 – 4 schools are common in nutritional research and inform future full-scale trials.[28-30]

The study took place at Corte Sierra Elementary School (CSES; Avondale, AZ), which is one of 10 elementary schools in the Litchfield Elementary School District (LESD). CSES enrolls ~700 students spanning grades K – 5, and 50% of these children are eligible to receive NSLP free or reduced-price lunches (FRLs). The administrative staff at CSES were supportive of nutrition research, philosophically and financially, and the food service department personnel demonstrated excellent adherence to previous research protocols.

The study co-PIs (Cameron Scholtz and Dr. Carol Johnston) have previous experience with elementary school nutrition interventions. Dr. Johnston has conducted taste tests and focus groups. LESD's Director of Child Nutrition (DCN), David Schwake, RD, SNS, provided additional support for this project. Unless otherwise specified, all F&V, condiments, equipment, and food preparation services were provided by the school's food service department.

The taste testing protocol was approved by the Arizona State University (ASU) IRB (STUDY00005289), and informed consent was obtained from the parent or legal guardian, and verbal assent was attained from the child. The cafeteria intervention protocol (STUDY00008351) was deemed by the ASU IRB to be research not involving human subjects as defined by DHHS and FDA regulations. See Appendix A for IRB documentation. Participant flow and timeline for the study phases is presented in Figure 2 and Appendix B.

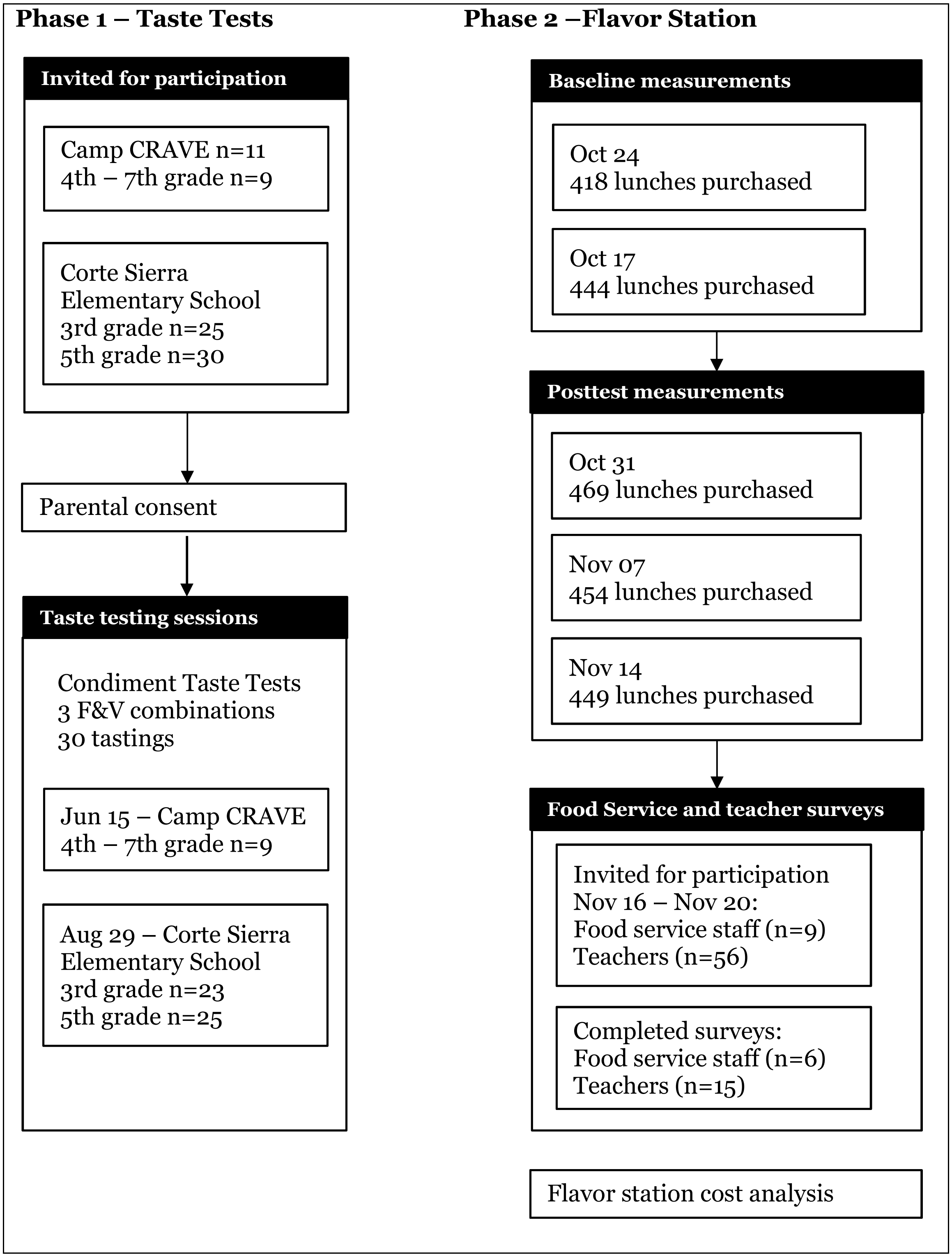

Figure 2. Project flow diagram of the process through the phases of the taste tests, flavor station baseline and posttest measurements, surveys, and cost analysis.

Phase 1: Taste Tests

Condiment taste tests were conducted with convenience samples from ASU Camp CRAVE (ACC) students aged 9 – 12 years (n=9), and CSES students aged 8 – 10 years in the 3rd (n=23) and 5th (n=25) grades. Investigative staff were provided with one hour of training. Investigators worked with the DCN and school administrators to determine the schedule and location of the taste tests. Investigators prepared all condiment and F&V samples approximately 1 - 2 hours before the tastings. There were three tastings sessions (ACC=1; CSES=2), each lasting approximately 45 minutes. The ACC session took place in the ASU College of Health Solutions instructional kitchen facility. The CSES sessions were conducted in that school's cafeteria. All students were seated during testing. Students were permitted to have a bottle of water. During testing, soiled sample cups (2 oz; reditainer.com) and napkins were collected as students finished. Each child received small cups with samples of each condiment. Approximately every five minutes, a new trio of condiment/F&V samples was served to the students. Nine condiments consisting of various seasonings and toppings were tested for acceptance (Table 1). These condiments were chosen in consultation with the CSES administration, which sourced the products. Ranch dressing was included as a comparison because CSES had occasionally offered it on the salad bar during the previous school year; however, this dressing was not used on the salad bar during the present study. With each condiment sample, a small piece of fruit or vegetable (e.g. dippers) was provided. These foods were chosen based on what was typically available on the school salad bar during the fall 2018 semester. See Appendix E for examples of prepared sample cups.

Table 1. Condiment and F&V pairings that were used in all three taste test sessions.

Condiment	F&V 1	F&V 2	F&V 3
Cinnamon/sugar mix	Apple	Banana	Pear
Grated parmesan cheese	Apple	Celery	Cucumber
Honey	Apple	Banana	Broccoli
Hummus	Broccoli	Carrot	Tomato
Peanut butter, creamy	Apple	Banana	Celery
Sriracha	Apple	Broccoli	Cucumber
Soft cheese spread	Apple	Broccoli	Celery
Tajin	Apple	Broccoli	Cucumber
Yogurt, plain, low fat	Broccoli	Carrot	Pear
Ranch dressing	Carrot	Cucumber	Tomato

Children had the opportunity to taste all condiments. One 5th-grade student was following a strict ketogenic diet and only permitted to sample half of the condiment/F&V combinations. Fruits included small pieces of apple, banana, and pears. Vegetables include small pieces of broccoli, carrot, celery, cucumber, and tomato. The same condiment/F&V combinations were used for all tasting sessions. Investigators led the students through the tasting procedure with a narrative instructional script read at the beginning.

> "*You were given 3 cups that contain a condiment, each with a different fruit or vegetable. One at a time, we will ask you to please taste each of the condiments. You do not have to swallow it; you may spit it into your napkin after tasting. Please make sure that you taste each condiment one at a time. If you like it a lot, mark the happy face on the right. If you don't like, mark the sad face on the left. If you like it a little, or dislike it a little, mark a face in between. At the bottom of the page, there is a*

question about how often you eat the condiment. Please read it carefully and answer it honestly.

First taste the ___________.

Second, taste the ____________.

Third, taste the _____________."

While tasting, the children completed a one-page survey (Appendix C).[34] The tasting portion of the survey contained a 7-point Likert-type scale with happy, neutral, or sad cartoon faces. These ratings from best to worst tasting were "Super good" (7), "Really good" (6), "Good" (5), "May be good/may be bad" (4), "Bad" (3), "Really bad" (2), and "Super bad" (1). The frequency question was a 6-point Likert scale: "Every day" (6), "Most days" (5), "Once a week" (4), "Several times a month" (3), "Several times a year" (2), "Rarely/never" (1). The backside of the first survey page also recorded grade level, age, and gender, but no personally identifiable information was collected. The sampling order of the condiments was the same for every child. Children were instructed to not talk with each other or view each other's papers during testing.

