Instrumental and Sensory Characteristics of Selected Nutritionally Improved School Foods

By Alyson Mandeville

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ABSTRACT OF THE THESIS

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By ALYSON MANDEVILLE

Thesis Director

Dr. Henryk Daun

Childhood obesity is a growing problem in the United States. Recently enacted Federal and State regulations require school foods to be improved nutritionally. The objective of this study was to determine quality of selected newly developed school foods using instrumental and sensory methods. From the National School Lunch Program reimbursable meals chicken nuggets, macaroni and cheese, and pierogies were selected. From the Competitive Foods apple snacks were used. Surface color parameters (L, a*, and b*) were determined by colorimeter and digital camera. A texture analyzer (TA-xT2i) was used to measure texture specific to each product. Sensory Quantitative Descriptive analysis was used to evaluate six to eight sensory attributes per product. The results were compared with similar traditional products. Chicken nuggets with whole grain breading were darker red (L 132.43 and a* 147.96) and coarser, while home style were more yellow (b* 188.44) with firmer breading (407.59 g) and original variety was less yellow and red (b* 182.69 and a* 138.01) with softer meat texture (462.26 g/cm). Macaroni and cheese with 26% reduced fat was significantly saltier and less viscous than original (1486.21 g), however not significantly different in color, cheese aroma, or sweetness. Pierogies with 70% more protein per serving were significantly different with a firmer, grainier filling and darker surface color with values of L 59.14 and b* 14.98 and peak force of filling 7968.9 g. Freeze dried enriched apple snacks were significantly lighter in color, more red (L 170.13 and a* 137.71), firmer texture with average 2821.24 g peak force, more sour, bitter and had a rougher surface texture than air-dried apple snacks. Instrumental color, texture, and sensory characteristics of nutritionally improved products differed significantly from the similar traditional products. Additional efforts of processors will be necessary to prepare nutritionally improved products with high children's acceptability.

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LIST OF ABBREVIATIONS

Center of Disease Control (CDC)

Division of Adolescent and School Health (DASH)

American Obesity Association (AOA)

Body Mass Index (BMI)

American Academy of Pediatrics (AAP)

British Nutrition Foundation Task Force on Obesity (BNTF)

American Pregnancy Association (APA)

Quantitative trait locus (QTL)

U.S. Department of Health and Human Services (HHS)

Institute of Medicine (IOM)

U.S. Department of Agriculture (USDA)

School Nutrition Dietary Assessment Study-II (SNDA-II)

Economic Research Service (ERS)

Dietary Guidelines for Americans (DGA)

National School Lunch Program (NSLP)

Food & Drug Administration (FDA)

General Accounting Office (GAO)

Body and Mind (BAM)

National Institutes Health (NIH)

American Dietetics Association (ADA)

National School Lunch Annual Summary (NSLAS)

Recommended Daily Allowances (RDA)

Foods of Minimal Nutritional Value (FMNV)

Reference Daily Intakes (RDI)

School Food Authority (SFA)

Traditional Food-Based Menu Planning (TFBMP)

Enhanced Food-Based Menu Planning (EFBMNP)

Nutrient Standard Menu Planning (NSMP)

Assisted Nutrient Standard Menu Planning (ANSMP)

Food Nutrition & Service (FNS)

Protein Digestibility-Corrected Amino Acid Score (PDCAAS)

International Organization for Standardization. (ISO)

Hazard Analysis and Critical Control Points (HACCP)

Food, Drug and Cosmetic (FD&C) Act

Quantitative Descriptive Analysis (QDA)

Food Based Menu Plan (FBMP)

International Commission on Illumination (CIE)

Browning Index (BI)

Analysis of Variance (ANOVA)

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LITERATURE REVIEW

1.0 Introduction

Over one third of children ages 12 to 19 years old are overweight (Ogden, et al. 2008) Childhood obesity has increased three-fold from 1980 to 2000 according to Center of Disease Control (CDC) data (Division of Adolescent and School Health (DASH), 2008). The health consequences and social difficulties associated with childhood obesity make this a tremendously problematic situation. Many institutions and individuals are involved in trying to figure out the sources and solutions to childhood obesity. More information on childhood obesity can be found in Appendix I. Creative programs addressing childhood obesity have found to be most effective when having multiple components such as interaction of the school, family, community, nutrition education, physical activity, counseling and measurable signals for improvement. Programs to prevent and educate children about obesity can reach a large number of children at school.

A program that has been making a large impact on the healthy food choices in the schools are the meals served as part of the National School Lunch Program (NSLP). Appendix II contains more information on the NSLP. As part of the NSLP, the USDA sets federal nutrition requirements for the schools to follow when creating a menu plan. The nutritional values of the meals served to students are reported to the government as a weekly average. Federal nutrition requirements are that the meals meet one third of the Recommended Daily Allowances (RDA) for protein, calcium, iron, vitamin A and vitamin C as appropriate for the levels for the age group served. The meals should also be limited to 30% calories from fat and 10 % calories from saturated fat. Another recommendation is the schools try to be consistent with the most current Dietary Guidelines of America (2005).

The impact of meals served by the NSLP is often times lowered by the food choices outside the NSLP called competitive foods (Appendix II). Found in school snack lines, vending machines, and school stores, competitive foods do not have federal nutritional requirements. Items sold in schools as competitive foods are many times high in calories, sugar, fat, and sodium. As a result of schools and the government being concerned about childhood obesity and a total healthy school environment, a new law was introduced concerning the nutrition of competitive foods. The USDA created a law that at the state level competitive foods would need to follow a local wellness policy (Appendix II). This would provide nutritional requirements for competitive foods to be followed by schools in that state. In New Jersey the model nutrition policy for competitive foods requires limits on fat, saturated fats, portion sizes of beverages, and availability of certain beverage dessert choices depending on age group (Appendix II). The schools were required to enact this law starting September 2007.

Manufacturers of school food products recently have been making nutritional improvements so they can offer schools healthier choices. Schools have many choices of what products to purchase from manufacturers or even between manufacturers with the same type of products. Therefore, it is important for school food supplier to highlight the qualities that make their products better. Improving the nutritional quality of their products helps schools comply with requirements and increases marketability to buyers (i.e. School Food Authorities). Items sold as competitive foods may have to make changes to comply with the new requirements of the state according to their model nutrition policy. Nutritional quality improvements made to products can affect taste, price, and convenience. The nutritional information of a product is reported to the school by the information gained by the processor. When schools serve meals that meet federal and state nutritional requirements this provides healthy quality choices to the students.

Affordability is an important aspect to school foods along with nutrition. More affordable food products are made possible through donated commodities used by school food processors. The food industry provides a service for the schools and the government to use excess commodities donated from the United States Department of Agriculture (USDA) to the schools in the food products they manufacture. Food industry school food suppliers process the donated surplus USDA raw food commodities to create usable school food products. Schools that buy the food products do not pay the cost of the donated raw materials in the products.

The varieties of products sold to schools may differ in nutrition or price or have other unique characteristics. Understanding the nutritional differences as well as food attributes of color, taste, aroma, texture, cost, and convenience are important to the quality of the food products. The product characteristics of nutrition, color, texture and sensory properties are the objective of this study. School food processors benefit from the understanding of the detailed characteristics of their products. When products have been nutritionally improved different characteristics between products will be known.

1.1 Evaluation of food attributes

Food quality has many definitions. For the purposes of our research quality is defined as safe, nutritious, aesthetically pleasing, readily available, convenient to use, and reasonably priced (Daun, 1993). Food product quality can be measured as the total features of a product able to conform to requirements (International Organization for Standardization (ISO), 2005). Government, schools, processors, and consumers (students) have various requirements and expectations of how quality is assessed. Consumers hold the schools accountable for good manufacturing practices when storing or serving the food products. Schools require the processors use good manufacturing practices, inspected by FDA or USDA, and have a Hazard Analysis and Critical Control Points (HACCP) plan to ensure safety. The federal law regulates the Good Manufacturing Practices/Quality System requirements for production of food items through section 520 of the Food, Drug and Cosmetic (FD&C) Act. Therefore, the food served is safe.

Aesthetically pleasing foods depend on appearance, aroma, taste, texture, and other attributes. Measured by instrumental and sensory techniques for evaluation of product attributes such as color, aroma, flavor, texture and others. The characterizing of product quality changes over time. Measured by color, texture and sensory methods changes were reported for a broad range of products such as Arctic charr (Gines et al. 2004), starch based custard desserts (De Wijk et al. 2006), and spaghetti (Cocci et al. 2008). These are major factors of evaluating food quality. Peri (2006) refers to nutritional and sensory properties like appearance, aroma, taste and texture combined as "biological quality". When the consumer and customer needs are combined with biological quality this represent overall food quality. The customer needs are met by the expectations of product availability, convenience, and affordability.

1.2 Quality as a measure of color

The surface color is a major attribute often of first consideration for product quality and acceptance (Abdullah et al. 2004, Du et al. 2004, Hatcher et al. 2004, Leon et al. 2006, Pedreschi et al. 2000). Each product should have an expected color. The visual evaluation of appropriateness for color can be influenced by the original appearance, naturally occurring or restored with color additives. To measure the quality of the food a color profile has to be established for comparison. Standards of color have been experimentally appointed by the FDA making use of resources like the Munsell Book of Color to ensure the product is of an acceptable range to maintain quality. Color is dependent on the food properties, light source and observer. Food products are translucent, transparent, or opaque materials, which transmit light seen by the eye in different ways. Each product has different measurements needed to determine total color of the food. A color is the result of visible wavelength light energy measured in a combination of lightness, hue, and saturation. The transmission of light is changed by geometric factors of the food producing gloss, haze, or different directionality. The source of illumination will change the color observed since the energy of the visible wavelengths must be contained in the light source in order to be seen. Bronsan et al. (2004) measures color with the conditions of “Good lighting can reduce reflection, shadow and some noise giving decreased processing time.” Light sources have been calculated to represent natural daylight in a combination of bulbs at different color temperatures measured in Kelvin (C 6774K, D65 6500K, and D 7500K respectively). Another factor of color measurement is the observer. A preferred measurement is the 45-degree angle of the light source to the object so the observer is at a 90-degree angle to the object. The same positioning of illumination and observer will allow reproducible color values. Given the proper set up of contributing factors the color can be determined by visual or instrumental methods. Color analysis of uniform homogeneous color can be evaluated for quality using a standard measurement of L a*b* using a colorimeter for accurate reproducible results. Alternatively, non-homogeneous surface color can be measured by images taken by a digital camera. Using a computer and digital camera for color analysis called computer vision values of red, blue, green can be converted to L a*b* by software programs such as Adobe Photoshop (Yam et al, 2004). The digital camera makes it simple because it is a familiar piece of equipment that is easy to use.

1.3 Quality as a measure of texture

As a measurement of food quality, texture is important for observing both defective and acceptable food products. A group of properties based on physical structure, sense of touch, and functions of mass, distance, and time compose the definition of texture (Bourne, 2002). The classifications of this testing are puncture, compression-extrusion, cutting-shear, compression, tensile, torsion, bending and snapping and deformation. A comprehensive definition of food texture analysis and methods for evaluation can be found at Bourne (2002), Rosenthal (1999), and Texture Technologies (2009).

The various methods for food texture analysis depend on the properties of the food. A common texture instrument measures force. A simple test of measuring the force to push a probe into a food surface is used to measure texture known as a puncture test. The force to deform the sample is similar to the way molar teeth bite and chew. However, the puncture test assumes a semi-infinite geometry because of the small surface area measured. A compression test will measure the larger surface area of the food sample by forcing it to flow or fracture and deform dependent on its composition. When the direction of the force applied to the sample is parallel to the direction it is sliding this is known as shear. A food product can also be measure for the force to be divided into two sections, bent or pulled apart. Using any test the most accurate data depends on a consistent sample temperature, size, shape, speed, distance and direction.

Instrumental techniques are not the complete textural quality of a product since they do not determine the consumers' perception. A sensory texture analysis is needed to measure the quality of a food dependent on its acceptability. Human experience of a trained expert can be correlated to physical properties results for insight on the reaction of texture differences. Using the human senses to manipulate the food product by eating allows for many different variables to be identified. In study of apple firmness a difference of five newtons using instrumentation is detectable by human perception (Harker et al. 2006). The process of eating can measure the actions of biting, chewing, swallowing, etc. and what sensations are perceived at any given point. Since texture has a high affect on liking of the product, the quality of a food can depend on the description of its meeting standards.

1.4 Quantitative Descriptive Analysis

Quantitative Descriptive Analysis (QDA) is a method of sensory evaluation used to describe products by using humans as instruments, calibrated by standard references after being trained to recognize the value on a scale. A comprehensive understanding of

QDA can be found at Meilgaard et al. 1999, Lawless et al. 1999, Moskowitz, 1988, and Murray et al. 2001. When a trained panel is used consistently over time they can be used for shelf-life studies, quality assurance for product problems, and products placement versus competitors. Training for QDA panels requires people to be committed and motivated beyond having normal odor and taste perceptions. The panel is responsible for the terminology used to describe the specific products without involvement of the facilitator. Based on consensus of the panel descriptive terms are measured from weak to strong of an unstructured 15 centimeters line scale for each attribute. The measurement of reference standards gives each panelists information on how to determine the placement of their rating. After training of reference standards, the panelists measure the samples in individual booths with replicates of the same sample to analyze repeatability. The results of panelist's can also be compared to show individual, replication, and product differences. Even though two panelists use the scale differently it is the relative differences that are measured in QDA, so that the same ratio is possible because the panelists are measuring the same way. The disadvantages of QDA are the way it is conducted may vary the results. Amount of training for descriptive panels studied by Chambers et al. (2004) found at four hours of training panelists were able to decipher all texture and some flavor attributes, and by 60 hours and 120 hours the results became more reliable and discriminating. Also, terminology use is important since a "dumping effect" may occur when one attribute influences the other such as the increased sweetness influenced by the increase in color red, however adequate training can prevent this type of error. Advantages of QDA allow products to be detailed to singular terms giving a precise description to each product. Although not the consumer's perception and no information on liking or hedonics, the comparison of several products can be made relative to one another for small or large difference across many attributes based on consumer language descriptions.

1.5 Conclusions from the Literature Review

Appealing to the heightened awareness of childhood obesity, more nutritious products will be available to schools. As processors make the changes to their products to benefit the nutritional value, the food quality should not diminish. Federal and state nutritional regulations present the constraints to which products should fit into the NSLP or as a competitive food, however ultimately the products need to maintain and the interest of schools and their children. Therefore, food quality properties of color, taste, texture, and nutritional value will assess the food characterization of each product to decide product descriptions.

OBJECTIVES

The general objective of our research is to contribute to the improvement of school food products. Our more specific objective is to evaluate selected commodity processed products of New Jersey National School Lunch Program (NSLP) to identify technical information about the products' food quality. The parameters of the NSLP and New Jersey's Model Nutrition Policy are used to assess the food products' placement in the schools in New Jersey. Nutritional, physical and sensorial characterization of each product is evaluated for usefulness in giving an overall picture of food quality. Products' surface color, texture, and sensory characteristics are reported for a traditional product and a nutritionally improved product of the same type although not its identical match to show the effect on food quality.

METHODS

3.0 Selected school lunch products

Products selected for this study were based on availability. Each product selected had to have one product with an improved nutritional value and one with no nutritional modifications. The selection of products was also based on popularity within the schools. The most popular commodity processed products in school lunch program according to a school year 1998 national ranking of largest quantity purchased by schools out of all the purchases were fluid milk at 16.1 %, pizza 7.0 %, ground beef 5.1 %, cheese 4.4 %, potatoes 3.8 %, and chicken nuggets 2.4 % respectively (Daft et al, 1998). Milk, fruit drinks, ice cream, cookies, pizza, snack chips, and French fries were most frequently cited as leading a la carte sellers in elementary schools and middle/secondary schools (Daft et el, 1998). Due to the time limitations of this study only four types of products were selected. Samples selected for analysis were chicken nuggets, macaroni and cheese, pierogies and apple snacks. Chicken nuggets, macaroni and cheese, and pierogies are samples from the NSLP menus. Apple snacks were selected as examples of competitive foods. Products referred to, as “original” products, have no modifications made to their ingredients. Products with similar ingredients that have been nutritionally improved are referred to by their unique attribute that identifies their nutritional change. The products selected were of similar type but not meant to be an identical match to original products.

3.1 Information of selected products

A. Chicken Nuggets

Three varieties of chicken nuggets were selected. “Original” breaded white and dark meat blend chunks, and “Home-style” breaded breast chunks with dried egg whites (all white meat) are the non-nutritionally modified. “Whole grain” breaded nugget shaped chicken breast patties with rib meat were selected as improved by addition of whole grains to the breading. All chicken nuggets were frozen when prepared using a conventional oven at 450 F for 12 minutes. In accordance with the Food Based Menu Plan (FBMP) (Appendix II) one serving size of chicken nuggets with dried egg white and all white meat are equivalent to two ounces meat or meat alternate and one serving grains or breads, chicken nuggets with white and dark meat are equivalent to two ounces meat or meat alternate, and chicken nugget with whole grain breading are two ounces meat or meat alternate and one serving grains or bread alternate. One serving is five pieces of chicken nuggets. The following are the ingredients for each product:

Home-style Breaded Breast Chunks with Dried Egg Whites (All White Meat)

Ingredients: Chicken breast with rib meat, water, dried whole egg, seasoning (salt, onion powder, modified corn starch, natural flavor), and sodium phosphates.
BREADED WITH: Enriched wheat flour (enriched with niacin, ferrous sulfate, thiamine mononitrate, riboflavin, folic acid), water, enriched bleached wheat flour (enriched with niacin, ferrous sulfate, thiamine mononitrate, riboflavin, folic acid), salt, modified corn starch, spices, dextrose, garlic powder, partially hydrogenated soybean oil, oleoresin paprika and annatto, xanthan gum, and natural flavors. Breading set in vegetable oil.
ALLERGENS: EGG, WHEAT.

Original Breaded white and dark meat blend chunks

Ingredients: Chicken breasts with rib meat, chicken leg meat, water, sodium phosphate and salt.
BREADED WITH: Bleached wheat flour, salt, spices, soybean oil, dextrose, partially hydrogenated soybean oil, leavening (ammonium bicarbonate), natural flavor, mono and diglycerides Battered with: Water, bleached wheat flour, salt, spices, garlic powder, natural flavor. Breading set in vegetable oil
Contains: WHEAT

Whole Grain Breaded Nugget Shaped Chicken Breast Patties with rib meat

Ingredients: Chicken Breast with rib meat, water, vegetable protein product (isolated soy protein, magnesium oxide, zinc oxide, niacinamide, ferrous sulfate, Vitamin B12, copper gluconate, Vitamin A Palmitate, calcium pantothenate, pyridoxine hydrochloride, thiamine mononitrate, riboflavin), whole dried egg, seasoning (salt, flavor, modified corn starch) sodium phosphate
BREADED WITH: Whole-wheat flour, wheat flour, dextrose, salt, soybean oil, yeast. Battered and predusted with: water, whole wheat flour, corn starch, salt, spices, garlic powder, onion powder, guar gum, leavening (sodium acid pyrophosphate, sodium bicarbonate, monocalcium phosphate) modified corn starch. Breading set in vegetable oil.

B. Macaroni and Cheese

A model school lunch main entrée item was selected for the characterization of original macaroni and cheese and nutritionally improved reduced fat macaroni and cheese. The samples were placed in bags and heated in boiling water for 30 minutes. For the purpose of Food Based Menu Planning (FBMP) (Appendix II) the serving size of six ounces provides two ounces equivalent meat alternate for both products and one and a quarter servings of bread alternate and one-half servings of bread alternate for original and reduced fat respectively. The following are the ingredients of each product:

Home-style Original Macaroni and Cheese

Ingredients: Water, pasteurized process cheese (cheddar cheese [pasteurized milk, cheese culture, salt, enzymes, annatto], water, dehydrated cream] cream, dipotassium phosphate], sodium phosphate, salt, paprika extract), macaroni (enriched semolina [enriched with niacin, ferrous sulfate, thiamin mononitrate, riboflavin, folic acid], egg whites), nonfat dry milk, modified food starch, cheese flavor (a dehydrated blend of whey, cheddar cheese [milk, cheese culture, salt, enzymes], butter, buttermilk solids, sodium phosphate, natural flavor, yellow 5, yellow 6), flavoring (dried whey, maltodextrin, corn syrup solids, salt, guar gum, cream, powdered buttermilk, butter flavor, flavor, annatto, turmeric), sodium phosphate.

Reduced Fat Home-style Macaroni and Cheese

Ingredients: Water, pasteurized process cheese (cheddar cheese [pasteurized milk, cheese culture, salt, enzymes, annatto], water, dehydrated cream] cream, dipotassium phosphate], sodium phosphate, salt, paprika extract), dry enriched multigrain macaroni (semolina, grain and legume flour blend [lentils, chickpeas, egg white, spelt, barley, flaxseed, oat fiber, oats], durum flour, niacin, iron [ferrous sulfate], thiamine mononitrate, riboflavin, folic acid), modified food starch, nonfat dry milk, cheese flavor (a dehydrated blend of whey, cheddar cheese [milk, cheese culture, salt, enzymes], butter, buttermilk solids, sodium phosphate, natural flavor, yellow 5, yellow 6), flavoring (dried whey, maltodextrin, corn syrup solids, salt, guar gum, cream, powdered buttermilk, butter flavor, flavor, annatto, turmeric).

C. Pierogies

Another model school lunch meal main entrée component was selected for characterization of pierogies or half moon shaped pasta filled with potato and cheese in original and nutritionally modified increased protein formulations. The cooking procedure is the same for both samples as follows “Boiled by dropping frozen pierogies in water that’s already been heated to a rolling boil over high heat. Pierogies will float in about 5 to 7 minutes; drain” according to the manufacturer’s instructions on the label. For the purposes of a FBMP (Appendix II), one serving or three pierogies provides two and three-quarters servings of grain or bread alternative, quarter cup of fruit or vegetable, and three-quarter ounce equivalent meat alternate for the traditional pierogies and two and three-quarters servings of grain or bread alternative, one-eighth cup fruit or vegetable, and two ounces equivalent meat alternate for the high protein pierogies. The following are the ingredients for both products:

Child Nutrition Potato & American Cheese Pierogies

> Ingredients: Water, enriched wheat and durum flours (wheat flour, durum flour, niacin, ferrous sulfate (reduced iron), Thiamine, Mononitrate, Riboflavin, Folic Acid), Process American Cheese (Cheese [pasteurized milk, cultured milk, skim milk, salt, enzymes, calcium chloride], Water, Cream, Sodium Citrate, [emulsifier], Sodium Phosphate, Salt, Annatto), Dehydrated Potatoes (Potatoes, Mono & Diglycerides, Sodium Acid Pyrophosphate, Citric Acid), Margarine (Partially hydrogenated and Fully Refined Soybean oil, Water, Salt, Vegetable Mono & Diglycerides, Lecithin, Sodium Benzoate, Artificially Flavored, Colored with Beta Carotene [a source of Vitamin A], Vitamin A Palmitate added), Salt, Dehydrated Onions, Dry Whole Eggs, Spices.
>
> CONTAINS: WHEAT, MILK, SOY, and EGGS
>
> High Protein Child Nutrition Potato & American Cheese Pierogies
>
> Ingredients: Water, enriched wheat and durum flours (wheat flour, durum flour, niacin, ferrous sulfate (reduced iron), Thiamine, Mononitrate, Riboflavin, Folic Acid), Process American Cheese (Cheese [pasteurized milk, cultured milk, skim milk, salt, enzymes, calcium chloride], Water, Cream, Sodium Citrate, [emulsifier], Sodium Phosphate, Salt, Annatto), Dehydrated Potatoes (Potatoes, Mono & Diglycerides, Sodium Acid Pyrophosphate, Citric Acid), Whey Protein Isolate (Whey Protein Isolate, Soy Lecithin) Dry Whole Eggs, Salt, Spices
>
> CONTAINS: WHEAT, MILK, SOY, and EGGS

D. Apples

A competitive food product, Crunchy Apple Cinnamon Wedges, was selected composed of the following ingredients: Freeze-dried apples, crystalline fructose, cinnamon, and lactoferrin (milk derived protein). Additional information on the package is a health claim reading “While many factors affect heart disease, diets low in saturated fat and cholesterol may reduce the risk of this disease”. Comparatively, unsweetened unsulfured dried apple slices were selected as the original form of the product. The ingredients are Granny Smith apples. Samples were evaluated at room temperature.

3.2 Nutritional facts

The nutritional facts from the manufacturer of each product were collected for comparison of total nutritional value. Additionally, samples of chicken nuggets and pierogies were sent to a certified outside laboratory to be analyzed (Silliker, Inc. Northeast Laboratory Allentown, PA).

3.3 Instrumental color methods

A Minolta CM-2500d Spectrophotometer with Spectra Match software was used to measure surface color of homogeneous samples pierogies and macaroni and cheese in L a*b* units of color. The (International Commission on Illumination (CIE) 1976) color space measures L for the luminance or lightness component with a range 0 to 100 (dark to light), and a* (from green to red) and b* (from blue to yellow) with a range -120 to 120. After preparing samples to manufacturer’s instructions described above, ten pieces randomly selected were measured for surface color. Measurements were taken as an average of three locations across the surface from left to right. All the pierogie and macaroni and cheese samples were measured using the same methodology.

Heterogeneous surface color samples apple snacks and chicken nuggets were measured according to the procedure of Yam et al. (2004) by using a digital camera along with Adobe Illustrator software to convert the RBG (red, blue, green) values to L a* b* values. Ten randomly selected pieces were measured as overall L a* b* values. The Browning Index (BI) was calculated for apple snacks and chicken nuggets by following the equation of BI = (100*(x – 0.31)) / (0.172) where x = (a + (1.75*L)) / ((5.645 L) + (a – (3.012*b))) (Palou et al. 1999). All the apple snack and chicken nugget samples were measured using the same methodology.

3.4 Instrumental texture methods

A Texture Analyzer TA.XT2 was used to measure ten samples of each product prepared to manufacturer's instructions. The sample was measured for texture with product specific probe and testing parameters. The same ten samples of each variety measured for color were used to measure texture. Since texture measurements are product dependent, below is a description of methodology used for each product.

A. Chicken Nuggets

Chicken nugget firmness was measured using a Warner Bratzler-style knife blade (TA-7) with the usual triangle cutout with a rounded corner. The cutting of the chicken nugget was placed center and perpendicular to the knife blade. The tests were run to determine peak force with a pre-test speed of 8.0 millimeters per second; a test speed of 4.0 millimeters per second; and a post-test speed of 8.0 millimeters per second as the peak force (Texture Technologies Corp. 2008; Lyon and Lyon, 1998). A conical probe (diameter 1.6 centimeters and height 1.5 centimeters) was used to measure the coating surface texture and firmness. The chicken nugget was placed center to the cone when tested at a speed of 55 millimeters per minute and 25 % depth into the sample. (Dogan, et al 2005)

B. Macaroni and Cheese

Macaroni and Cheese products were prepared as stated above then 200 grams was evaluated at 120 ° F immediately after heating using a standard Kramer shear cell fitted with a 35 millimeter diameter cylinder at entry speed 4.3 millimeters per second (D'Egidio et al. 1982). Peak force in grams was recorded to measure firmness. The back extrusion of the probe measuring the negative area of force versus time graph was used to measure stickiness.

C. Pierogies

After being cooked and drained as stated above pierogies were cooled and evaluated at room temperature. Outside pasta and inside filling were measured separately for firmness as suggested by the manufacturer. The sealed pasta edge with no filling was measured for firmness. To measure the pasta firmness a 2 millimeters diameter cylinder puncture probe was used with a test speed of 2 millimeters per second to find peak force in grams. Then the filling firmness was measured by removing all the filling of one sample and compressing with a 50 millimeter cylinder probe at a test and post test speed of 2 millimeters per second to find peak force in grams and negative area of force time graph to measure stickiness after compression.

D. Apples

Both apple snacks, freeze-dried and air-dried, were measured at room temperature and ambient relative humidity using the same method. A puncture test determined the firmness of the apple pieces by using a 2 millimeter diameter probe to measure the force of an irregular surface at pre-test and post-test speed of 5 millimeter per second, 2 millimeters per second test speed, and 20 grams trigger force (Deng et al, 2008). Firmness or hardness is the maximum force needed to break the surface. The samples were measured in three places across the length of the sample. The length, width and height, and peak force in grams of the samples were recorded.

3.5 Sensory methodology

The same methodology was used for all selected products sensory Quantitative Descriptive Analysis (QDA) panel. Volunteers screened and trained were selected based on ability to taste and discriminate flavors in triangle test, verbally communicative, willingness, availability, no known food allergies, and previous experience if applicable. The number of panelist were chosen from Moskowitz (1988) recommendation of 6 to 8 judges for QDA to obtain good information. A relatively small panel from five to eight judges was used in these experiments. Consequently higher standard deviation is expected as compared to instrumental measurements.

Panelists from Rutgers University evaluated chicken nuggets (four female, four male mean age 29 years old, three panelists with previous experience), macaroni and cheese and apple snacks (three female, two male mean age 37 years old, one panelist with previous experience), and pierogies (three female, three male mean age 39 years old). The chicken nugget panels were split into two groups of four because of the constraints of scheduling and lack of compensation. Panelists were presented with various commercial and test samples to create terminology to describe the products. For each product terms were selected and defined (Table 1).

Table 1. Descriptors used to evaluate chicken nuggets, macaroni and cheese, pierogies, and apple snacks with terms and definitions.