Survey data was manually entered into the Statistical Package for Social Sciences (SPSS (PASW), version 23, IBM Corporation. Somers, NY) by trained investigative staff and each survey form was be verified by two investigators. Descriptive statistics were computed for gender, grade, and age. Mean tasting ratings were tallied and the five highest rated condiments (cinnamon/sugar, honey, peanut butter, parmesan cheese, and yogurt) were made available at the flavor station from October 31 through November 14 of the fall 2018 semester.

Phase 2: Flavor Station

Data from Phase I surveys were used to select the top five flavorings used in Phase#2 (Table 2). F&V and condiments were quantified by direct physical weighing of each. Weighing has been found to be significantly more accurate than indirect observation (e.g. graded scales, photos).[157] Additionally, the current study collected weights in aggregate, instead of per child. This method limited investigator interaction with students and the subject burden.

Table 2. Condiments selected for inclusion in the Phase 2 flavor station intervention, and the method of serving.

Flavoring	Serving method
Cinnamon and sugar mix (1:4)	Shakers
Grated parmesan cheese	Single-serve packet or shakers[a]
Honey	Single-serve packet
Peanut butter, creamy	Single-serve packet
Yogurt, plain, low fat	Tub with serving spoon

[a] Dispensed in single serve packets during week 1; shakers during weeks 2 – 3.

Students who brought lunch from home did not receive F&V from the salad bar. Teachers and staff who desired F&V were served from a separate source. Only F&V that originated from the salad bar were weighed. This included several prepared items such as bean salad and pasta salad with vegetables. Cooked vegetables from entrées were not weighed.

The investigative staff received one hour of hands-on training at the elementary school. Training was considered successful when direct observation affirmed the trainee's adherence to procedures. Additionally, all F&V weighing and tray waste collections were supervised by a member of the research team. New measurements were routinely compared against historical records to detect any variations in trends.

Based on historical lunch attendance records, a sufficient amount of salad bar food was prepared and weighed before the lunch shift begins. The project workflow was similar to previous plate waste trials conducted by the PIs. Students returned soiled trays to a table next to the dishwashing area. Investigative staff separated all uneaten salad bar food into separate waste bins, which were weighed at the end of each lunch period. In addition, at the end of the lunch period, the remaining (unserved) salad bar food was weighed.

All weights were measured on a digital gram scale (Smart Weigh ACE200, Chestnut Ridge, NY) and recorded to the nearest whole gram increment. Prior to each lunch period, a 5 kg laboratory calibration weight was used to calibrate the scale. Salad bar F&V and flavor station condiments were weighed (or counted) before the start of lunch, during both 20-minute intermissions, and after the lunch period. F&V waste was measured at the end of both intermissions and at the end of the lunch period.

On Monday through Wednesday of the first intervention week, the school principal used the school's intercom to announce to the student body that the flavor station offerings would begin during Wednesday's lunch. On that Wednesday morning, flavor station flyers were posted at children's eye level around the cashier's podium and throughout the salad bar and cafeteria area. The intercom promotions were not continued after the first intervention day, but the flyers remained in place for the duration of the experiment.

The lunch line flow is depicted in Appendix D. Students lined up at the cashier podium, and after paying for lunch, each student selected a tray with entrée at the hot food counter. The students proceeded along the salad bar to make F&V selections consisting of eight fruit and seven vegetable options. The students self-served these F&V using serving spoons or tongs. All students were required to select at least 1/2 cup of fruits and 3/4 cup of vegetables; this was verified by visual inspection from food service staff. Students with too few F&V were instructed to return to the salad bar to obtain their minimum amounts of F&V. After making their F&V selections, students could optionally visit the flavor station table to obtain condiments. Two flavor station tables were located on either side of the salad bar exit doors. As students exited the salad bar area, they could optionally stop at the flavor station to add condiments for their F&V. The method of condiment distribution varied (Table 2). Yogurt was served from a tub with a serving spoon. Peanut butter and honey were obtained as individually wrapped, single-serve packets. Cinnamon/sugar and parmesan cheese were dispensed from shakers. Investigative staff monitored the flavor station on test days, otherwise it was monitored by food service staff.

Two baseline measurements were made on October 17th and 24th, followed by three weeks of intervention and posttest measurements on October 31st, November 7th, and November 14th (Figure 1 and Appendix B). All field weight and counting measurements were made by two investigators. Field data (i.e., F&V and condiment measurements) were manually input into Microsoft Excel by trained investigative staff. The amount of F&V consumed per child on a given day was calculated (served - wasted) and divided by the count of lunches purchased to determine quantities per child.

Cost Analysis

Peer-reviewed, published, school food interventions rarely report costs or address potential resource issues.[31,32] With cooperation from the DCN and school administrative staff, a limited cost analysis was performed. The cost of condiments served was totaled for each of the three intervention days. There were no additional measurable costs to provide the flavor station (e.g. new hardware, dispensers, etc.). Daily condiment costs were divided by the number of lunches purchased to determine mean cost of condiments per child.

Staff Surveys

Staff perceptions of the flavor station were assessed at the end of the trial. The DCN, school principal, teachers, and kitchen staff were invited to complete an optional (available for 2 weeks) web-based survey (Qualtrics.com). The surveys were adapted from a previous USDA Fresh Fruit and Vegetable Program evaluation report.[167] In keeping with the USDA's abbreviation convention, the survey instructions presented the flavor station intervention as "…an intervention to encourage fruit and vegetable consumption, known as the Flavors to promote Fruit and Vegetables Program (FFVP)". The surveys did not collect any personally identifiable information. During the third posttest week, the DCN and school principal informed staff and teachers that a FFVP survey would open the following Monday and be available for two weeks. Emails with the survey link were sent at 8am on Monday. On the following Monday, the Qualtrics system auto-generated a reminder to any recipients who had not yet responded. The DCN and the assistant school principal also sent an email reminder to their respective staff. All teachers have a school email address. Some food service staff used a shared email address and completed their surveys on a shared computer in the CSES kitchen.

Data Analysis

Data were analyzed using Excel for Office (version 16.0.10730.20264, Microsoft Corporation) and the Statistical Package for Social Sciences (SPSS (PASW) version 24, IBM Corporation. Somers, NY). Basic descriptive statistics included means and standard deviations. A repeated measures test was used to analyze condiment ratings and frequency of consumption. A one-sample t-test was used to analyze F&V consumption. Pearson correlation coefficients were used to test for possible correlations among the different variables tested. Qualitative assessments established temporal trends by visual inspection of plotted means. To evaluate sustainability, capital outlays related to the flavor station intervention were used to conduct the cost analysis.

CHAPTER 4

RESULTS

During Phase 1, condiment taste tests were conducted with eligible children aged 8 - 12 years (n=57). Fifty three percent of the participants (n=27) were female, 84% were aged 8 - 10 years (n=53), and 95% were in grades 3 - 5 (n=54) (Table 3). The children judged 10 condiment samples, each with three F&V permutations, for a total of 30 different tastes per child. One 5th-grade student following a ketogenic diet was only permitted to sample half of the condiment/F&V combinations.

Table 3. Characteristics of children who participated in Phase 1 taste tests.

Demographic characteristic	Subgroup	*n*	%
Gender	Male	27	47
	Female	30	53
Age (y)	8	20	35
	9	5	9
	10	28	49
	11	2	4
	12	2	4
Grade Level	3	23	40
	4	2	4
	5	29	51
	6	1	2
	7	2	4

Taste Tests

Data from the Phase 1 taste tests were used to design the intervention used in Phase 2. The children's highest rated condiments from the taste tests determined the flavors used in the Phase 2 intervention. Excluding ranch dressing, the top five rated flavors (displayed as mean score) were creamy peanut butter (5.3), cinnamon/sugar (5.0), honey (5.0), grated parmesan cheese (4.6), and low-fat Greek yogurt (4.4) (hedonic scale from 7 = "Super good" to 1 = "Super bad"; Figure 3; Appendix C). Other than peanut butter, mean taste ratings were not correlated with mean frequency of consumption. The condiments that were most frequently consumed outside of school were grated parmesan cheese (3.7), soft cheese (3.5), creamy peanut butter (3.3), Tajin (2.9), and Sriracha (2.8) (Fig 3 and 4). Although popular in taste, ranch dressing was not frequently consumed outside of school (2.4).