Term	Definition
Yellow	Outside surface color measured from light yellow to dark yellow
Orange	Outside surface color measured from light orange to dark orange
Black pepper	Odor associated with ground black pepper
Cinnamon	Odor associated with ground cinnamon
Cheese	Odor associated with medium cheddar cheese
Egg	Odor associated with cooked egg
Flour	Odor associated with cooked starch
Butter	Odor associated with fresh salted butter
Oil	Odor associated with cooked vegetable oil
Sweetness	Flavor associated with sucrose
Saltiness	Flavor associated with sodium chloride
Sourness	Flavor associated with citric acid
Bitterness	Flavor associated with caffeine
Crispiness	The force and noise with which a product breaks or fractures (rather than deforms) when chewed with the molar teeth (first and second chew).
Juiciness	The amount of moisture released upon the first and second chews.
Hardness	The force to attain a given deformation, such as the force to compress between molars
Surface texture roughness	Roughness sensed on teeth, palate, and tongue, typically caused by products such as walnuts, spinach, and wine
Chewiness	Degree of chewing needed to break up the sample requiring a good deal of mastication, toffee-like texture.
Viscous	The mouthfeel associated with consuming very viscous fluids like heavy whipping cream or honey.
Hardness	The force required to bite through the sample using molar teeth in first bite
Sticky	Degree to which sample sticks to palate and around the teeth during mastication.
Grainy	The feeling of coarse uniformed particles in the mouth during mastication
Lumpy	The feeling of large irregular particles in the mouth during mastication

Chicken nuggets were evaluated using yellow, orange, black pepper aroma, saltiness, crispiness, juiciness, and hardness. Apple snacks were evaluated using yellow, orange, cinnamon aroma, sourness, sweetness, bitterness, rough surface texture, and chewiness. Macaroni and cheeses were evaluated using yellow, orange, cheese aroma, saltiness, sweetness, and viscousness. Pierogies were evaluated using yellow, egg aroma, flour aroma, butter aroma, oil aroma, saltiness, sourness, hardness, stickiness, lumpiness, and graininess.

Panelists were then trained for each attribute using reference standards from literature and as suggested by the panel for the QDA method in a total of six one hour sessions (Meilgaard, Civille, Carr, 2006) Training was conducted in a conference room setting with minimal noise and natural daylight. Each product was presented immediately after preparation to be tested in replicates of a blind randomized block design (Table 2) over two sessions on a 15 centimeter unstructured line scale with weak and strong end anchors. A three-way analysis of variance (ANOVA) was used to find sensory evaluation data with factors of product, panelist, and replicate at a significance level $p < 0.05$. Correlations are reported as coefficient of determination R^2 (Pearson's coefficient squared) calculated for attributes of sensory and instrumental results to find their relationship.

Table 2. An example of a randomized block design is for the five panelists to see each of the three variations of the product numbered by a series on a random number table in this example (040, 157, and 880) in a randomized order in replicate over two blocks or sessions.

Panelist 1	040	157	880	
2	157	040	880	Block 1
3	040	157	880	
4	880	040	157	
5	040	880	157	
Panelist 1	157	880	040	
2	040	880	157	Block 2
3	157	040	880	
4	040	880	157	
5	157	880	040	

RESULTS AND DISCUSSION

Results are presented separately for selected food products as chicken nuggets, macaroni and cheese, pierogies, and apple snacks respectively.

4.0 Chicken nuggets nutritional quality

The results of chicken nugget nutritional analysis are presented in Table 3 in the form of "nutritional facts" as read on the label and from the Silliker Lab analysis. The nutritional information is compared as if the serving size is 100 grams for all variations.

Table 3. Nutrition facts for home-style, whole grain, and original chicken nuggets from Silliker Lab analysis and as shown on the manufacturer's package label.

	Home-style		Whole Grain		Original	
	Silliker	Label	Silliker	Label	Silliker	Label
Calories	240	242	240	267	263	258
Calories from fat	120	NA	140	NA	158	NA
Protein (g)	15	13	13	15	15	13
Fat (g)	14	17	15	14	17	18
Sat. Fat (g)	3	4	4	3	4	4
Cholesterol (mg)	50	83	35	52	95	46
Fiber (g)	2	2	2	2	2	2
Carbohydrates (g)	13	10	13	21	13	11
Sugars (g)	--	--	1	--	--	2
Sodium (mg)	530	418	430	506	611	359
Vitamin C	--	--	--	--	--	--
Vitamin A IU	--	--	--	--	2	--
Iron (mg)	10	4	6	1	8	6
Calcium (mg)	--	--	--	--	2	2

The nutritional information on the labeled package did not match with the laboratory results from Silliker in all cases. The nutritional facts from the manufacturer compared to the laboratory results using the same serving size show 33 and 17 milligrams more cholesterol for home-style and whole grain but 46 milligrams less for original respectively. The cholesterol contained in the meat may vary between samples; therefore a large sample size might help to create better agreement between measurements. Another major difference was the label showed 112 milligrams less sodium than the lab results for home-style nuggets. Original nuggets also had a 239 milligram difference between label and lab results form sodium, while the whole grain nuggets were measured as having 76 milligrams more sodium when analyzed by the lab. The reason for large variation in sodium readings was inconclusive for the parameters of this study. Even though this is not required for reporting level in the NSLP, it is a major contributor to high blood pressure and health issues.

Nutritional quality of the chicken nuggets was determined by the contribution of the different coating ingredients and meat extension ingredients. According to USDA Food Standards and Labeling Policy Book, the name used by each product as chunks or "nugget-shaped" is required for "products made from chopped meat or poultry and containing binders, extenders and/or water" (USDA, 2003). All varieties of chicken nuggets contained breast and rib meat, while the additives changed to leg meat, dried egg white, or vegetable protein and dried egg white for original, home-style, and whole grain nuggets respectively. The nutritional contribution of leg meat or dark meat with a higher fat content resulted in original having the highest fat content of 18 grams per 100 grams. Increasing additives of protein sources (dried egg white and vegetable protein) had lower fat and increased protein; whole grain nuggets having least fat 14 grams per 100 grams and most protein 15 grams per 100 grams. The breading main ingredient changed slightly for each nugget (bleached wheat flour, enriched wheat flour, and whole wheat flour for original, home-style, and whole grain respectively). The whole grain nuggets had double the carbohydrates leading to the most calories and the most sodium of all the varieties.

4.1 Chicken nuggets color

Results of the color analysis of home-style, whole grain and original chicken nuggets are presented in Table 4 and Figure 1 as L (lightness), a* (green to redness), and b* (blue to yellowness) values for the surface color of selected samples. Figure 2, 3, 4 show a sample of the original, whole grain, and home-style chicken nuggets surface color images respectively.

Table 4. The average L, a*, b* color values for surface color of original, whole grain, and home-style chicken nuggets.

	L	Standard error	a*	Standard error	b*	Standard error
Original	148.53a	4.44	138.01a	0.77	182.69a	1.04
Whole grain	132.43ab	5.11	147.96ab	1.21	184.37ab	1.20
Home-style	147.17a	6.01	142.48abc	0.87	188.44abc	1.64

Change in letter indicates significance at ($p < 0.05$)

Figure 1. The average L, a*, b* color values for surface color of original, whole grain and home-style chicken nuggets.

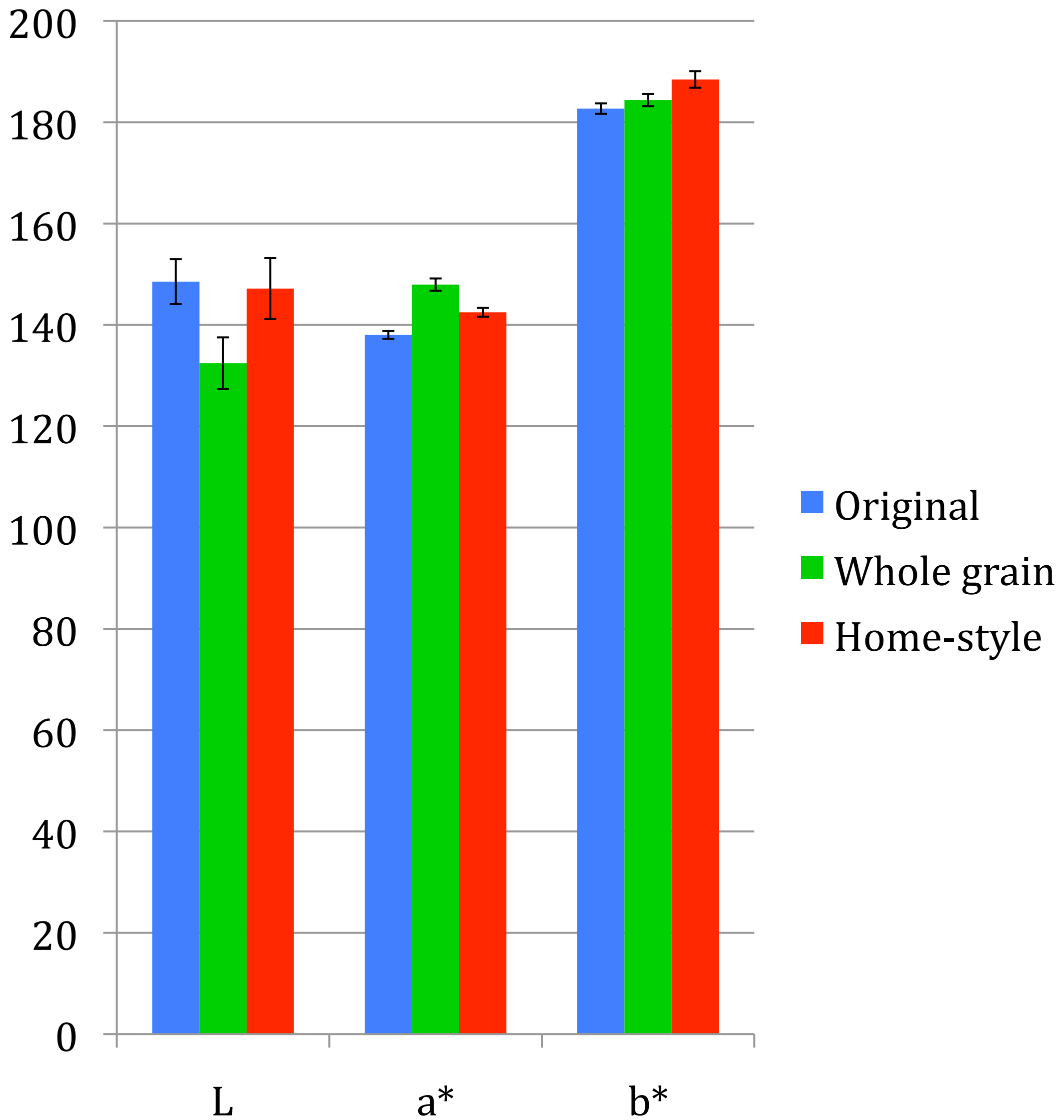


Figure 2. Surface color of Original chicken nugget cooked.

Figure 3. Surface color of Whole grain chicken nugget cooked.

Figure 4. Surface color of Home-style chicken nugget cooked.

Significant differences ($p < 0.05$) were found for the surface color of the chicken nuggets between whole grain and others for lightness (L) but not between original and home-style (Table 4 and Figure 1). There is a significant difference ($p < 0.05$) between all varieties for a* (redness) and b* (yellowness) for whole grain, original and home-style respectively. Browning index values indicated the whole grain nuggets are significantly ($p < 0.05$) browner than home-style (478.91 and 395.5 respectively) and home-style was significantly ($p < 0.05$) more brown than original (362.65). Whole-wheat flour was used for coating the whole grain nuggets other than bleached wheat flour used in the other coatings, so logically the whole grain nuggets are browner. Annatto was used in the breading of the home-style nugget, which could explain the more yellow color. Bleached wheat flour was used in the original breading creating a lighter, less red, and less yellow color.

4.2 Chicken nuggets texture

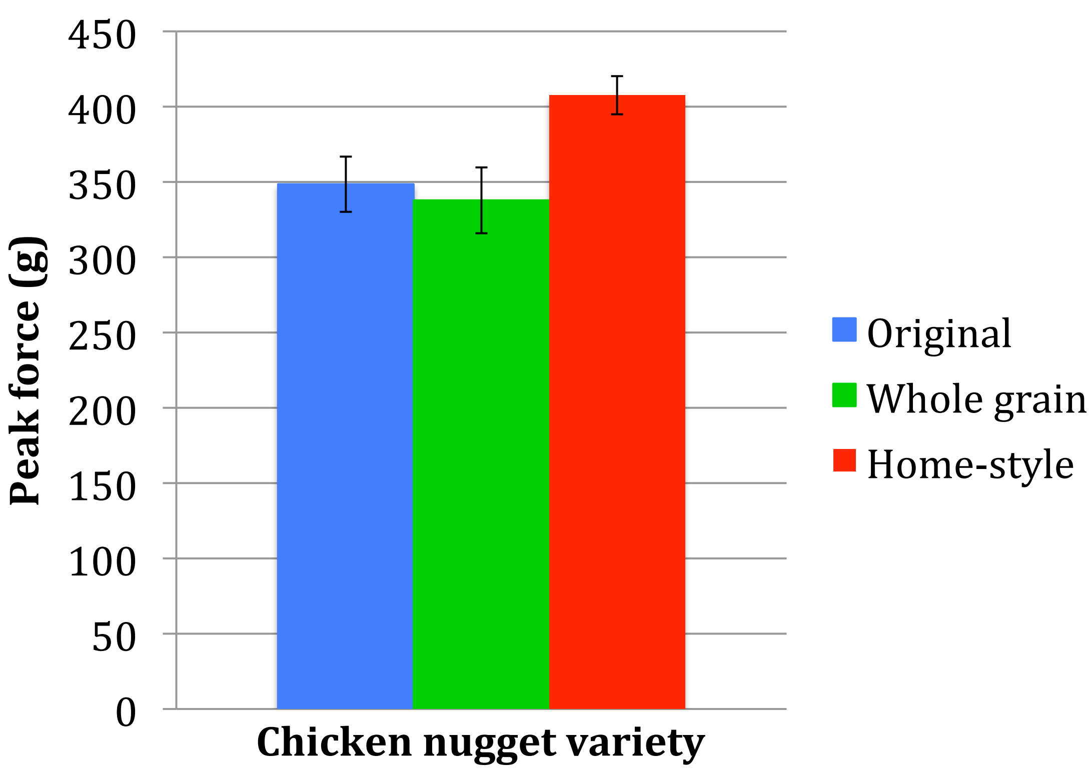
The chicken nugget coating texture results are shown in Table 5 and Figure 5 to measure the hardness of each variety (original, whole grain, and home-style) respectively.

Table 5. The average maximum peak force of the outside coating texture for original, whole grain, and home-style chicken nuggets.

	Peak force	Standard error
Original	348.48a	18.33
Whole grain	337.80a	21.87
Home-style	407.59ab	12.67

Change in letter (a - b) indicates significance at ($p < 0.05$)

Figure 5. The average maximum peak force of the outside coating texture for original, whole grain, and home-style chicken nuggets.