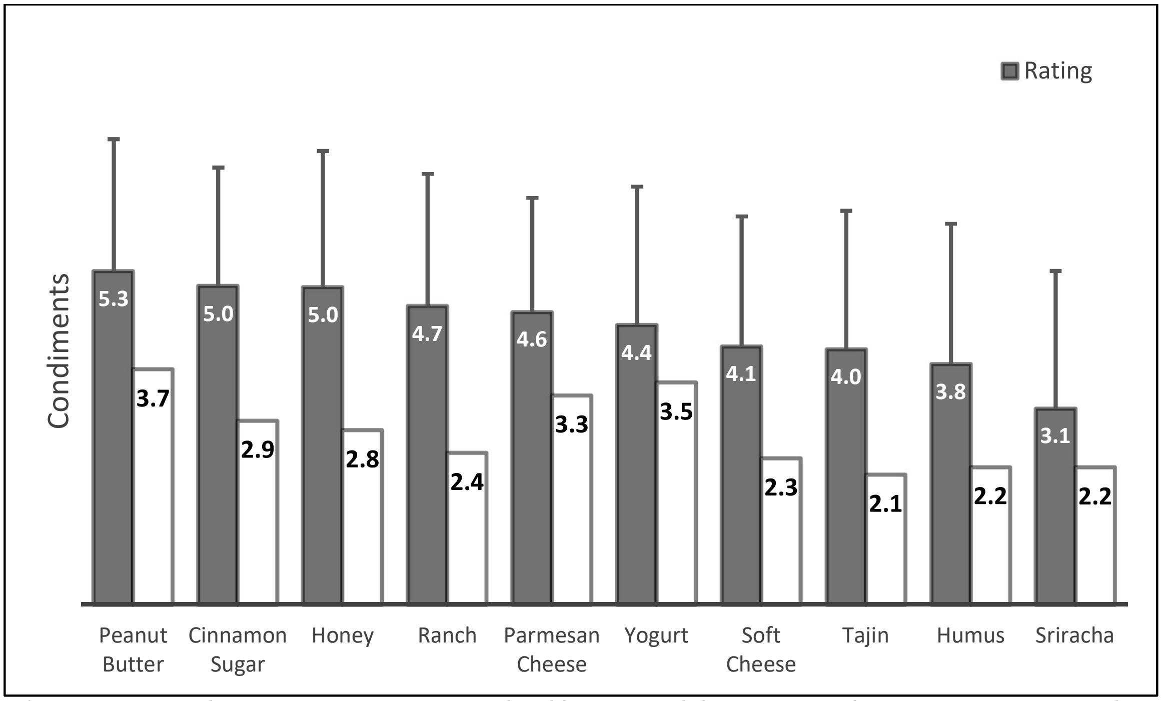

Figure 3. Condiment taste ratings and self-reported frequency of consumption outside of school (n=57). Ratings were a hedonic seven-point scale from 7 = Super good to 1 = Super bad. Frequencies were an ordinal six-point scale with 6 = Every day; 5 = Most days; 4 = Once a week; 3 = Several times a month; 2 = Several times a year; 1 = Rarely/never. Data were means ± SD.

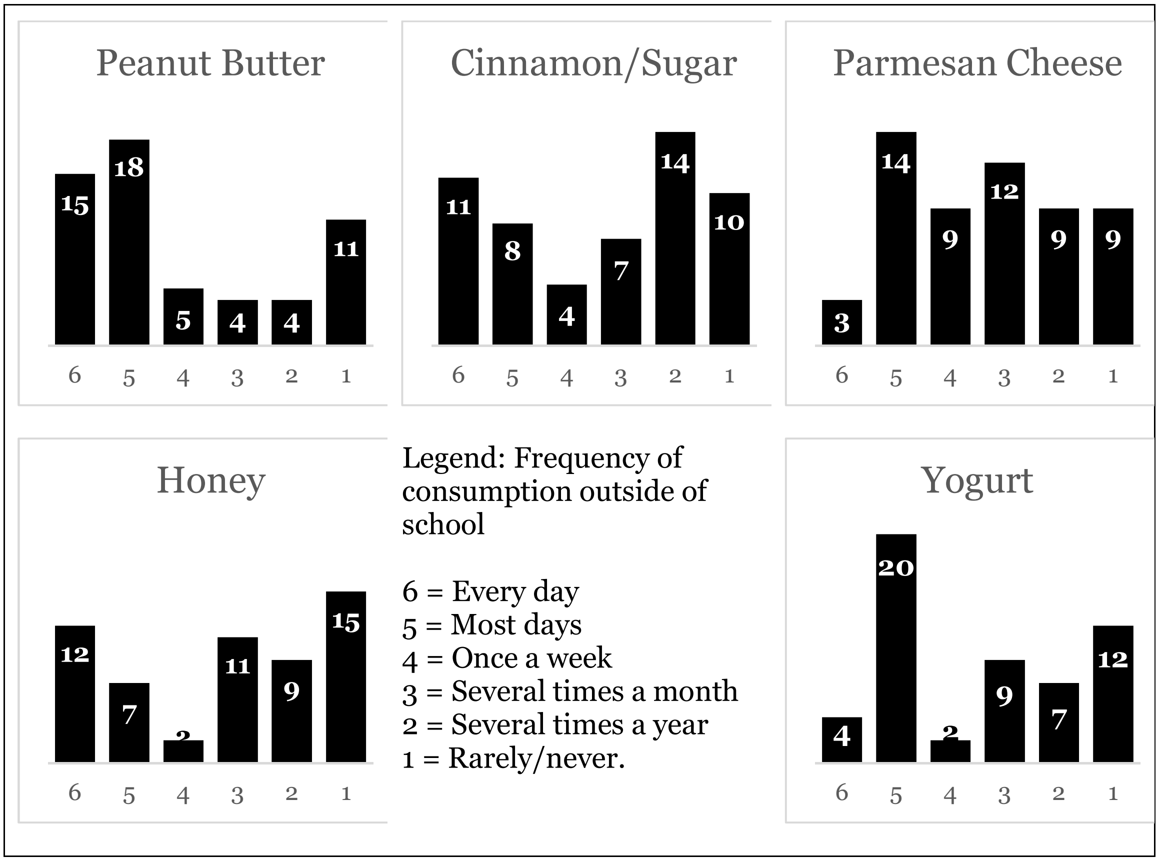

Figure 4. Self-reported frequency of consuming each condiment outside of school for the top five highest rated flavors (n=57).

Fruit and Vegetable Consumption and Waste

During each intervention day of the five-week study, an average of 447 students purchased school lunch and self-served F&V at the salad bar (Table 4). There were no significant differences in the quantities of lunches purchased across the five measurement days (P=0.381). The average number of lunches purchased during the posttest measurement days was six percent higher than the baseline measurement days (431 vs 457). The fluctuations in student attendance were within historical parameters. There were no atypical school functions (e.g. field trips, early out) on measurement days.

Table 4. Counts of lunches purchased on each weekly measurement day.[a]

Grade	Week 1 Baseline	Week 2 Baseline	Week 3 Posttest	Week 4 Posttest	Week 5 Posttest	Mean
Kindergarten	66	74	77	69	72	72
1st Grade	52	52	51	48	51	51
2nd Grade	79	81	91	79	82	82
3rd Grade	73	73	81	90	77	79
4th Grade	69	78	81	78	80	77
5th Grade	79	86	88	90	87	86
Total	418	444	469	454	449	447

[a] Lunch purchases did not vary significantly across time.

The amounts of salad bar F&V selected, consumed, and wasted are presented in Figure 5. Mean F&V consumption per child at baseline was 43 g and rose to 60 g at posttest week three; an overall increase of 17 g. Mean F&V waste increased from 98 g at baseline to 118 g at week three. Total F&V selection per child increased from 142 g at baseline to 178 g at week three. Over three posttest measurements, there was a significant linear trend in F&V consumption (r=0.986; P=0.014) and waste (r=0.960; p=.040). At baseline, an average of thirty percent of the F&V selected were consumed and this increased to an average of 34% for the posttest days (Figure 6; one-sample t-test P=0.002). The proportion of F&V wasted decreased from 69% at baseline to an average of 66.3% for the posttest days (Figure 5; one sample t-test P=0.015). Figure 6 displays the weekly change in proportion of F&V consumed and wasted during the trial. See Appendix E for an example of a F&V waste collection bin.

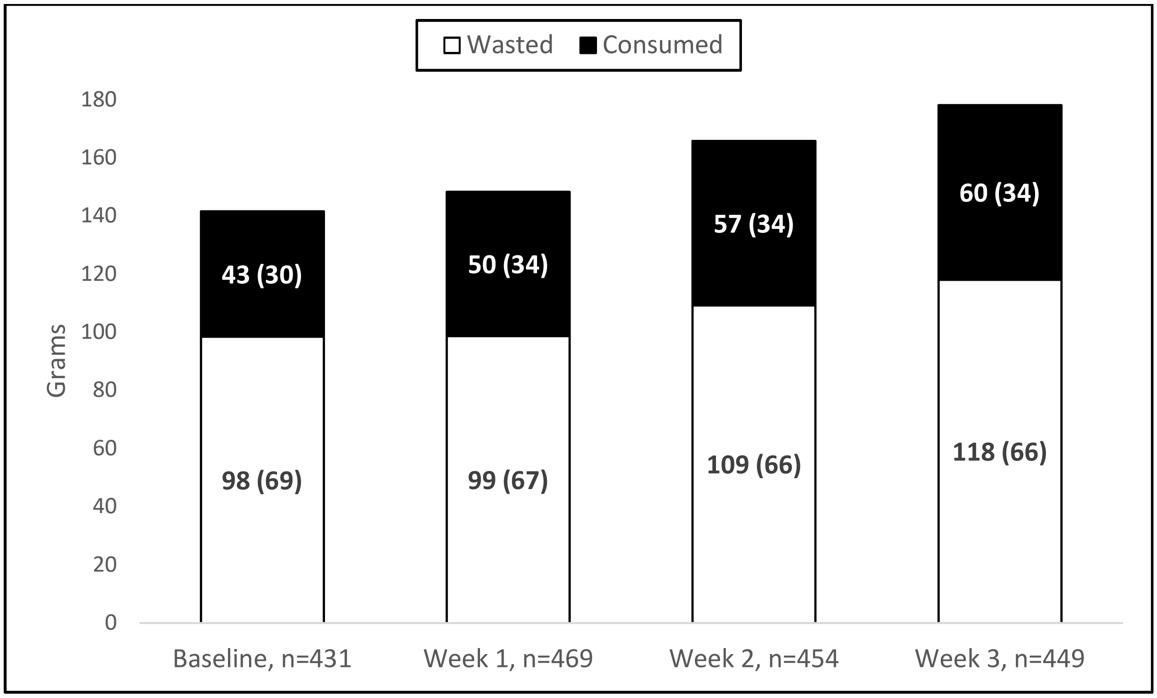

Figure 5. Daily average quantities per child of salad bar F&V consumed and wasted during baseline (average of two measurement days) followed by three weeks of the flavor station intervention. Chart data are grams followed by percent of total selected in parentheses (data were rounded). There was a linear trend for F&V consumption in grams over time (r=0.986; *P*=0.014) and for waste (r=0.960; *P*=.040).

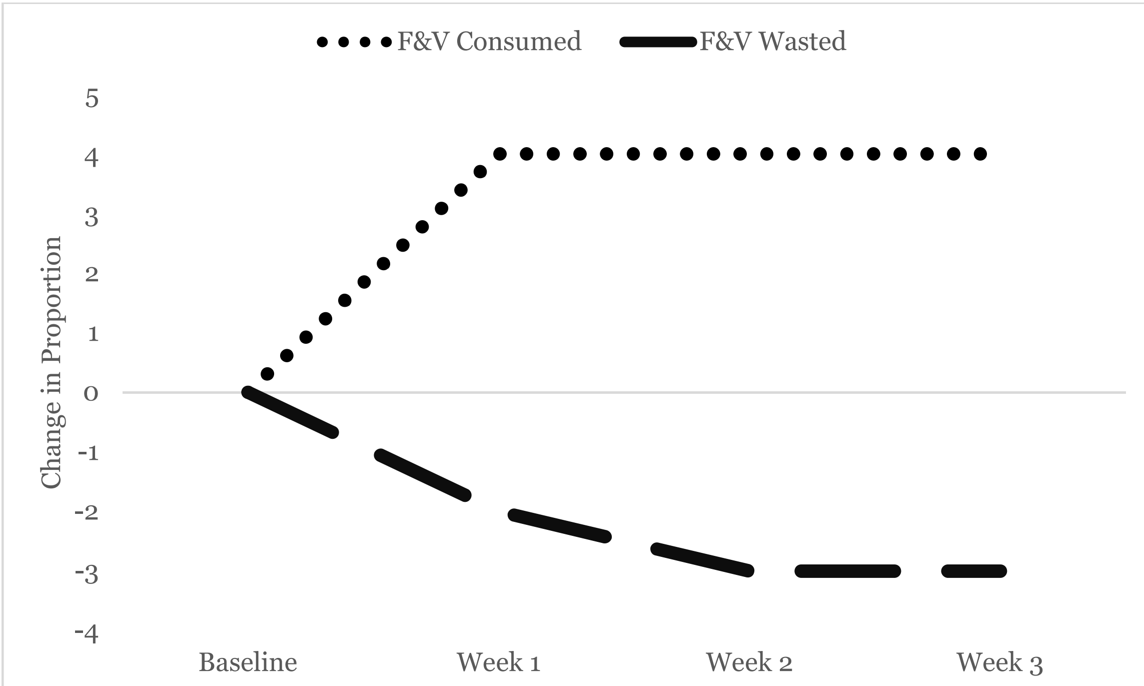

Figure 6. The change from baseline for proportion of F&V consumed and wasted during the trial. Both trends were significant (*P*<0.05).

Condiment Quantities and Costs

Average daily peanut butter selection per child increased each week (3.7 g, 5.4 g, 6.0 g), and this linear trend was significant (r=.999; p=0.029) (Figure 7 and 8). The amount of parmesan cheese taken declined linearly over three weeks, while cinnamon/sugar, honey, and yogurt selections peaked in the second week before declining in the third week (Figure 7). During the three posttest measurement days, a total of 1,372 children purchased lunch and the total cost of condiments used was $121.83, or $0.09/child (Table 5). The average daily cost of providing the flavor station during each of the three weeks was $37.33, $47.30, and $37.19.

Students who desired a packaged condiment (e.g. peanut butter, honey or parmesan cheese) received one packet of the respective condiment(s). The total count of peanut butter packets selected increased over the three-week intervention (82, 115, 126 packets respectively) (Table 5). The quantity of honey packet selection peaked at week 2 (69, 127, 38). Fifty-one parmesan cheese packets were selected during the first, and only, week of availability. All condiments were offered via existing kitchen hardware and utensils. The flavor station was monitored by research staff on measurement days and by food service staff on all other days. The food service department reported no additional measurable costs while providing the flavor station.

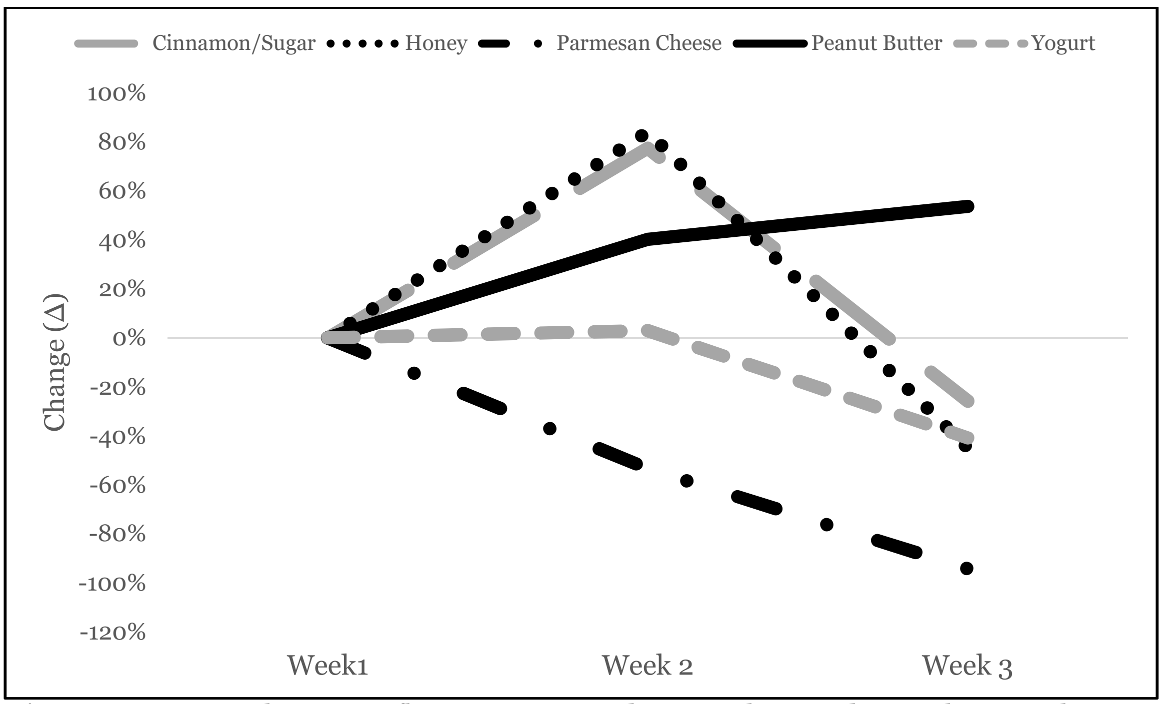

Figure 7. Percent changes in flavor station condiment selection during the 3-week intervention.