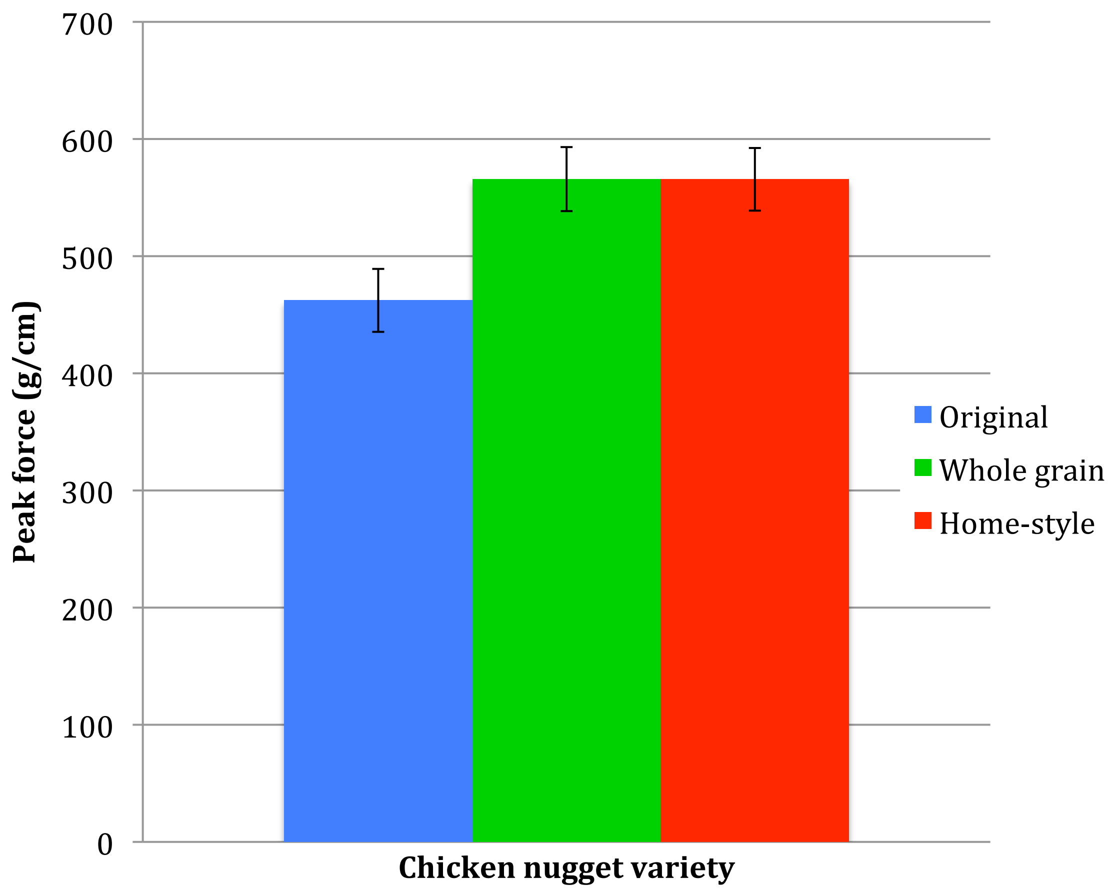
Coating texture measured by peak force found the home-style is significantly ($p < 0.05$) harder than the original and whole grain, but the latter two are not significantly different (Table 5 and Figure 5). The whole grain is more fracturable with a quicker break than the other coatings related to crispness, however there is not a significant difference between varieties (Dogan et al. 2005). Using ANOVA sensory crispness was not significantly different, though the panel did find a trend with the edge crispness as more crisp than the middle of the top and bottom coatings and whole grain as the crispiest as shown in Table 7. The results of the chicken nugget meat texture measured as peak force divided by width in grams per centimeter are shown in Table 6 and Figure 6 for each variety (original, whole grain, and home-style) respectively.

Table 6. Average peak force in grams per centimeter as a measure of hardness of chicken nugget meat texture for original, whole grain, and home-style varieties.

	Peak force (g/cm)	Standard error
Original	462.259ab	26.868
Whole grain	565.783a	27.324
Home-style	565.595a	26.738

Change in letter indicates significance at ($p < 0.05$)

Figure 6. Average peak force in grams per centimeter as a measure of hardness of chicken nugget meat texture for original, whole grain, and home-style varieties.



Chicken nuggets measured instrumentally showed the original have a significantly ($p < 0.05$) softer texture than home-style and whole grain. There was no significantly difference for peak force in grams per centimeter for home-style and whole grain (Table 6 and Figure 6). Often in chicken nuggets of chopped low function quality meat a binder is used like dried egg white because it produces a firm gel with the addition of nutritionally beneficial protein. Studies of dried egg white or other vegetable proteins show varying results such as increased hardness sausages and beef roll but no change in chicken batter (Carballo et al. 1995, Pietrasik, 2003, Fernandez et al. 1998) The significant texture differences may be increased by the egg white and vegetable protein, however the original nuggets have an already decreased the peak force hardness because of the higher fat content.

4.3 Chicken nuggets descriptive analysis

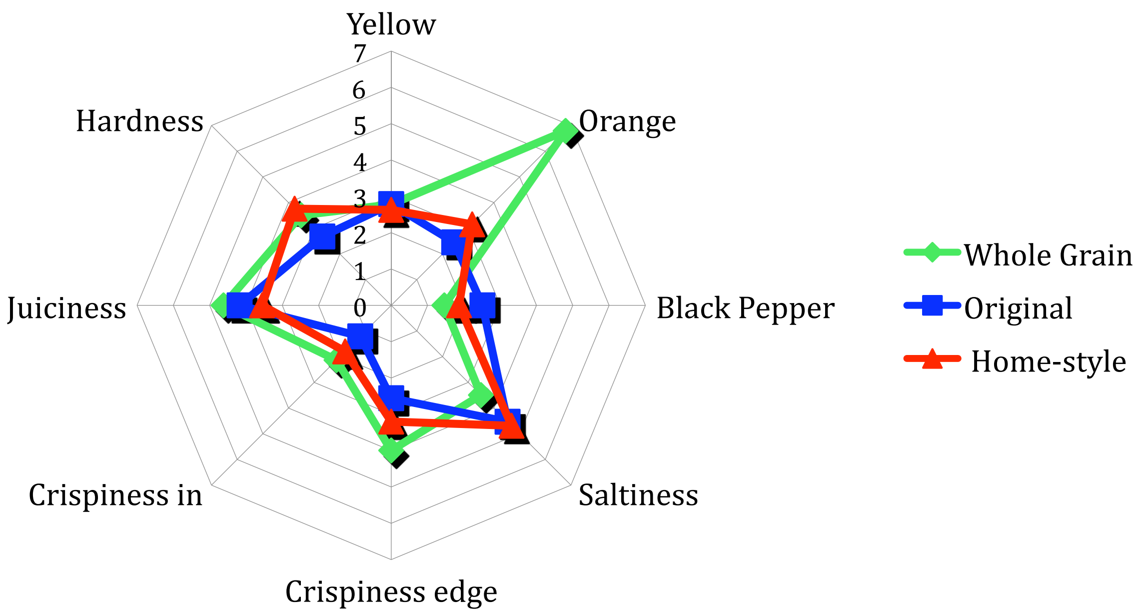
The QDA chicken nugget panel results are given in Table 7 as the mean value for each attribute measured as weak to strong for the varieties original, whole grain, and home-style respectively. The mean values are plotted in Figure 7 to show the characterization of each value for visual comparison between original, whole grain, and home-style chicken nuggets.

Table 7. The mean values of each attribute measured by the QDA panel for original, whole grain, and home-style chicken nuggets.

Attribute	Original	Whole Grain	Home-style
Yellowness	2.79	2.78	2.63
Orangeness	2.45	6.79a	3.15
Black Pepper aroma	2.51	1.46	1.87
Saltiness	4.53	3.49	4.69
Crispiness of outside edge	2.56	3.99	3.20
Crispiness of outside top and bottom center	1.21	2.13	1.79
Juiciness	4.18	4.62	3.56
Hardness	2.68	3.51	3.76

Change in letter indicates significance at ($p < 0.05$)

Figure 7. The QDA attribute mean values are shown for original, whole grain, and home-style chicken nuggets.



Using ANOVA from data of the chicken nugget sensory panel (Table 7), the whole grain nuggets were found to be significantly ($p < 0.05$) darker orange than the original and home-style. There was no significant difference for orange between original and home-style nuggets. Dark orange is significantly correlated to browning index with $R^2 = 0.98$. Original chicken nuggets were significantly ($p < 0.05$) less hard than whole grain and home-style. There was no significant difference between the whole grain and home-style nuggets. A correlation was found $R^2 = 0.95$ for peak force (grams per centimeter) and hardness mean scores from the QDA panel. Using the descriptors in Table 1 sensory panelists found replicate difference for black pepper aroma. The spices used in each formulation were not indicated on the label and therefore not identifiable by the parameters of this study. It may be that each sample had a different black pepper aroma and more samples could help to determine the variation seen by the panelists. Also, juiciness had a significant ($p < 0.05$) group effect from the variation of a small group panel. A common trend was found for both groups that the home-style had the least juiciness. According to results of sensory panel another trend found was the whole grain nuggets were less salty than the others. The nutrition label (Table 3) disagrees with these results as it shows the original nuggets with the least sodium and whole grain nuggets with the most. However, Silliker (Table 3) found the whole grain nuggets to contain the least amount of sodium, which agrees with the sensory panel results.

4.4 Macaroni and cheese nutritional quality

The results of nutritional analysis are presented in Table 8 in the form of "nutritional facts" as read on the manufacturer's label.

Table 8. Nutritional facts information from manufacturer's label per serving size (6 ounces) of Reduced fat Macaroni and Cheese and Original Macaroni and Cheese.

Macaroni and Cheese	Reduced fat	Original
Serving size	6 oz	6 oz
Calories	238	289
Calories from fat	98	133
Protein (g)	13	15
Fat (g)	11	15
Sat. Fat (g)	6	8.1
Cholesterol (mg)	35	48
Fiber (g)	1	1
Carbohydrates (g)	23	25
Sugars (g)	5	4
Sodium (mg)	847	1,017
Vitamin C	0	0
Vitamin A IU	612	666
Iron (mg)	1	1
Calcium (mg)	308	359

Macaroni and cheese is served as a meal component part of the NSLP reimbursable meal therefore subject to follow federal nutritional requirements (Appendix II). As part of NSLP nutritional values are averaged over a week to report nutritional qualities of foods served. However, if macaroni and cheese were to be served as the main meal daily for one week it would be difficult to follow recommendations. Serving food with no more than 30 % calories from fat and no more than 10 % calories from saturated fat as stated in federal law has been a challenge for schools. In the original macaroni and cheese 46 %

calories are from fat. In the nutritionally modified version of macaroni and cheese, the total fat is reduced by 4 grams per serving. The reduced fat macaroni and cheese has 41 % calories from fat. Using the same serving size the original macaroni and cheese has more calories and calories from fat, total fat, saturated fat and cholesterol, and more sodium. The reduced fat macaroni and cheese has fewer servings of grain or bread alternate. Therefore to balance the menu planning of a food based system the reduced fat macaroni and cheese would require more grain or bread products during the meal or as averaged over the week.

4.5 Macaroni and cheese color

Results of the color analysis for original and reduced fat macaroni and cheese are presented in Table 9 and Figure 8 as L (lightness), a* (green to redness), and b* (blue to yellowness) values for the surface color of selected samples. Figure 9 and 10 show a sample of the reduced fat and original macaroni and cheese surface color.

Table 9. The average L, a*, b* color values for surface color of original and reduced fat macaroni and cheese at 120 ° F.

	L	a*	b*
Original Macaroni and Cheese	162.35	140.05	192.99
Reduced fat Macaroni and Cheese	156.22	141.28	191.92

Figure 8. The average L, a*, b* color values for surface color of original and reduced fat macaroni and cheese at 120 ° F.

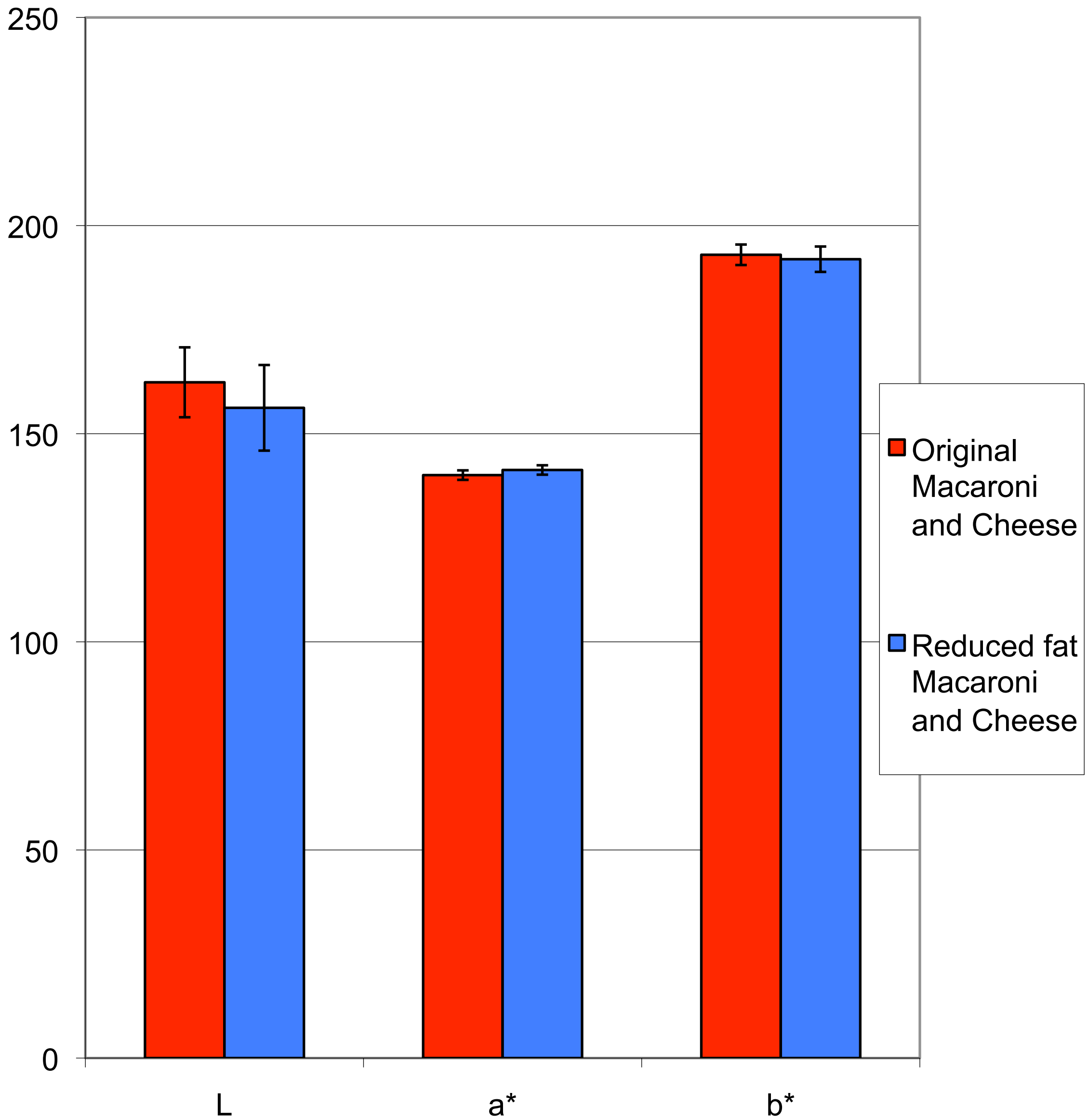


Figure 9. Surface color of Reduced Fat Macaroni and Cheese at 120 ˚ F.