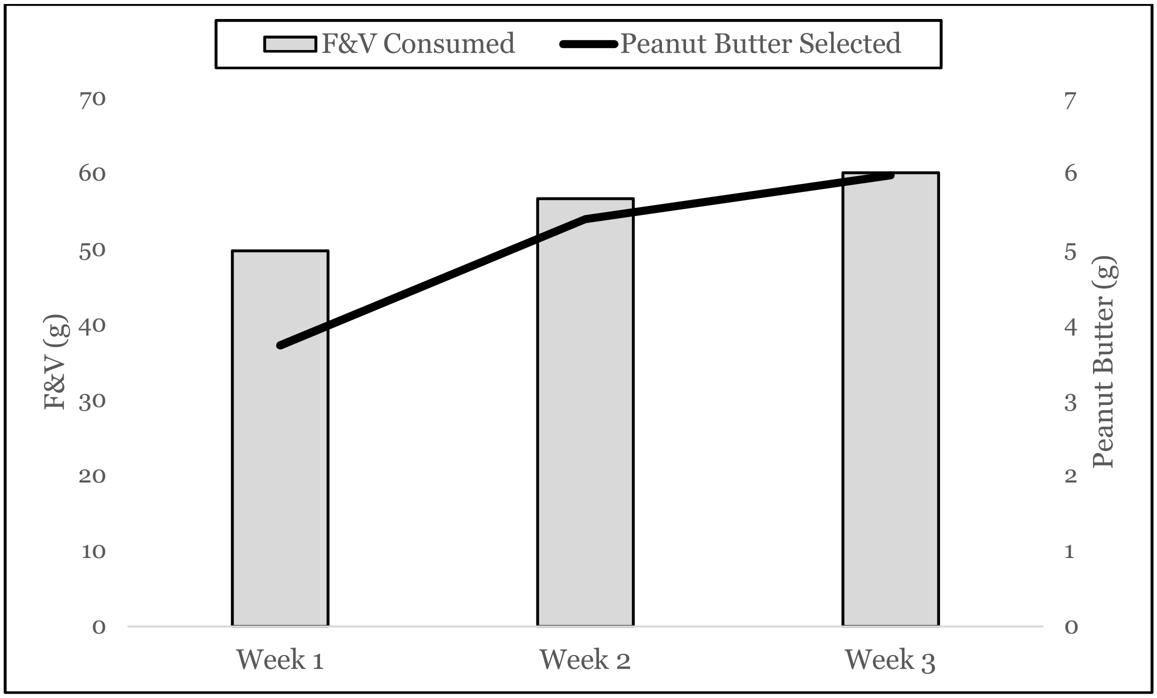

Figure 8. Salad bar F&V consumption compared with flavor station peanut butter selection during each posttest measurement day. There was a linear trend in peanut butter selection (r=.999; p=0.029).

Table 5. Costs and quantities of flavor station condiments selected on each posttest measurement day.[a]

	Week 1		Week 2		Week 3	
Condiment	Cost ($)	Qty	Cost ($)	Qty	Cost ($)	Qty
Cinnamon/sugar	0.62	--	1.09	--	0.46	--
Honey	5.01	69	9.22	127	2.76	38
Parmesan cheese	6.08	51	1.79	--	0.22	--
Peanut butter	15.17	82	21.27	115	23.30	126
Yogurt	10.45	--	13.93	--	10.45	--
Total daily cost	37.33		47.30		37.19	

[a] Units of measure: 1 peanut butter packet 21 g; 1 honey packet 9 g; 1/4 yogurt 57 g. Cinnamon/sugar and parmesan shaker servings were not measurable.

Staff Surveys

CSES food service personnel (n=9) and teachers (n=56) were invited to complete a web-based survey regarding their opinions of F&V and the flavor station. Completed surveys were received from six food service personnel and 15 teachers (67% and 27% of the total invited employees, respectively). Most food service staff and teachers who responded to the survey strongly agreed or somewhat agreed that students like the fruits (90%) or like the vegetables (90%) (Table 6). Only 15% of food service staff and teachers agreed strongly/somewhat that the FFVP was *not* worth the effort. Sixty-five percent agreed strongly/somewhat that the FFVP should continue at their school; thirteen percent answered to the contrary ("disagree strongly" or "disagree somewhat").

Table 6. Posttest survey of food service staff and teachers regarding opinions about the FFVP intervention at Corte Sierra Elementary School (n=20).[a]

Question text from survey	Agree % (n)[b]	Disagree % (n)[c]	Don't know or n/a % (n)[d]
Students like the FFVP fruits	90 (18)	0 (0)	10 (2)
Students like the FFVP vegetables	90 (18)	0 (0)	10 (2)
Students eat more fruits and vegetables at school on FFVP days	65 (13)	15 (3)	20 (4)
Students eat fewer unhealthy snacks at school on FFVP days	35 (7)	20 (4)	45 (9)
I think the FFVP is NOT worth the effort it takes	15 (3)	65 (13)	20 (4)
I would like the FFVP to continue at Corte Sierra	65 (13)	15 (3)	20 (4)

[a] Five-point Likert scale.
[b] "Agree strongly" (5) or "agree somewhat" (4).
[c] "Disagree strongly" (1) or "disagree somewhat" (2).
[d] n/a = "Don't know or not applicable" (3), or no answer.

Some food service staff and teachers acknowledged major or minor challenges in offering the FFVP (Table 7). Food waste, staff training or time, and neophobia were the biggest perceived challenges. Sixty percent of respondents felt that F&V waste was a major challenge. Approximately one third (35%) felt that inadequate time or inadequate training of food service staff or teachers was a major challenge. Thirty percent felt that "students don't like to try new F&V" was a major challenge, but only ten percent indicated that "students don't like F&V" was a major challenge. Most respondents (75%) did not see mess related to FFVP distribution or clean-up as a major challenge. Most respondents perceived no challenges regarding inadequacy of F&V quality, variety, or amounts (80%, 85%, and 80%, respectively).

Table 7. Food service staff and teacher perceptions of potential challenges that may impact implementation of the FFVP (n=20).

Question text from survey	Major challenge % (n)	Minor challenge % (n)	Not a challenge % (n)	Don't know or n/a % (n)[a]
Students don't like fruits and vegetables	10 (2)	50 (10)	20 (4)	20 (4)
Students waste too much	60 (12)	20 (4)	10 (2)	10 (2)
Messy to distribute and clean up	25 (5)	40 (8)	10 (2)	25 (5)
Inadequate food service staff (or teacher) training or information	35 (7)	30 (6)	15 (3)	20 (4)
Inadequate food service staff (or teacher) time	35 (7)	35 (7)	10 (2)	20 (4)
Class time interrupted or taken away from student learning	20 (4)	25 (5)	20 (4)	35 (7)
Students don't like to try new fruits and vegetables	30 (6)	45 (9)	10(2)	15(3)
Inadequate quality of FFVP produce	0 (0)	20(4)	55 (11)	25 (5)
Inadequate variety of FFVP produce	0 (0)	15 (3)	60 (12)	25 (5)
Inadequate amounts of FFVP produce	0 (0)	20 (4)	60 (12)	20 (4)

[a] n/a = "Don't know" or no answer.

CHAPTER 5

DISCUSSION

The 17g increase in F&V consumption noted herein is in range with changes noted in other elementary school cafeteria interventions. Miller et al. conducted a school lunch study at one elementary school with one baseline day and two posttest measurement days. That intervention tested 50% larger portion sizes of applesauce, oranges, and carrots and saw consumption increase by 42 g, 16 g, and 13 g, respectively. Whereas the present study weighed all F&V, the Miller et al. design calculated the average starting weights of 10 samples of each vegetable.[168] Getlinger et al. tested the effect of scheduling recess before lunch at one elementary school and reported vegetable consumption increased by 11 g, but fruit consumption decreased by 4 g.[169] The results of the present study are also in line with multicomponent designs. A meta-analysis by Evans et al. evaluated the impact of a variety of single- and multi-component school-based study designs (e.g. curricula, marketing, parental involvement, policies) and calculated a mean F&V consumption increase of 20 g, excluding fruit juice.[147]

Many school studies aimed at increasing F&V consumption have not reported the costs of the interventions. It is safe to assume that most multicomponent interventions have been implemented at greater expense and participant burden than the present study, yet many of those studies have recorded changes in F&V consumption similar to or less than the present study.[165,170,171] Horne et al. evaluated Food Dudes, a multicomponent F&V intervention, at two elementary schools in Ireland. Teachers were trained to show Food Dudes videos, distribute free F&V, measure the amount of F&V consumed, and distribute rewards to children based on their having tried or consumed the F&V. Take-home packets were distributed to parents with information and tips for planning healthy lunches. Each packet contained a chart on which the parent was instructed to track the amount of F&V the child consumed at home. Over four posttest measurement days ending at 16 weeks, mean consumption of school-provided F&V increased 24 g.[170] A more recent evaluation of the long-term impact of Food Dudes at six primary schools in the UK found that daily consumption of school-supplied F&V had decreased at 12-month follow up (-5 g), calling into question the sustainability of an intervention that imparts a high degree of participant burden.[171]

In some previous studies, when children increased F&V selection, a potential side effect was often a concomitant rise in F&V waste.[168] In the present study during posttest, there was a significant increase in F&V consumption as a proportion of total selection, from 30% to 34%, and the proportion of F&V waste decreased, from 69% to 66%. This proportion of overall waste is similar to previous plate waste studies in elementary schools.[168,169] Miller et al. recorded 18% more applesauce waste and > 50% more orange waste during posttest. In that study, only two fruit and two vegetable options were provided, and all were served in pre-portioned, disposable cups (5 oz baseline; 8 oz intervention).[168] It is possible that participation was limited to students who already liked the taste of the three F&V offerings that were increased; there was no requirement to select any F&V. In the present study, CSES students self-served onto their trays from a salad bar that contained eight different fruit and seven different vegetable offerings. All CSES students who purchased lunch were required to select at least 1/2 cup of fruits and 3/4 cup of vegetables, a NSLP meal pattern requirement that was enforced by food service staff.[172] Visual observation by investigative staff confirmed that only a few students selected too little F&V, but many students routinely selected more than the minimum amounts.

Peanut butter was rated highest in the Phase 1 taste tests and was the most popular condiment choice of students during Phase 2. Selection of peanut butter packets increased each week during the intervention period. Selection of other condiments either peaked during week two, or in the case of parmesan cheese, declined steadily over three weeks.

In addition to its taste popularity among children, peanut butter is a nutrient dense food. The peanut (*Arachis hypogaea L.*) is a grain legume that is ranked sixth worldwide among oil crops, and thirteenth among food crops. Peanuts are considered an oil crop due to their high oil content.[173] School-age children may be delighted to learn that peanuts are also known throughout the world as “goobers” and “monkey nuts”. Natural peanut butter (as opposed to conventional/hydrogenated) is low in sodium, containing only 6 g of salt per 30 g (1 oz) serving.[174] The low sodium content of peanut butter accommodates the USDA Food and Nutrition Service (FNS) meal patterns and nutrition standards which specify sodium restrictions. Canned vegetables should contain ≤ 140 mg of sodium per half-cup serving.[172] Peanut butter is also high in fiber and contains some organic acids. Two tablespoons (32 g) of peanut butter contain 188 calories, six grams of carbohydrates, 16 grams of lipids, eight grams of protein, and 1.9 grams of fiber.[175]

Peanuts are excellent sources of vitamin E, folate, niacin, pantothenic acid, and thiamin, as well as the minerals copper, iron, magnesium, manganese, phosphorus, and zinc. The fat content of peanut butter enhances the absorption of fat-soluble vitamins (A, D, E, and K). Peanuts contain Co-enzyme Q10, a component of the electron transport chain which is utilized in the production of adenosine triphosphate (ATP), the body’s primary source of energy. Unlike animal proteins, peanuts contain phenolic acids, flavonoids, and phytosterols, bioactive molecules that provide antioxidant benefits in the human body. All 20 amino acids are found in peanuts, including arginine, which is important for the healthy functioning of the liver, muscles, and the immune system. Peanuts also contain resveratrol, a fat-soluble antioxidant made popular by research of the "French Paradox", though its efficacy in human health has not been clearly established.[176]

Peanut butter is readily available as a commodity to schools that participate in the NSLP or other USDA child nutrition programs. The USDA Commodity Supplemental Food Program includes smooth peanut butter (item #100395; 12/18 oz jars). The NSLP Food Product Information Sheets allow participating schools to order peanut butter in bulk containers (item #100396; 6/5 lb) or individual packets (item # 110854; 120/1.1 oz). Peanut butter is shelf stable and can be stored for long periods, thus schools may be able to purchase larger quantities at increased savings.

Serving peanut butter in a school is not without its challenges. Some students are likely to have peanut allergies. The USDA FNS publishes "Accommodating Children with Disabilities in the School Meal Programs", guidelines that school authorities should follow to ensure that healthy food is accessible to all students. These guidelines include requirements for accommodating food allergies. A child with a peanut allergy may not be served any food that contains peanuts or includes peanuts as an ingredient. The school must provide a safe, peanut-free location where students may optionally eat their meals. (CSES has established a "peanut free table" in its cafeteria.) A school's food service department is responsible for knowing the makeup of all foods served, even those without adequate labeling. Guidelines for food storage, food preparation, and food and utensil cleaning must be followed to prevent cross contamination. The FNS does not endorse prohibitions on allergy-prone foods or food groups (e.g. peanuts, milk, eggs, soy), but if a school does ban a specific food then that food must never appear on its campus.[177]

Peanut butter was rated highest in taste tests, was the most frequently consumed condiment outside of school, and appeared to be the most popular condiment that children selected for their lunch F&V. Peanut butter is robust in its ability to be paired with many different F&V (e.g apples, bananas, carrots, celery). Thus, peanut butter is an excellent choice for school administrators interested in starting a flavor station. Although some portion of the student population will likely have a peanut allergy, CSES follows USDA and local guidelines, and serves peanut butter and jelly (PBJ) sandwiches every day. In 25 years of service at CSES, the DCN had not witnessed any peanut related lunchroom issues. CSES offers three entrée foods at each lunch and due to its high popularity, PBJ sandwiches are always one of these entrées. Each day, approximately 30 – 35% of students choose PBJ for their lunch entrée.

The flavor station intervention was implemented for a total daily cost per child of only nine cents ($0.09). Since peanut butter comprised most of this expense, using bulk peanut butter would have furthered lowered costs. Bulk peanut butter from a pump may also decrease mess and further lower staff burden. Interventions that require more complicated delivery mechanisms (e.g. custom materials, specialized curricula, activities, and/or staff/parent involvement) increase staff burden and are more expensive to implement and propagate. In the United Kingdom, the 5 A DAY Programme's school fruit and vegetable scheme (SFVS) provides one additional daily piece of fruit or vegetable per student along with F&V-related teacher training, cooking classes, and games. SFVS was established in 2004 at a cost of £42 million and received an additional

£77 million to continue running through 2006. A non-randomized control trial by Ransley et al. that evaluated the SFVS found that daily F&V consumption (estimated by 24-hour recall) increased by 0.5 servings at three months, but vegetable intake returned to baseline at seven months, and F&V intake was unchanged by the end of the second year.[152]

The surveys used in the present study were adopted from a previous evaluation of the USDA Fresh Fruit and Vegetable Program which noted response rates from food service staff and teachers of 85% and 87%, respectively.[167] A literature search found few previous attempts to survey the opinions of food service staff on any topic. Approximately 23 studies have cited Bartlett et al. since 2013, but none have surveyed food service staff or teachers. PubMed contained only 19 results for "school food service staff survey satisfaction"; none relevant to the present study. In the present study, most food service staff (67%) completed the survey, but the teacher response rate was lower (27%). Most CSES teachers chose not to visit the cafeteria during lunch, and thus, may have been less familiar with salad bar operations and the flavor station intervention. Compared with one study that was an unpublished dissertation, CSES food service staff appeared to have responded equally favorably toward use of the flavor station as those employees who were surveyed about using their school's computer technology for food service operations; 4.0 and 4.01, respectively (5 = "very satisfied"; 5-point Likert scale).[178] More studies have included teachers in F&V intervention surveys, but comparisons are still hampered by variations in survey questions and details about the reporting of survey results.

A survey of childcare providers (n=486) regarding their views on the "Color Me Healthy" physical activity and nutrition program for children aged 4 – 5 years noted that most teachers rated the program excellent or very good, 73.5% and 23.6%, respectively. The survey response rate to the printed version of the survey was 36.3% and no emailed surveys were returned.[179] A more recent evaluation of "Color Me Healthy" reported that ninety percent of teachers (n=10) felt their children were more willing to try F&V, but details about teacher satisfaction with the program was not reported.[180] Sweitzer et al. conducted a quasiexperimental, multicomponent study (parent handouts, classroom activities, educational stations, teacher training) to increase F&V consumption in children aged 3 – 5 years (n=132). Seventy-five percent of teachers in the intervention group indicated that the program was a "good fit" for the curriculum and environment. Teachers received $50 gift cards for participating in interviews and records indicated that 100% of teachers participated in the F&V related classroom activities; survey response rate was not reported.[181] A process evaluation of the USDA Fresh Fruit and Vegetable Program at one New Jersey elementary school recorded that 82% of teachers indicated that the implementation was "very good" ("4" on a 4-point scale). However, in interviews with stakeholders (teachers and school staff), 60% expressed concern about their school's ability to implement the program, noting problems of inconsistent delivery, difficulty discussing nutrition with students, unpopularity of some F&V snacks, and shortage of volunteers.[182] In the present study, no food service staff or teachers indicated major challenges to implementing the flavor station.

School-based dietary interventions are compatible with other public health goals.[17,39,172] Although the changes detected in this intervention may not appear substantial, minor incremental improvements are often sufficient to improve the overall health of a population. Slightly lowering a risk factor for a population of children may be more beneficial than attempting to create a large impact for only the children at highest risk. Small improvements in F&V consumption at the population level may be more sustainable and better suited for encouraging long-term behavior change.[183,184]

Flavor Station: Qualitative Observations

Beginning two days prior to the start of the intervention, availability of the flavor station was communicated to students via flyers in the cafeteria and through morning intercom announcements from the school principal. On the first day of the intervention, most students did not appear to realize the purpose of the flavor station or how to use it. Research staff assisted the students by describing the condiment choices and suggesting applicable condiment/F&V pairings (e.g. yogurt on sliced peaches or peanut butter with apple slices). Students at CSES have a wide variety of F&V from which to choose and few lunch trays were completely alike.

The second week provided numerous changes in student behavior toward the flavor station. By this time, most students were noticeably familiar with and desiring of the flavor station condiments; a line formed on several occasions. After exiting the salad bar area, those who desired condiments would readily stop at the flavor station table. Although most students partook in at least one condiment, a minority (~10-15%) expressed no interest. The usage of parmesan cheese declined in the second week. Two changes may have influenced this trend. Individual serving packets of parmesan cheese were replaced with shakers. However, parmesan cheese was never observed to be a popular choice for F&V. During the first week, most children who selected parmesan cheese did so, not for their F&V, but for their entrées. Staff and researchers emphasized that the flavor station condiments were for F&V.