Figure 10. Surface color of Original Macaroni and Cheese at 120 ˚ F.

Reduced fat macaroni and cheese revealed a trend of darker color (Table 9 and Figure 8) than original with values of L 156.22 +/- 10.29 and L 161.52 +/- 8.05 respectively. However, no significant differences for L a* and b* were discovered. Lower fat content is most likely the contributing factor to a less white or darker color since fat is known to cause opacity and whiteness. The cheese sauce ingredients were the similar for the two products, however the variation of reduced fat had more modified food starch, which does not contribute greatly to the color.

4.6 Macaroni and cheese texture

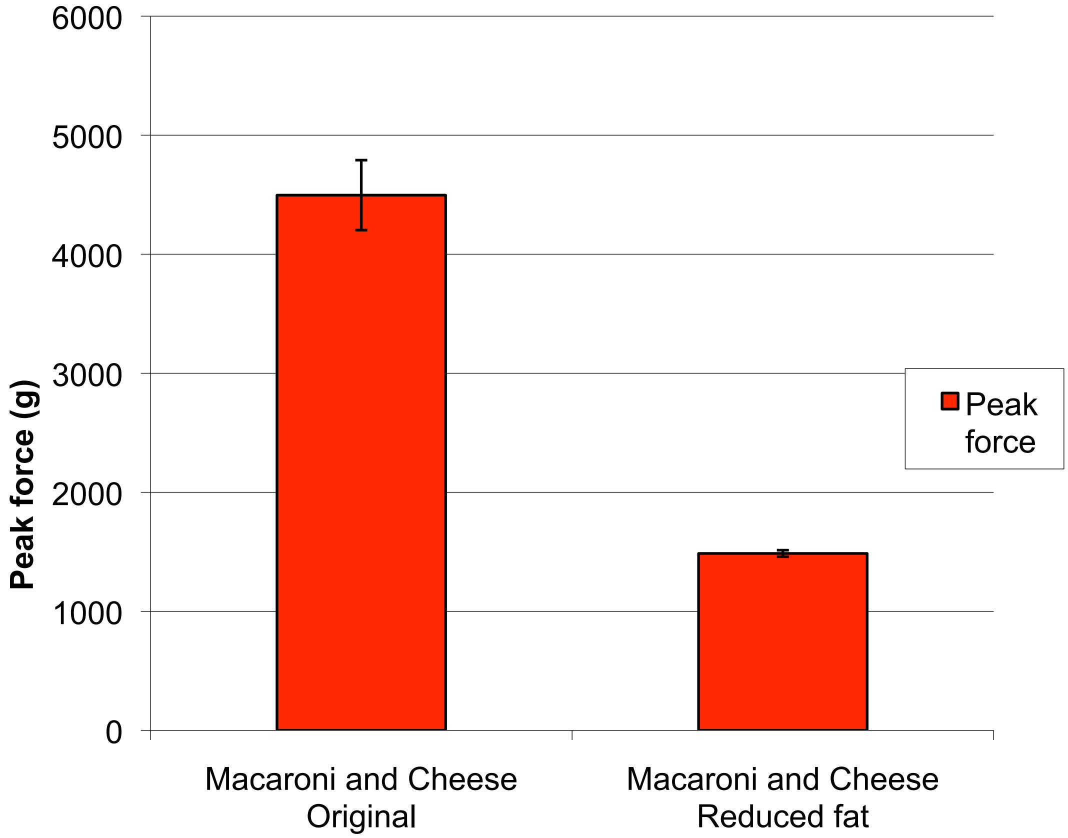
The results of hardness and stickiness for original and reduced fat macaroni and cheese are shown in Table 10. In Figure 11 the difference of hardness for original and reduced fat macaroni and cheese is given by average peak force.

Table 10. Average peak force in grams as a measure of hardness and average gram per second as a measure of stickiness for original and reduced fat macaroni and cheese at 120 ° F.

	Peak force	Standard error	Stickiness	Standard error
Macaroni and Cheese Original	4496.33a	294.04	3311.40	524.69
Macaroni and Cheese Reduced fat	1486.21	27.314	2807.07	164.35

Change in letter indicates significance at ($p < 0.05$)

Figure 11. Average peak force in grams as a measure of hardness for original and reduced fat macaroni and cheese at 120 ° F.



Macaroni and cheese texture was significantly ($p < 0.05$) firmer for original versus reduced fat measured by peak force in grams (Table 10). The reduced fat macaroni and cheese pasta was made from dry enriched multigrain using grain and legume flour blend [lentils, chickpeas, egg white, spelt, barley, flaxseed, oat fiber, oats]. When ingredients of dietary fibers, inulin, or soy protein were increased the firmness decreased (Tudorica et al., 2002, Brennan et al., 2004, Limroongreungrat and Huang, 2007). A decrease in hydration from the water holding properties of the additives could cause the reduction of starch gelatinization therefore firmness.

Stickiness measured instrumentally was not significantly different for original and reduced fat macaroni and cheese. Using ANOVA the sensory panel found no significant difference in viscosity for original compared to reduced fat macaroni and cheese, although there was a significant ($p < 0.05$) difference between first and third replicate. Samples were heated separately for each replicate and measured on different days. Pasta under frozen conditions has been found to soften from moisture migration and breakdown of starches, but heating of macaroni and cheese gels the texture of the cheese sauce and pasta therefore minimizing texture decreases from other factors (Anon, 2002). Frozen lasagna cooked did not change texture when heated and reheated suggesting the changes in texture are not corresponding just to freezing conditions (Redmond, et al. 2005).

4.7 Macaroni and cheese descriptive analysis

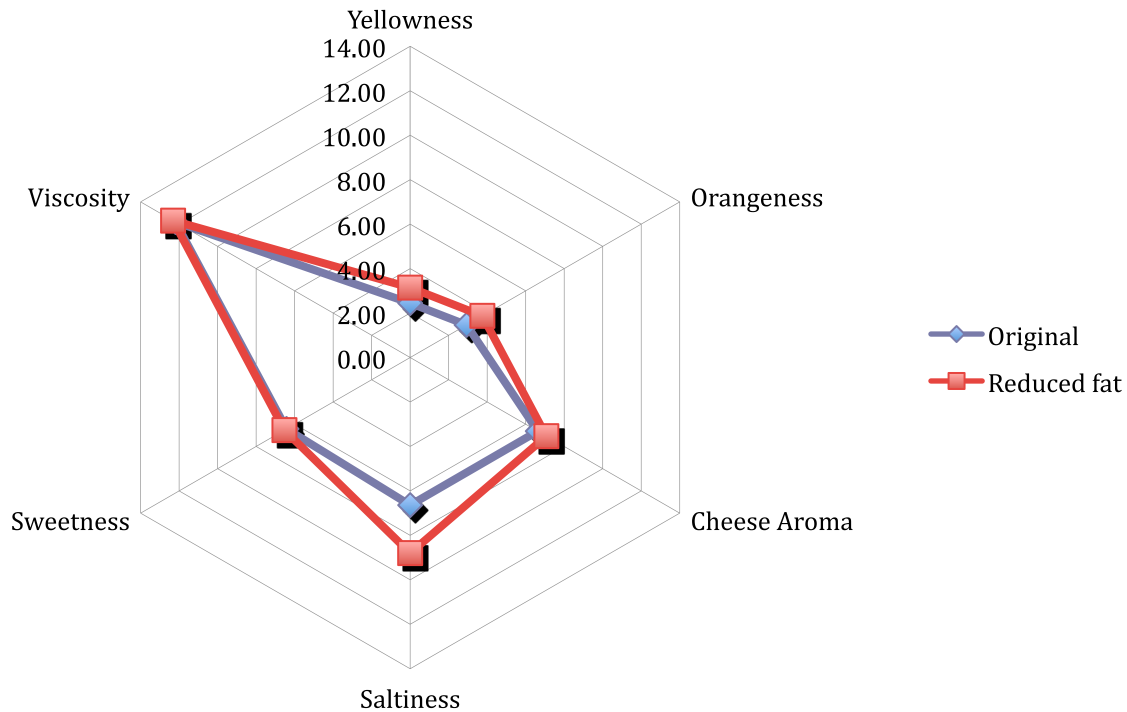
Information gathered from the panelists of the macaroni and cheese QDA panel is reported as mean values for each attribute used to describe the macaroni and cheese products. The mean values are shown in Table 11 and Figure 12.

Table 11. The mean values of each attribute measured by the QDA panel for original and reduced fat macaroni and cheese served at 120 ° F.

	Original	Reduced fat
Yellowness	2.45	3.14
Orangeness	2.93	3.75
Cheese Aroma	6.63	7.07
Saltiness	6.64	8.80a
Sweetness	6.42	6.53
Viscosity	12.19	12.31

Change in letter indicates significance at ($p < 0.05$)

Figure 12. The mean values of each attribute measured by the QDA panel for original and reduced fat macaroni and cheese served at 120 ° F.



Macaroni and cheese sensory panel using ANOVA found the reduced fat macaroni and cheese to be significantly ($p < 0.05$) saltier than original. The nutritional information (Table 8) shows the macaroni and cheese original had more sodium. It might be the water from the cheese sauce was released through synerisis. The salt could have concentrated in the areas of the sauce with less water. Also, food modified food starch added in the ingredients of the reduced fat macaroni and cheese could help lessen synerisis. In the sensory data a trend was found that reduced fat macaroni and cheese was rated darker yellow and orange. However, the sensory data in Table 11 using ANOVA was found to be not significantly different for all other attributes besides saltiness.

4.8 Pierogie nutritional quality

The results of the nutritional analysis are shown in Table 12 as the "nutrition facts" from the manufacturer's label and Silliker nutrition analysis.

Table 12. Nutritional information for original and high protein pierogies shown as manufacturer's label and Silliker laboratory analysis of nutrition.

	Original		High Protein	
	Label	Silliker	Label	Silliker
Serving size	146 g			
Calories	270	280	320	330
Calories from fat	70	70	100	95
Protein (g)	10	12	17	17
Fat (g)	8	8	11	11
Sat. Fat (g)	4	4	7	6
Cholesterol (mg)	30	30	50	20
Fiber (g)	2	3	2	3
Carbohydrates (g)	39	42	37	41
Sugars (g)	1	1	1	1
Sodium (mg)	710	610	840	753
Vitamin C %	10	0	8	--
Vitamin A %	2	6	--	8
Iron %	10	15	10	20
Calcium %	10	15	25	15

Pierogies are part of the NSLP reimbursable meal main entrée component subject to federal nutritional requirements. The percentage of calories from fat is 26 % for original and 31 % for high protein pierogies. The original pierogies have less calories, fat, cholesterol, and sodium, and more vitamin C and A, however less protein and calcium. High protein pierogies have seven more grams protein per serving resulting in a higher meat alternate equivalent than the original.

4.9 Pierogie color

The original and high protein pierogies' surface color was evaluated after pierogies were boiled as prepared by manufacturer's directions. Shown in Table 13, Figure 13, and pictures of each variety in Figure 14 and 15 are the results and example of each products' surface color.

Table 13. The average L, a*, b* values for surface color of cooked high protein and original pierogies.

	L	Standard error	a*	Standard error	b*	Standard error
High Protein	59.14a	1.63	2.07a	0.08	14.98a	0.31
Original	72.58	0.62	0.61	0.03	11.32	0.28

Change in letter indicates significance at ($p < 0.05$)

Figure 13. The average L, a*, b* values for surface color of cooked high protein and original pierogies.

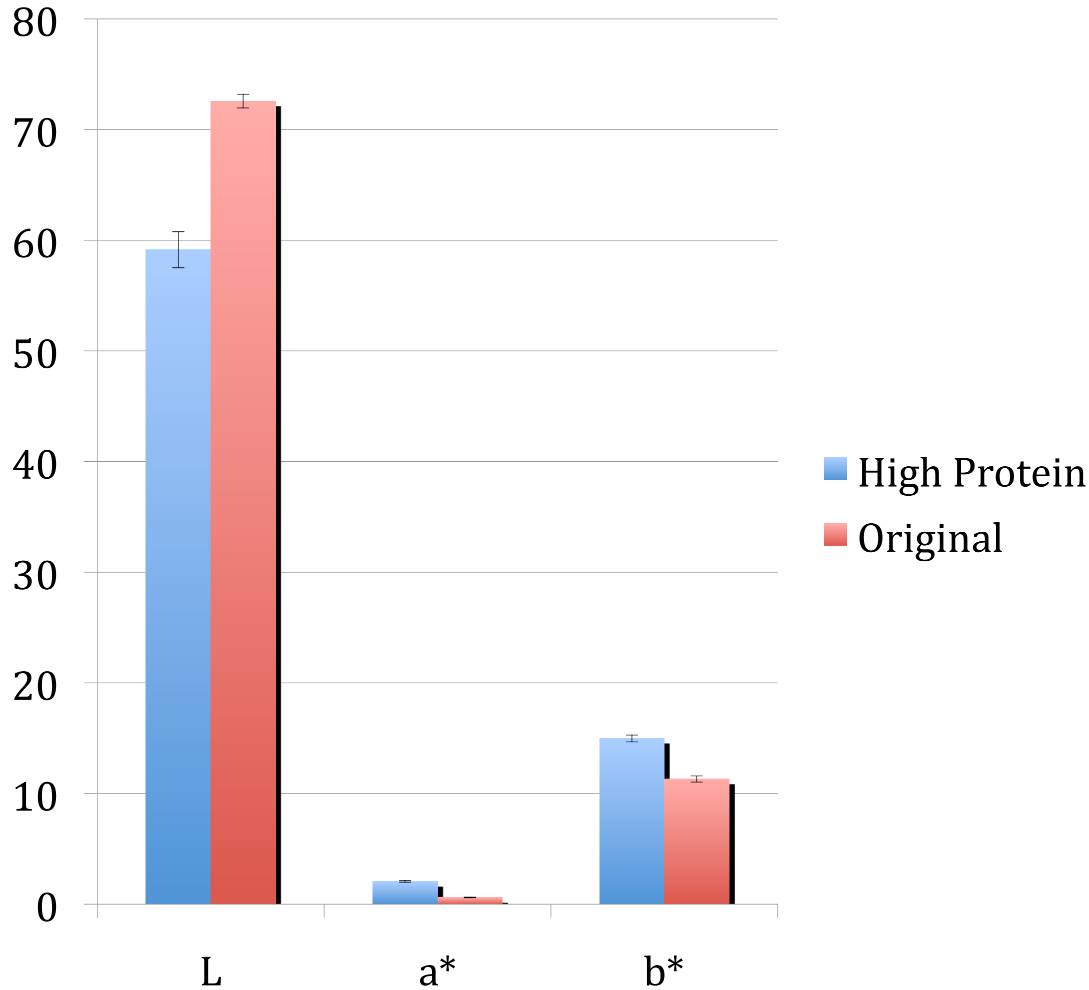


Table 14. The b* (yellowness) values of surface color and QDA panel mean rating of yellowness for cooked high protein and original pierogies.

	b*	Dark yellow mean score
High Protein	14.97	3.83
Original	11.31	1.85

Figure 14. Surface color of cooked original pierogie.