During the second week some mischief was noted by school staff. Several students were observed returning to the flavor station after lunch to take packets of peanut butter and/or honey on their way to recess. Some of these packets were splattered outdoors on school fences and sidewalks. Two students sprinkled excessive amounts of cinnamon/sugar onto their trays. Two kindergarten students were observed placing yogurt serving spoons in their mouths. Following these incidents, the food service staff began removing the flavor station after each class was served and returning it prior to the arrival of the next class. This prevented students from taking additional condiments on their way to recess. Due to the issue of peanut butter packets leaving the cafeteria, the school district cancelled the flavor station on Friday of the second week and Monday of the third week. It should be noted that students at this school have always self-served their salad bar selections, including spoons for ranch dressing and salsa, without issues of mischief or undue mess.

During the third week, all students understood which condiments the flavor station offered and how to pair them with their F&V. The children moved more quickly along the flavor station tables, asking for specific condiments. One student, upon realizing that his tray contained a whole apple, quickly returned to the salad bar for slices because he remembered they were easier to dunk into peanut butter. During the third week, only one instance was observed of a student attempting to approach the closed flavor station after lunch in an (unsuccessful) attempt to acquire more peanut butter packets.

Limitations

CSES had an existing salad bar, participated in the USDA NSLP, and enrolled a large population of students who qualify for FRLs. The results reported herein may not be generalizable to schools without salad bars or with differing demographics. CSES operated one of the highest functioning kitchens in the school district; less efficient school kitchens were not considered for inclusion. The 17g increase in the present study was realized over three weeks in October and November. In previous years, the DCN observed that salad bar F&V selection appeared to increase throughout the semester. However, neither consumption nor waste were measured by the DCN. For each lunch session, CSES routinely offers at least eight different choices of fruits and eight different choices of vegetables. The school district was experiencing delivery issues with their produce supplier during the fall 2018 semester and this may have imparted slightly more variability than normal in salad bar offerings.

High survey nonresponse has potential to impart sampling bias.[185] Although the teacher survey response rate was low, studies evaluating the accuracy of surveys have found that low response rates can provide results that are statistically meaningful.[186,187] One third of Food Service staff and teachers felt that a lack of preparedness (training or time) was a significant challenge to maintaining the FFVP. Investigators in the present study were in close communication with district administrators, school administrators, and the DCN. In future studies, investigators should seek to create a more open dialogue with school employees who are likely to interact with the salad bar and flavor station.

Only 25% of staff indicated that mess was a major challenge. Reported incidents of messiness were largely a function of the distribution mechanism. Packets of peanut butter and honey could be removed from the cafeteria by students, a problem catalyst that would be removed by implementing a pump distribution mechanism. Had this been done in the current study, it may have improved staff perceptions of messiness related to providing the flavor station.

The current study pilot trail data are not complex. The limitations of this study are items that can be addressed in follow up studies. This study was limited by the type of distribution mechanisms available. Peanut butter and honey were served in packets, but bulk jars were more affordable and would permit little or no mess outside of the cafeteria. Yogurt was distributed in a tub but adding a pump may also improve its distribution. The DCN was not able to obtain and implement pumps in time for inclusion in this study. To conserve costs, the school district provided an existing supply of parmesan cheese packets, but these were exhausted by the end of the first week and loose parmesan cheese was substituted.

Feasibility

The present study assessed the viability of providing a flavor station to improve the palatability of salad bar F&V in an elementary school cafeteria. The cost of taste test materials included F&V samples, condiment samples, 2 oz cups, and napkins. Eight investigative staff prepared all food and trayed all sample cups in approximately three hours. These same staff were enough to facilitate a smooth taste testing process. Each staff member worked on a specific task. As some staff cleared soiled cups, others collected or handed out survey sheets, while others delivered new samples. Fewer staff could have prepared the sample cups. During the taste tests, an approximate 1:4 ratio of investigative staff to students seemed ideal; a higher ratio might have formed a less rigorous process. Most children were very attentive during the 45-minute tastings but it is unknown how much longer their attention may have been held. LSED administration and CSES staff were very accommodating of this research project and there was a high degree of trust between them and the investigative staff. The efficiency with which the CSES food service staff operated the school kitchen helped ensure this project’s success.

The choice to use condiment packets instead of pumps was an issue that follow up studies need not replicate. Other school principals within LESD have expressed interest in implementing the flavor station and district administration is supportive of nutrition research.

The present study provides a conceptual framework for implementing a flavor station within an elementary school cafeteria. For future similar studies, a project checklist should include the following:

1. Assess children's condiment/F&V taste preferences
2. Provide winning flavors that enhance the taste of F&V
3. Measure consumption pretest and posttest
4. Gather perceptions of the school staff related to F&V and to the intervention
5. Assess costs associated with implementing and maintain the flavor station

Next Steps

The flavor station design employed in this study demonstrated that the provision of condiments near a salad bar can increase children's lunchtime F&V intake. The affordability and simplicity of the flavor station suggests that it can be easily replicated in other schools, although this remains to be tested. In the current study, peanut butter was children's favorite and most selected condiment. The current study evaluated individual peanut butter packets, but a more affordable solution is to purchase bulk creamy peanut butter and dispense it with a pump mechanism. Moreover, dispensing condiments in a pump will discourage the removal of peanut butter from the cafeteria and eliminate opportunities for mischief related to the smashing of packets. Thus, a future study should compare the feasibility of pump dispensers compared with packets or serving spoons. The distribution mechanisms of other condiments could be evaluated likewise. The USDA provides commodity yogurt to NSLP schools. Given that yogurt's taste was rated highly by children, and that is was the second most frequently consumed condiment outside of school, a future study should further evaluate yogurt for inclusion as a salad bar condiment. Including an alternative to peanut butter would also be in line with the USDA's directive to make healthy school foods accessible to all students.[177] Key takeaways from the current study are that 1) peanut butter was highly popular; 2) peanut butter can be dispensed more affordably in bulk; 3) the flavor station was inexpensive to implement. LESD comprises 11 elementary schools and follow up studies should attempt to include more of these locations. A possible quasiexperimental design would be to create five pairs from 10 schools (excluding CSES), matched on similar student demographics and randomly assigned to receive either a flavor station with peanut butter pump or serve as a passive control. This would provide data at the district level and perhaps facilitate recruitment of other school systems for future studies.

A typical goal of school F&V interventions is to cause children to consume more F&V. However, an alternative strategy may be to encourage children to waste less F&V. In the current study, the proportion of F&V waste was reduced by 3%. A future study could focus on how children use condiments; for example, dispensing directly onto F&V or dispensing into a cup. The duration of a follow-up intervention should be extended to evaluate whether changes are sustained through the academic year. Given the variety of possible condiment/F&V combinations, more combinations should be evaluated. This could be done through taste tests in which peanut butter is paired with an extensive variety of F&V. These taste tests could be followed by marketing or educational phases that would communicate the most popular pairings to students. The primary goal building children aware of imaginable pairing choices is to increase F&V consumption and decrease F&V waste. However, an added benefit might be to flatten the flavor station learning curve and smooth the flow of foot traffic through the lunch line. Given the occasional congestion around the flavor station, its arrangement and layout should be examined further. Horizontal and vertical placement in relation to salad bar traffic flow could be compared. Placing the condiment(s) directly on the salad bar or in other areas of the cafeteria might also be evaluated to determine which configuration produces the least condiment mess and best flow of foot traffic.

The teacher survey response rate was lower than anticipated. A future study should seek to reassess the attitudes and beliefs of food service staff and teachers about child nutrition, school F&V, and the flavor station. A gift card incentive could be offered to increase participation rates for school staff surveys. In the context of school F&V interventions, food service staff appear to be an under-evaluated demographic. Many of the food service staff at CSES did not have their own computer at work, nor a school email address. In addition to re-issuing web-based surveys, opinions could also be gathered via printed surveys that are delivered directly to staff, or through focus groups. There is a lack of research about salad bar F&V flavorings and school food service staff perceptions of related interventions. More research is needed because school lunch is an important source of F&V for many children.

Conclusions

This pilot trial found that the provision of condiments that are rated highly by children can increase children's consumption of F&V. Many adults would not consider eating their F&V without flavorings, yet children are often expected to consume unflavored F&V. The simple addition of a peanut butter pump during school lunch is an affordable strategy to encourage children to eat more F&V. Peanut butter is a shelf-stable, nutrient-dense food that pairs well with a variety of F&V and aids in the absorption of fat-soluble vitamins. Providing a flavor station with peanut butter in packets or via a pump mechanism is a sustainable solution that is supported by the USDA's commodity pricing program and the FNS school nutrition guidelines, making it an excellent choice for school administrators seeking to improve their student's F&V consumption.

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APPENDIX A

IRB APPROVAL

NOT HUMAN SUBJECTS RESEARCH DETERMINATION

Carol Johnston
SNHP: Nutrition
602/827-2265
CAROL.JOHNSTON@asu.edu

Dear Carol Johnston:

On 11/15/2016 the ASU IRB reviewed the following protocol:

Type of Review:	Initial Study
Title:	Use of Evocative Art to Improve Children's Fruit and Vegetable Consumption
Investigator:	Carol Johnston
IRB ID:	STUDY00005289
Funding:	None
Grant Title:	None
Grant ID:	None
Documents Reviewed:	• example art work, Category: Technical materials/diagrams; • school district approval, Category: Off-site authorizations (school permission, other IRB approvals, Tribal permission etc); • protocol, Category: IRB Protocol;

The IRB determined that the proposed activity is not research involving human subjects as defined by DHHS and FDA regulations.