Figure 15. Surface color of cooked high protein pierogie.

High protein pierogies were significantly ($p < 0.05$) darker, more red and yellow than original (Table 13). The added protein for the pierogies could be from added cheese or whey protein as seen on the label of ingredients. More cheese would result in a more yellow and red color and whey protein could result in a darker color.

5.0 Pierogie texture

Results of texture analysis of high protein and original pierogies are given as average maximum peak force for pasta and filling. Table 15 and Figure 16 show the pasta sealed edge firmness as the maximum peak force measured in grams for high protein and original pierogies. Table 16 and Figure 17 show the filling hardness as the maximum peak force measured in grams for high protein and original pierogies.

Table 15. Average peak force of cooked pierogie pasta sealed edge for original and high protein varieties.

	Peak force (g)
Original	47.48
High Protein	45.17

Figure 16. Average firmness of cooked pasta sealed edge of original and high protein pierogies as measured by force in grams versus time in seconds.

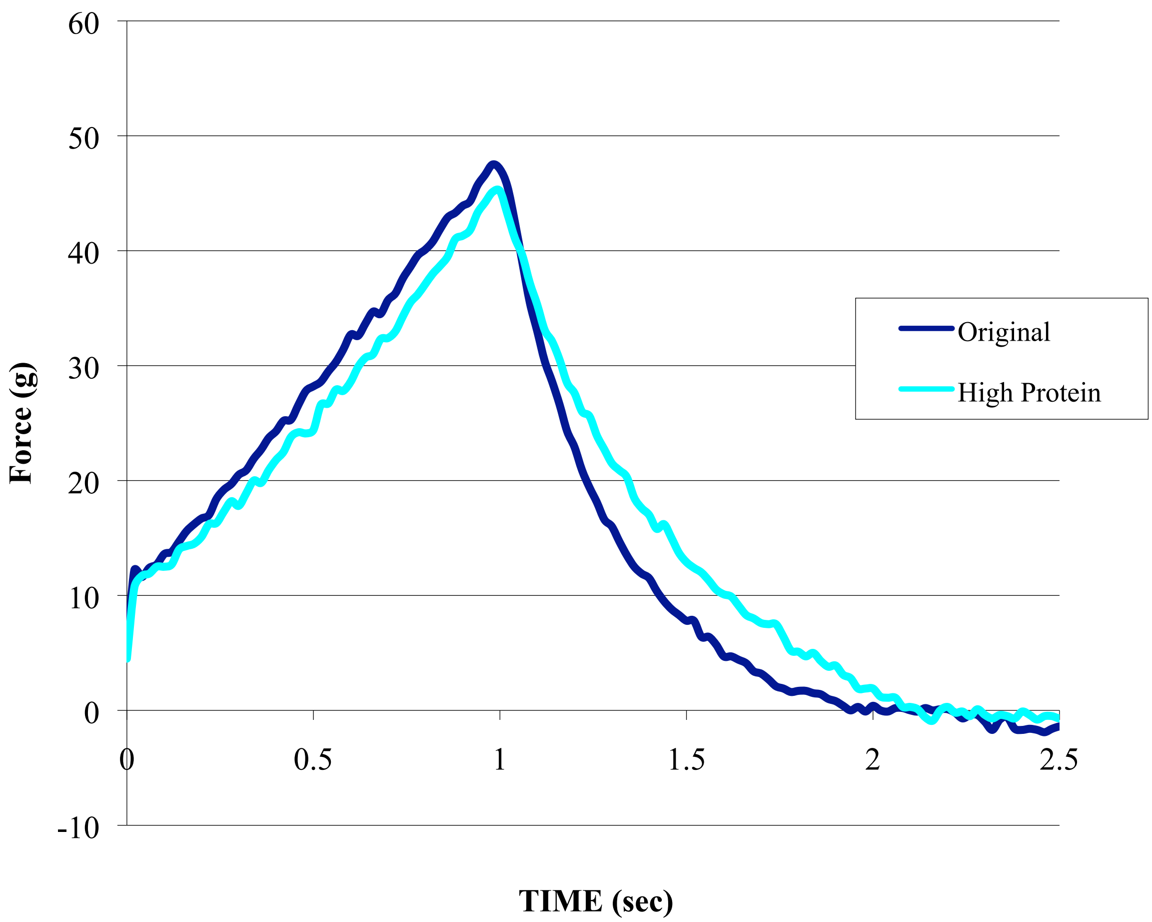
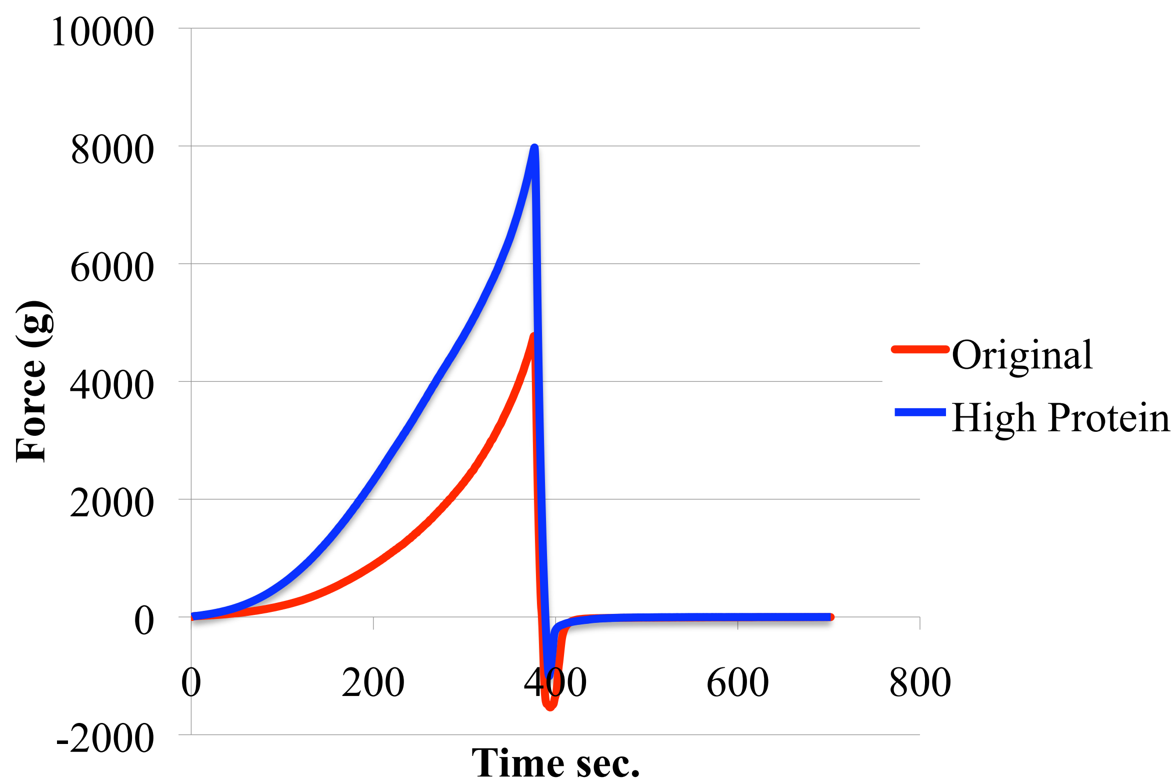


Table 16. Average maximum peak force in grams measuring firmness of filling for cooked original and high protein pierogies.

	Peak force (g)
Original	4770.56
High Protein	7968.9a

Change in letter indicates significance at ($p < 0.05$)

Figure 17. Average firmness of cooked original and high protein pierogie filling as measured by force in grams versus time in seconds.



Pierogies texture was measured by the peak force in grams for determination of the pasta firmness showing the high protein pierogies were not significantly different. However, instrumental measurements found the pierogie filling was significantly ($p < 0.05$) firmer for the high protein pierogie than the original as measured by peak force in grams (Table 16**).** Instrumentally, the original filling was found to be significantly ($p < 0.05$) stickier than the high protein filling (3753.50 and 1458.05 grams second respectively). The ingredients of the pierogies differ mainly with the ingredients of the original pierogies having margarine, while the high protein did not. High protein pierogies also contained whey protein and cheese more than original pierogies. The higher fat content of the high protein pierogies without the margarine could be from the cheese, which would also contribute, to the cholesterol, sodium, and protein. Texture of the filling with cheese and whey protein increasing in hardness was in agreement with Peksa et al. (2002). More protein contributing much more to cooked mashed potato hardness than dry matter from potato powder, which was low in protein (Peksa et al. 2002) The addition of cheese and whey protein with no margarine could also contribute to the grainy texture and less stickiness found instrumentally. In the parameters of this study it is inconclusive if the filling was stickier for original although a trend was shown for the original filling to be stickier by sensory analysis, which is in agreement with instrumental results.

5.1 Pierogie descriptive analysis

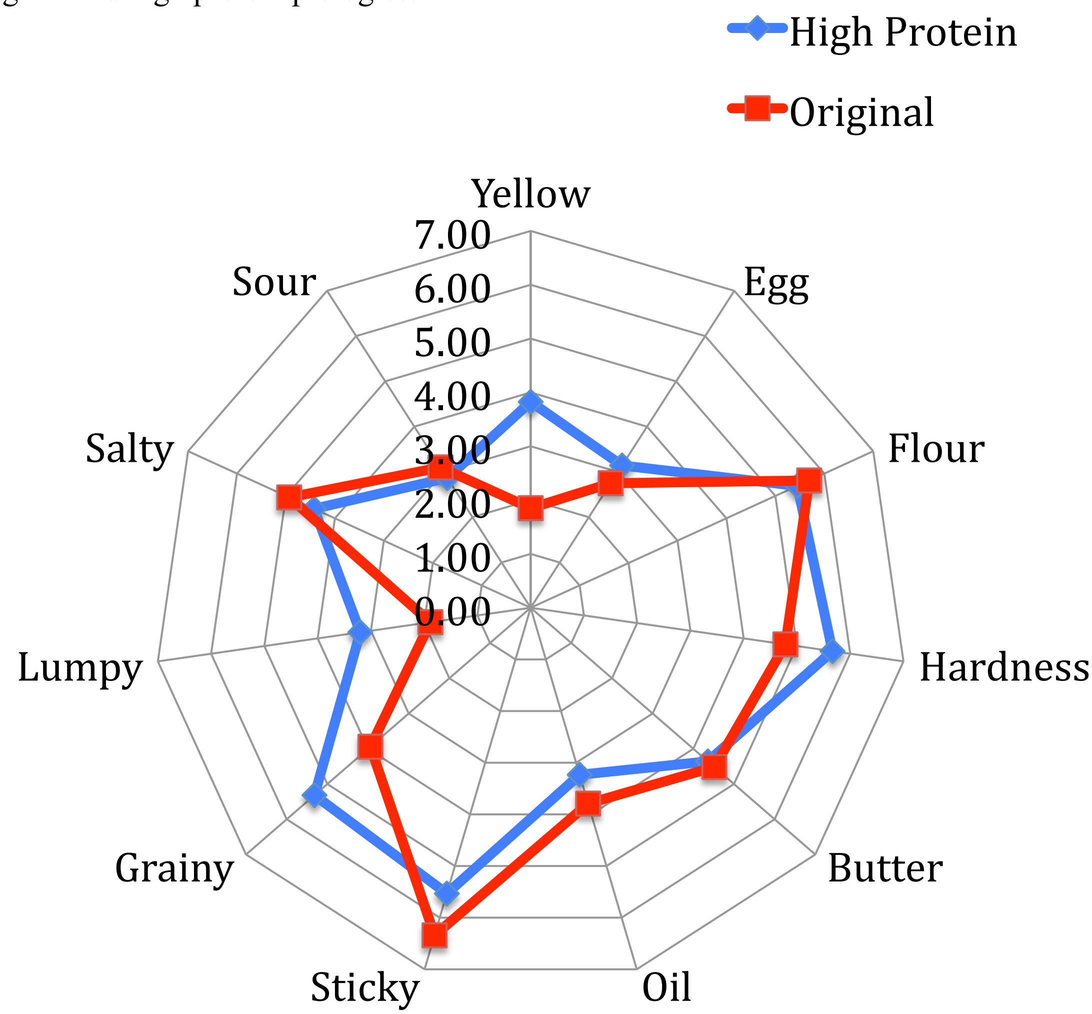
The results of the pierogie QDA panel evaluation of the attributes in Table 1 used to describe the original and high protein pierogies are reported in Table 17 and Figure 18 as the mean value.

Table 17. The mean values of each attribute measured by the QDA panel for cooked original and high protein pierogies.

	High Protein	Original
Yellow	3.83a	1.85
Egg	3.14	2.75
Flour	5.45	5.69
Hardness	5.67a	4.78
Butter	4.36	4.52
Oil	3.23	3.79
Sticky	5.53	6.34
Grainy	5.32a	3.94
Lumpy	3.20	1.88
Salty	4.43	4.93
Sour	2.87	3.10

Change in letter indicates significance at ($p < 0.05$)

Figure 18. The mean values of each attribute measured by the QDA panel for cooked original and high protein pierogies.



Using ANOVA, the sensory panel found the high protein pierogies to be significantly ($p < 0.05$) darker yellow than the traditional. The instrumental yellowness (b*) correlated to yellowness evaluated by sensory panel scores (Table 18) with $R^2 = 1$. Using ANOVA, the sensory panel data measured the high protein pierogies' pasta as significantly ($p < 0.05$) harder than the original pierogies. The firmness of the pasta was inconclusive, as the differences between sensory and instrumental analysis may not agree. Filling from the sensory panel (Table 17) showed the high protein pierogies' filling to be significantly ($p < 0.05$) grainier, but not sticky or lumpy using ANOVA. Pierogies sensory panel using ANOVA and the descriptors in Table 1 resulted in a significant ($p < 0.05$) butter aroma product replicate interaction, oil aroma replicate difference, and no significant differences for saltiness and sourness. The original pierogies have margarine and the high protein pierogies do not which may explain differences in butter aroma and oil although the characteristics are not described as margarine and therefore unidentified by the panel.

5.2 Apple nutritional quality

Nutritional information on apple snacks is shown in Table 18 as the manufacturer's label "nutrition facts".

Table 18. Nutrition facts of apple snacks air-dried and freeze dried.

Apple Snacks	Air dried	Freeze dried
Serving size	40 g	
Calories	120	146
Calories from fat	--	--
Protein (g)	1	--
Fat (g)	--	--
Sat. Fat (g)	--	--
Cholesterol (mg)	--	--
Fiber (g)	3	4
Carbohydrates (g)	30	37
Sugars (g)	22	25
Sodium (mg)	--	55
Vitamin C %	2	--
Vitamin A %	--	--
Iron %	4	--
Calcium %	--	--

Apple snacks are outside of the NSLP served as a competitive food. Both the freeze-dried and air dried apple products are contain no fat, therefore complying with the NJ Model Nutrition Policy for all age groups. Comparisons of improved nutrition are justified for the freeze-dried apples based on the contents of the seasoning incorporated with lactoferrin. Although seasoned with cinnamon sugar resulting in more calories, carbohydrates, and sodium, the nutritional benefits come from lactoferrin.

5.3 Apple color

The results of the apple snack color analysis are shown in Table 19 and Figure 19 as the L, a*, b* values for dried and freeze dried apples. Figure 20 and 21 show a sample of the air-dried and freeze dried apple snacks surface color.

Table 19. Average values of L, a*, b* color for dried and freeze dried apple snacks.

Averages	L	Standard error	a*	Standard error	b*	Standard error
Dried	145.73	6.06	144.25	1.44	186.10	1.86
Freeze Dried	170.13a	6.09	137.71a	1.41	184.69	1.86

Change in letter indicates significance at ($p < 0.05$)

Figure 19. Average values of L, a*, b* color for dried and freeze dried snacks.

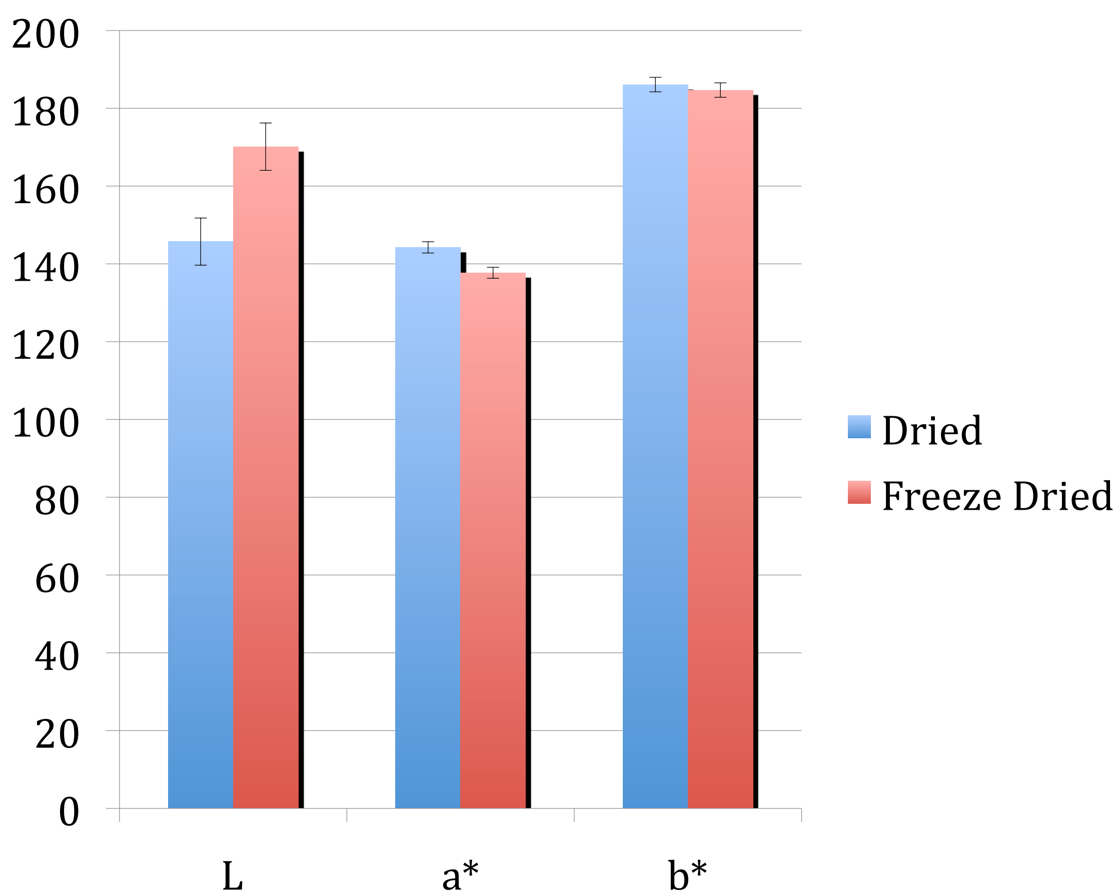
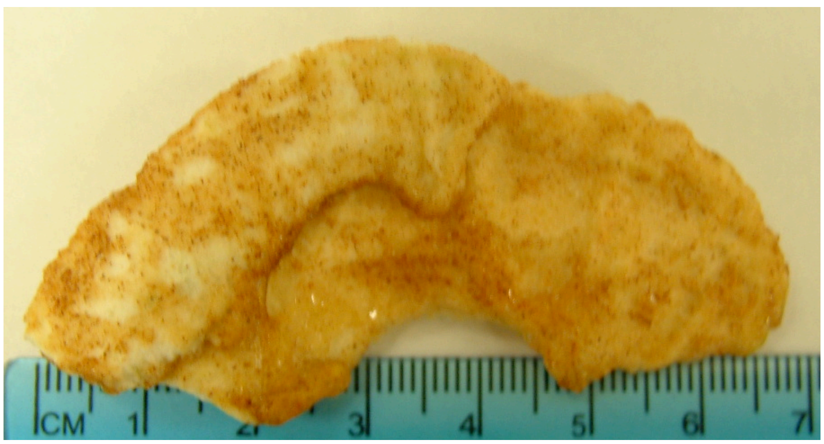


Figure 20. Surface color of dried apple snack at room temperature.

Figure 21. Surface color of freeze-dried apple snack at room temperature.



The instrumental color analysis showed the freeze dried apple snacks were significantly ($p < 0.05$) lighter and less red but not significantly different for yellowness (Table 19). Air-dried is significantly ($p < 0.05$) browner than the freeze-dried apples with browning index values 393.96 and 292.68 respectively. The browning of the air-dried apples comes from polyphenoloxidase (PPO) reaction that occurs with no sulfur added. The process of freeze-drying inactivates the polyphenoloxidase and starts out whiter like a fresh cut apple. Brown color of the freeze dried apples comes from the cinnamon.

5.4 Apple texture

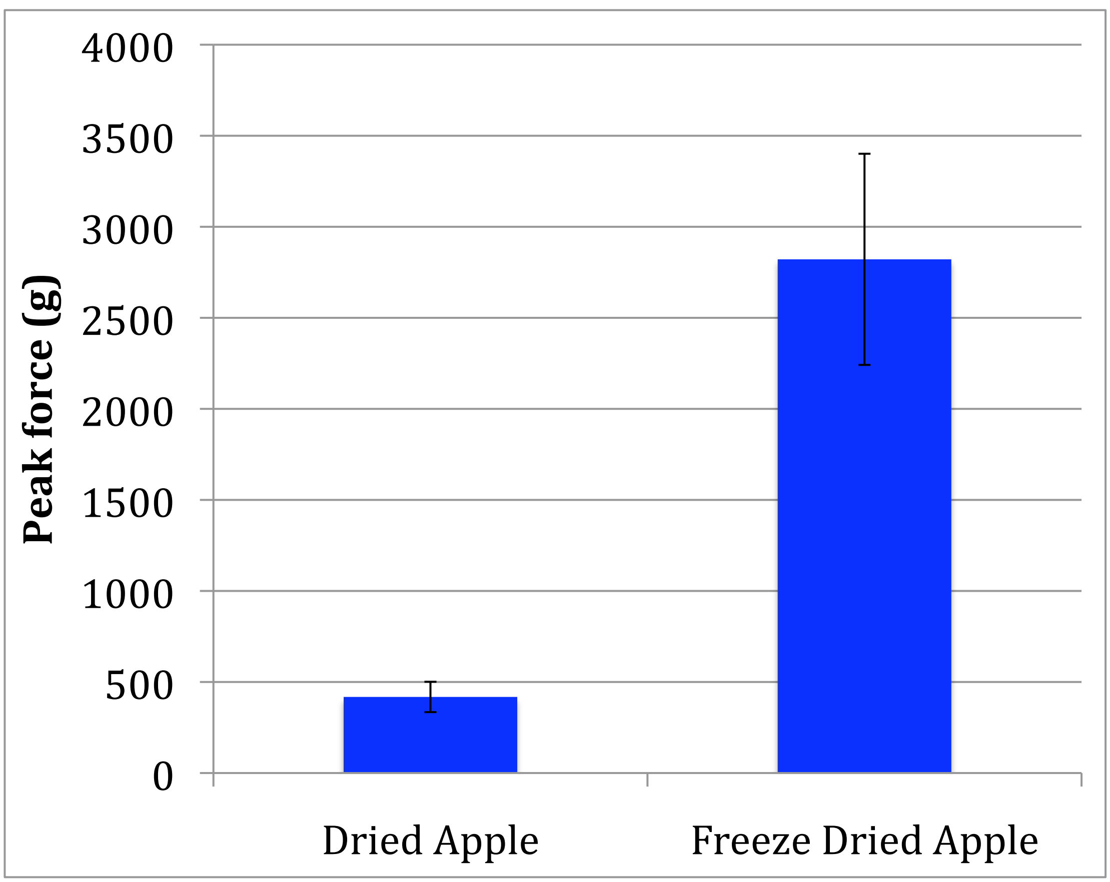
Textures of the apple snacks are reported in Table 20 and Figure 22 as the firmness of the apple pieces using puncture test to find the maximum peak force for each variety air-dried and freeze dried respectively.

Table 20. Average maximum peak forces of apples snacks air-dried and freeze dried

	Peak force (g)	Standard error
Dried Apple	417.91	83.35
Freeze Dried Apple	2821.24a	579.90

Change in letter indicates significance at ($p < 0.05$)

Figure 22. Average maximum peak forces of apples snacks air-dried and freeze dried.



Hardness measured instrumentally by peak force in grams determined air-dried apple snacks are softer than freeze dried with a large significant ($p < 0.05$) difference (Table 20). Also, freeze dried apples were significantly ($p < 0.05$) more brittle than air-dried apples measured by gradient of the force time graph 2227.41 and 277.74 grams per second respectively. The freeze-dried apples showed more fracturability with more peaks, which could be explained by the rough surface texture. In previous studies of hardness, freeze-dried Fuji apples had a more fragile structure and lower hardness than air-dried samples (Deng et al. 2008). In the Deng et. al (2008) study the air-dried become shrunken and tough. Although freeze-drying increases the shape and size of pores from ice sublimation retaining most of its original shape and making it less hard, the hardness was increased by other factors in this study. Since the freeze-dried apples were coated with sugar seasoning, the sugarcoated surface increased the peak force hardness. Additionally, the air-dried apples were not shrunken but at a higher moisture content than the freeze-dried leading to a considerably less brittle even soft bendable texture.

5.5 Apple descriptive analysis

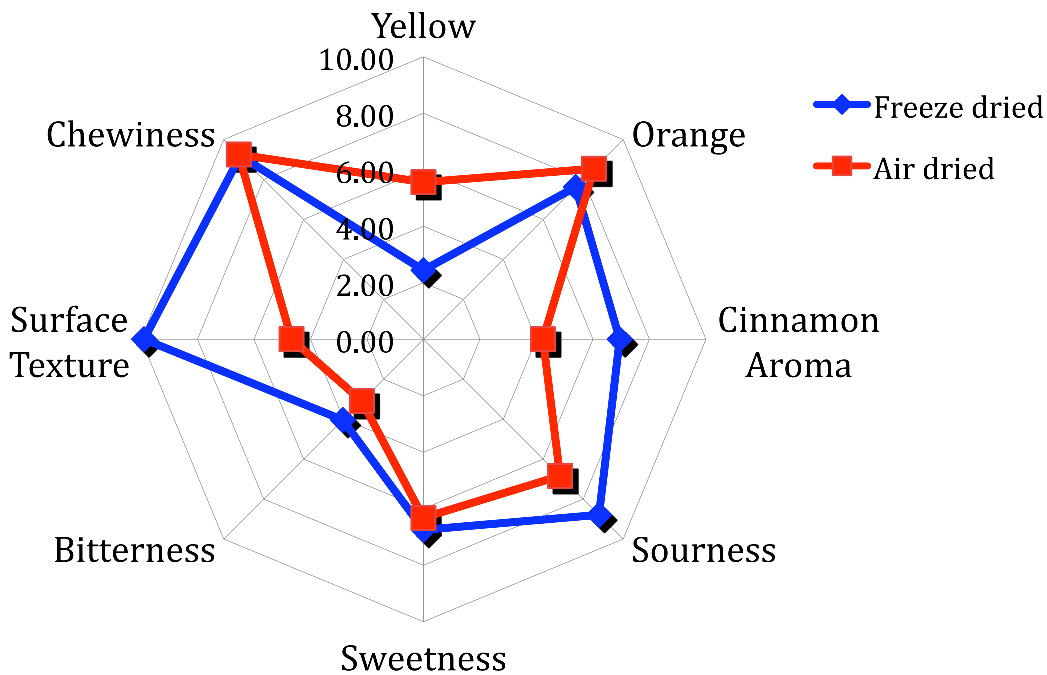
The results of the apple snack QDA panel evaluation of the attributes in Table 1 that are used to describe the air-dried and freeze dried apple snacks are reported in Table 21 and Figure 23 as the mean value.

Table 21. The apple snack QDA panel reported mean value of each attribute used to describe the air-dried and freeze-dried apple snacks

	Freeze dried	Air dried
Yellow	2.45a	5.56
Orange	7.62	8.54
Cinnamon Aroma	6.95a	4.23
Sourness	8.79a	6.84
Sweetness	6.75	6.32
Bitterness	4.04a	3.09
Surface Texture	9.89a	4.67
Chewiness	9.17	9.25

Change in letter indicates significance at ($p < 0.05$)

Figure 23. The apple snack QDA panel mean value of each attribute used to describe the air-dried and freeze-dried apple snacks



Using ANOVA, the sensory panel found the air-dried apples were significantly ($p < 0.05$) darker yellow than freeze dried. Instrumental b* (yellowness) are correlated to sensory panel yellowness scores $R^2 = 1$. Apples snacks using ANOVA found the surface texture was significantly ($p < 0.05$) rougher for the freeze-dried apples. No significant differences in chewiness resulted between the two apple products from the sensory panel (Table 21). Using the descriptors in Table 5 and ANOVA the apple sensory panel found the freeze-dried apples significantly ($p < 0.05$) more cinnamon in aroma, more sourness, and more bitterness than air-dried apple snacks (Table 21). The cinnamon aroma differences are logical since freeze-dried apples were seasoned with cinnamon and the air-dried apples were not. Additionally, the seasoning contains lactoferrin, which could contribute to the flavor of the apples, however used commercially topically on beef products and considered GRAS by the FDA; manufacturers using lactoferrin claimed no affect on taste. Yet, a sensory study on natural frankfurter casings with 2.5% and 5.0% whey protein peptides found the addition cause more bitter, sour and off-flavors than control (Muench et al. 2008). Apples freeze-dried could be more sourness and bitterness on their own without affect of lactoferrin therefore it is not conclusive.