IRB review and approval by Arizona State University is not required. This determination applies only to the activities described in the IRB submission and does not apply should any changes be made. If changes are made and there are questions about whether the activities would change the determination, contact the IRB at research.integrity@asu.edu to determine the next steps.

APPROVAL: EXPEDITED REVIEW

Carol Johnston
Nutrition
602/827-2265
CAROL.JOHNSTON@asu.edu

Dear Carol Johnston:

On 6/14/2018 the ASU IRB reviewed the following protocol:

Type of Review:	Initial Study
Title:	Child-favored condiments for salad bars to promote fruit and vegetable consumption in an elementary school setting
Investigator:	Carol Johnston
IRB ID:	STUDY00008351
Category of review:	(7)(b) Social science methods, (7)(a) Behavioral research
Funding:	None
Grant Title:	None
Grant ID:	None
Documents Reviewed:	• Corte Sierra Elementary School email, Category: Off-site authorizations (school permission, other IRB approvals, Tribal permission etc); • Camp CRAVE approval, Category: Off-site authorizations (school permission, other IRB approvals, Tribal permission etc); • Assent, Category: Consent Form; • Camp CRAVE waiver, Category: Other (to reflect anything not captured above);

	• parental permission site 2, Category: Consent Form; • Testing sheet , Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • protocol, Category: IRB Protocol; • parental permission site 1, Category: Consent Form; • Camp CRAVE release photo release form, Category: Other (to reflect anything not captured above);

The IRB approved the protocol from 6/14/2018 to 6/13/2019 inclusive. Three weeks before 6/13/2019 you are to submit a completed Continuing Review application and required attachments to request continuing approval or closure.

If continuing review approval is not granted before the expiration date of 6/13/2019 approval of this protocol expires on that date. When consent is appropriate, you must use final, watermarked versions available under the “Documents” tab in ERA-IRB.

In conducting this protocol you are required to follow the requirements listed in the INVESTIGATOR MANUAL (HRP-103).

APPENDIX B

PROJECT TIMELINE

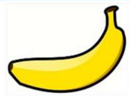
Project timeline from May 2018 – December 2018.

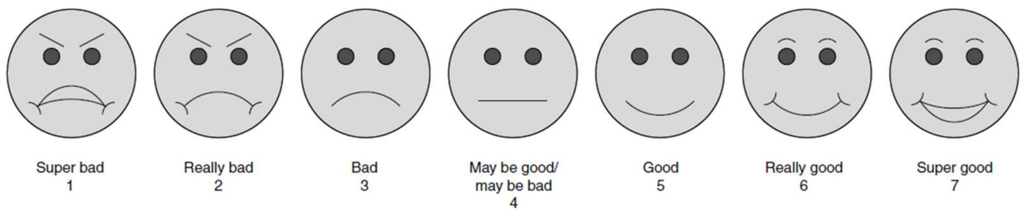
Study Activity	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
IRB approval	X									
School recruitment	X									
Staff training	X					X				
Taste testing	X	X		X						
Taste test analysis		X		X						
F&V baseline data collection						X				
Flavor station implementation						X	X			
F&V intervention data collection						X	X			
Staff surveys							X			
Data analysis (F&V, costs, surveys)							X	X	X	
Results dissemination								X	X	X

APPENDIX C

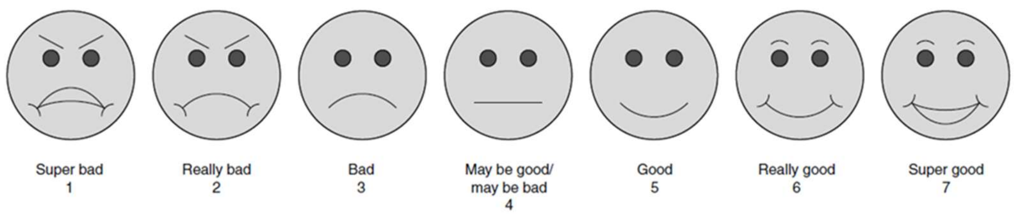
TASTE TEST SURVEY

PEANUT BUTTER 

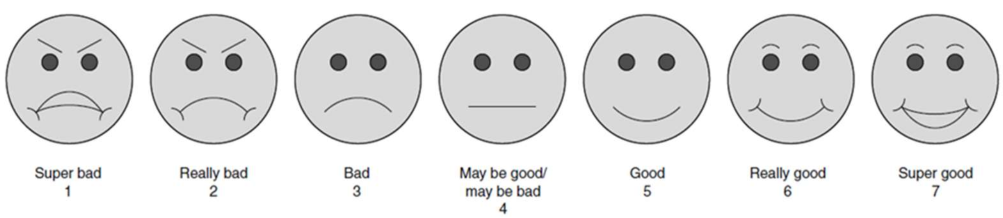
+BANANA 



+APPLE 



+CELERY 

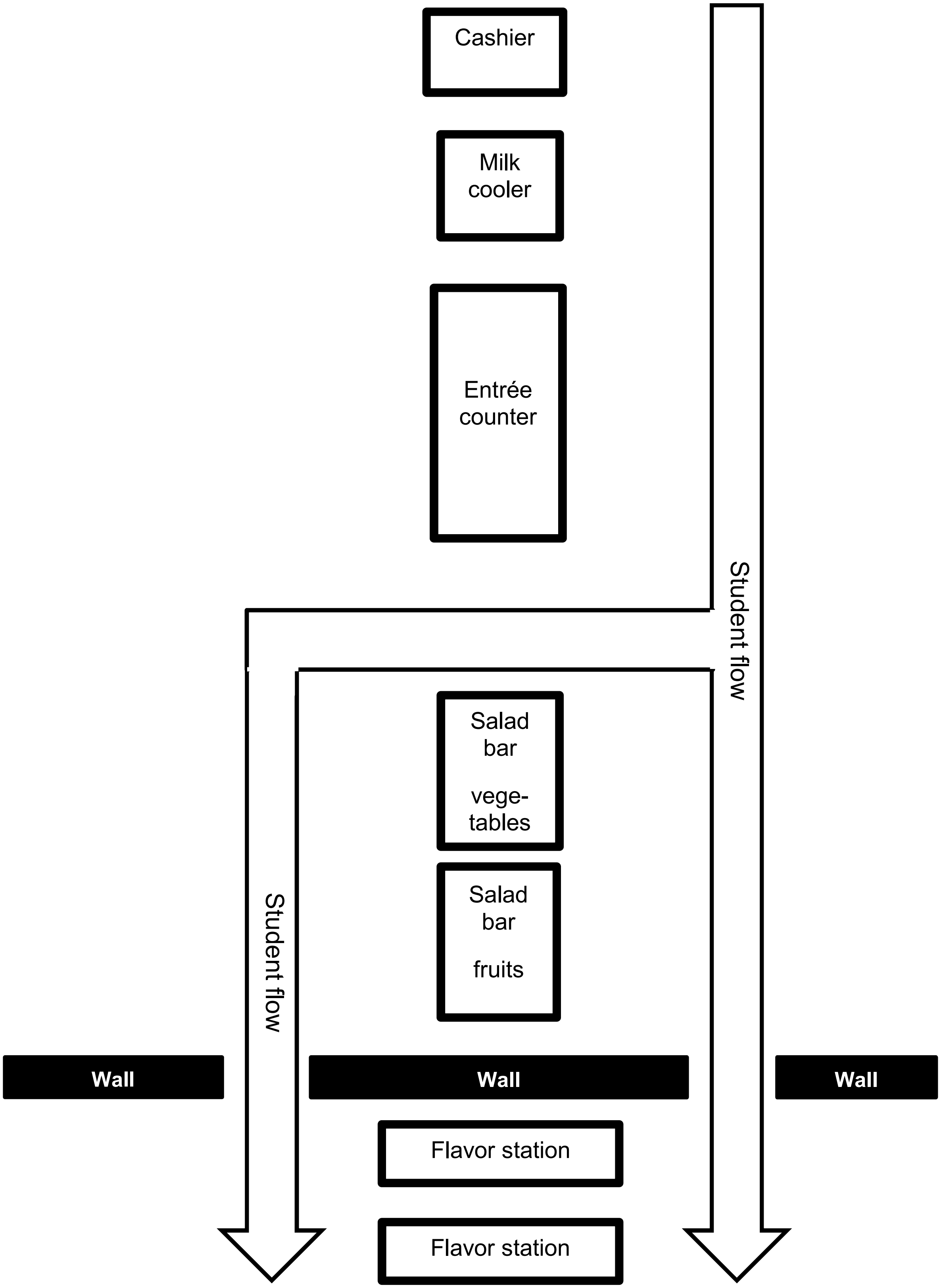


How often do you eat peanut butter?

Every day	Most days	Once a week	Several times a month	Several times a year	Rarely/never

APPENDIX D

LUNCH LINE FLOW


Cashier
Milk cooler
Entrée counter
Student flow
Salad bar
vege-tables
Salad bar
fruits
Student flow
Wall
Wall
Wall
Flavor station
Flavor station