5.6 Conclusions

All products showed differences in characterization, as each is a different product with unique attributes. Chicken nuggets with whole grains had the most calories, protein sodium and carbohydrates but the least fat according to the label. The whole grain coating was brown but not unlike other varieties of chicken nuggets in texture and taste. The macaroni and cheese reduced in total fat by four grams per serving was less fat, calories, and sodium though not significantly changed in color. The texture of the reduced macaroni and cheese was much softer and sensory data indicated saltier. The high protein pierogies with seven more grams of protein had a significantly difference in yellowness, filling hardness, graininess, and stickiness, but not a big difference in flavor. Comparatively air-dried apples were significantly browner, softer, and less brittle than freeze-dried apples. The freeze-dried apples had significantly more cinnamon aroma, sourness and bitterness. Product quality was not diminished for any products.

The increased nutrition did not change the safety or convenience of the products' preparation and each is readily available for school use. The manufacturer decides how each product will be priced therefore quality characteristics will depend on the aesthetics and nutrition. Since chicken nugget texture changed consumers will be able to decide whether they prefer softer or harder chicken texture. If whole grain nuggets are chosen for nutrition, it is important to realize the calories and sodium increased. Often when fat is reduced sugar is increased as was found by Dwyer et al. (2003) but the trade off is the sugar is coming from a high micronutrient dense ingredient like whole grains. Similarly, macaroni and cheese was reduced in fat and substituted with modified food starch. While still a relatively high fat product it did not change with much noticeable differences as long as the texture of the pasta is acceptable and freezing storage as well as heating is carefully managed. Contrasting, the pierogies changed greatly by additionally protein therefore while called the high protein version of the same product, it seems entirely new in color, texture, and sensory characteristics. Apple snacks with lactoferrin and sugar cinnamon seasoning were also an entirely different product. Therefore, its acceptability would depend on the texture and taste preferences of the consumer.

Product characteristics are important to the food manufacturer for detailed information about their product line. The description, ingredients, nutritional value, appearance, taste, aroma, texture, price and convenience are important to the schools that buy the products from manufacturers. The goal of the manufacturer is to sell their products. The knowledge provided in this research helps manufacturers to have an overall view of their products' characteristics that make the products attractive to schools and eventually students.

5.8 Suggestions for future work

Product quality was assessed from an expert trained panel. The characteristics identified by the panel may not correlate to the consumers' opinions. To judge the liking or preference of the school food products would be the next step to determine what product would be most accepted by school children. A study of each product compared by rating on a hedonic scale should be conducted to understand the acceptance of the products by school children.

APPENDIX I

1.0 Prevalence of obesity in the United States

Over nine million American 6 to 19 year olds are overweight.[1] The American Obesity Association (AOA) (2008) found older children 12 to 19 years old to be 30.4 % overweight and 15.5 % obese[2]. Additionally, a self-reporting nationwide 2004 Youth Risk Behavior Surveillance survey showed 15.4 % of students in 9th through 12th grade at risk for becoming overweight (Grunbaum, et al. 2004). Unfortunately, the trend of childhood obesity continues into adulthood. Freedman et al. (2001) showed a 70 % greater chance of overweight children becoming obese as adults versus normal weight children. Whitaker et al. (1997) showed increased chances of being obese at 21 to 29 years old from 8 % to 64 % when normal versus overweight at ages 10 to 14 years old. If the overweight child has an obese parent the chances the child becomes obese increases to 79 %. Overwhelmingly the national concern of rising prevalence of childhood obesity has urged many people to address the origins of childhood obesity and find how to prevent a further increase.

1.1 Defining Childhood Obesity

Obesity is defined as "the excessive accumulation of adipose tissue to an extent that health is impaired" (Arrone et al. 2002). Body fatness stored in adipose tissue correlates to a common measurement called body mass index (BMI). Measured as the ratio of weight in kilograms to height in meters squared, BMI is widely used and easily

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[1] Overweight children are measured as the 95th percentile or above BMI varying with age and gender.
[2] Obese adults are measured as BMI 30 or higher.

attainable. The (CDC) uses national weight and height measurements to create Growth Charts for the United States. Boys and girls from ages 2 to 20 years old show a sigmoid curve of changing BMI over time. Since the amount of body fat differs between boys and girls, the percentile BMI used to measure obesity is specified for children of the same age and gender (American Academy of Pediatrics (AAP), 2003). According to (CDC), the 85th percentile BMI signifies an "at risk" overweight and the 95th percentile BMI as the more severe overweight (DASH, 2008). The (CDC) avoids using the word “obesity” when referring to children and adolescents (AOA, 2008). Alternatively, the (AOA) uses the 85th percentile of BMI as a reference point for overweight and the 95th percentile for obesity (AOA, 2008).

A limitation of BMI is it does not show the difference between fat and muscle. Obesity is most accurately measured by the body’s fat and muscle composition. Quick gain of weight during puberty, a large or small-framed body, or a body with a lot of muscle will show an inaccurate BMI. The measure of weight such as waist circumference, skin-fold thickness, and underwater weight displacement can be combined with BMI for more accurate results. More accurate measures of muscle and fat are available from advanced technology. A machine in which the entire body is encapsulated called BodPod (Life Measurement, Inc. Concord, CA) measures the body’s weight through displayed air detected by pressure sensors. Bioelectrical Impedance measures body fat by using low electrical currents that pass through the body creating a measurement for lean muscle tissue. When energy from an x-ray is absorbed into the body, the amount of bone, total body mineral mass, fat-free soft (lean) mass, and fat tissue mass can be measured by a method called Dual Energy X-ray Absorptiometry

(CDC, 2008a). The information obtained from these techniques would require a doctor or specialist to understand. However any sudden changes in children's weight gain might be a sign of obesity.

1.2 Childhood development and obesity

Children's genetics and environment result in their individual patterns of mental, physical and social development. Early infancy, early childhood, and adolescence are critical for identifying obesity according to the British Nutrition Foundation Task Force on Obesity (BNTF), (1999). Breast-feeding or formula feeding influences early infancy weight gain. Several studies indicate that the risk of obesity later in childhood is inversely associated with the more consistent breastfeeding of the infant (Agras et al. 1990, von Kries et al. 1999, Gilman et al. 2001 and Hediger et al. 2001). The American Academy of Pediatrics (AAP) (2005) recommends, "Breastfeeding should be continued for at least the first year of life and beyond for as long as mutually desired by mother and child". The (AAP) (2005) found only 18 % of babies were exclusively breastfed for the first year. Infants' health is benefited from breast milk because all nutritional needs can be provided for development. Breast milk is easily digestible and less nutrient dense than formula. Infants' immune system develops by the many antibacterial and immunoglobulin proteins found in breast milk, which identify and deactivate pathogens and antigens (American Pregnancy Association (APA), 2008). A non-heme iron binding protein found in human milk, lactoferrin contributes to the immune system defense by having bacteriostatic, anti-viral, anti-fungal and anti-inflammatory effects. (Conneely, 2001 and Jenssen et al. 2009). Lactoferrin prevents bacteria from growing especially gram-positive bacteria by its binding of iron depriving bacteria of iron or interaction with bacteria surface (Jenssen et al. 2009). Additionally, breast milk carries flavors from the mother's diet to familiarize those foods flavors when the baby is introduced to them in the diet later on (Sullivan et al. 1993).

As infants develop their growth rate slows. Around age of two their BMI reaches a minimum called adiposity rebound. After this stage BMI increases gradually through adolescence into adulthood (Whitaker et al. 1998). Research has found the increased risk of obesity from children with an early adiposity rebound independent of high BMI and parental BMI (Dietz et al. 2001, Rolland-Carchera et al. 1984). As a result early adiposity rebound is a predictor of obesity, however the determination is made only after the event has occurred, so it is difficult to utilize. Quick increases of weight whether in early childhood and or infancy were found to be independently associated with obesity later in adolescence (Ekelund et al. 2006).

Another critical developmental stage in the growth of children is their maturation into adulthood. The timing of puberty or secondary sexual development signals for boys and girls by physical and hormonal changes in the body. On-set of puberty is commonly visually measured by physical recognition of the development of breast or gonads for girls and boys respectively. However, weight in excess or untrained physical examinations will cause error in measurement of first signs of breast development (Styne et al. 2004). Data of the initiation of puberty from the past twenty years is not easily compared to more precise current data because of various methodologies used in the studies (Styne et al. 2004, Himes et al. 2006). Early puberty or early menarche has been associated with obesity for girls (Styne et al. 2004, Adair et al. 2001, Himes et al. 2006 and Dunger et al. 2006). Although non-conclusive early secondary sexual development is being investigated to further explain its significance in relation to obesity.

1.3 Obesity linked to genetics

Variation in children's weight measured using BMI is substantiated by genetics (77 % on average) according to Perusse et al. (2000). Certain rare monogenic disorders such as Prader-Willi syndrome, Bardet-Biedl syndrome, and Cohen syndrome are associated with obesity, although more than one gene would be needed to explain how such a large number of children are obese (AAP, 2003). Families with more than one member being obese signal genetic traits may be responsible for the link of high heredity of BMI. Environmental factors affecting obesity become confounding to a study of genetics related to obesity. Therefore, the subjects with the least genetic variation and minimal environmental exposure are identical twins, which at a young age are studied to help understand gene response. Large populations are studied to select the genes in common associated with obesity. Quantitative trait locus (QTL) theory compares the whole genome of large populations to isolate sequences responsible for physiological reactions of obesity. The human obesity genome map resulted in more than 125 genes associated with obesity (Rankinen et al. 2006). A recent study of twins ages 7 and 10 year olds found the genes affecting weight at all ranges are the same that influence obesity (Haworth et al. 2008). Although genetics determine the reaction of the body, it is a complex system of responses that reveal the nature of humans and many of the genetic and environment interactions continue to be studied in relation to obesity.

1.4 Physiological obesity

Obesity and variation in body weight corresponds to how the body uses energy. The human body regulates input and output of energy to stay in homeostasis since the balance of temperature, pH, and nutrients is needed for cellular health (Smolin and Grosvenor, 2000). To maintain a balanced state the body burns energy at rest and when the body moves and or eats the rate of energy burning increases. When food is consumed the body uses it to produce energy and to balance the energy expended. If food intake is greater than needed by output energy, the food compounds proteins and carbohydrates are converted to fat and stored in adipose cells. A negative feedback control of the storage of fat will signal the brain of satiety so energy or food intake is limited. At the same time a gland called the hypothalamus regulates release of hormones and other signals to controlling the adipose or fat storage cells. Leptin, a hormone, secreted by adipose cells proportional to fat stored in the body acts on receptors of the hypothalamus to regulate energy intake by controlling neurotransmitters responsible for decreasing signals of increased appetite (Houseknecht et al. 1998). However, leptin resistance has been found in obese and overweight people from the desensitization of leptin receptors due prolonged high levels of leptin from large adipose cells. The leptin resistance causes people to not have the sensitivity of suppressing appetite. Leptin expression is stimulated by insulin resulting in a decreased insulin secretion from the pancreas and decrease effect of insulin on adipose cells. Insulin, a hormone secreted by the pancreas, released when food is eaten and the body breaks down the food into glucose for energy. The insulin keeps the body in homeostasis by regulating the blood glucose. The concentration of insulin is proportional to fat level of adipose cells. If excessive food is consumed resulting in high glucose or fat levels more insulin is released causing the insulin receptors to lose sensitivity. The receptors resistance to insulin decreases the effectiveness of lowering glucose, which leads to type 2 diabetes. Childhood obesity increases the risk of children with type 2 diabetes.

1.5 Environmental effects on obesity

Obesity results from the complex simultaneous interaction of genetic response and environmental factors. Lifestyle, physical activity, and diet impact likelihood of childhood obesity. Surroundings of family, community, and social networks directly affect child behavior. Parental low education level, poor socioeconomic status (Gutierrez-Fisac et al. 2002, Ball et al. 2003, Birch et al. 1981), and poor eating patterns (Wang et al. 2002, Galloway et al. 2005, van der Horst et al. 2007) are associated with their children's risk of obesity. Gender, race, socioeconomic status, locality, eating patterns, physical activity, sleep patterns, were all predictors for the prevalence of overweight children (Nawal-Lutfiyya et al. 2007). Consequences of overweight children can result in type 2 diabetes, hypertension, sleep apnea, low self-esteem, and depression. When children make a lifestyle change in physical activity and diet they may be able to prevent or decrease the prevalence of obesity (Dietz et al. 2001).

An increase in physical activity can help reduce weight by increasing energy output. Overweight children may need to change their behavior since many do not get enough physical activity. A 2005 national behavioral survey found 72 % of high school students were not at the recommended physical activity levels (Eaton et al. 2006). A 2003 national survey said only 28 % of adolescents participate in school physical education, which is a decrease of 14 % since 1991 (Lowry et al. 2004). Activities like playing video games, using the computer, and watching television contribute to their sedentary behavior. In a 1999 survey of adolescents in 9th through 12th grade, 43 % watched more than two hours of television each day (U.S. Department of Health and Human Services (HHS), 2000). Several studies have found a positive association between the time spent viewing television and increased prevalence of overweight children (Dietz et al. 1985, Gortmaker et al. 1996, Crespo et al. 2001). Also, television contributes to increased snacking and exposure to unhealthy food advertisements which may lead to excess calorie intake while at low metabolic rate. (Coon et al. 2002, Francis et al. 2006, Institute of Medicine (IOM) 2005, Treuth et al. 2000)

Many unhealthy choices made by children and their parents affect their health and risk of overweight. In 2000, only two percent of children met all the recommendations of the Food Guide Pyramid and 16 % did not meet any according to the U.S. Department of Agriculture (USDA) Team Nutrition (USDA, 2001). From 2003 to 2005 the number of students reported eating fruits and vegetables five or more times per day during the preceding week decreased from 22.0 % to 20.1 % respectively according to a nationwide Youth Risk Behavior Surveillance survey (Grunbaum et al. 2004, Eaton, et al. 2006). The items included in ‘fruits and vegetables’ were 100 % fruit juice, fruit, green salad, potatoes (excluding French fries, fried potatoes, or potato chips), carrots, or other vegetables. Many children instead of fruits and vegetables choose prepared and packaged foods with high sodium content. Even school foods are high in sodium. Connors et al. (2004) reviewed lunches served in a Texas lunch program finding sodium levels for all menu choices to be from 1478.9 milligrams to 1543.3 milligrams while foods offered to 7th to 12th grades had a mean for sodium of 1819 milligrams. Since the level of sodium has no federal standard for school foods, the School Nutrition Dietary Assessment Study-

II (SNDA-II) suggested using National Research Council "Diet and Health" recommendations as a guide for sodium content to average 800 milligrams or less per meal (Connor et al. 2004, Fox et al. 2001).

Unhealthy food choices can result in a lack of nutrients and excess calories. Economic Research Service (ERS) research found older children substituting milk with soft drinks resulted in more calories and less calcium, suggested as an aid in childhood obesity (Oliveira et al. 2003). The U.S. Department of Health and Human Services (HHS, 2004) reported 85 % of adolescent females do not consume enough calcium and during the last 25 years, consumption of milk, the largest source of calcium, has decreased 36 % among adolescent females (Cavadini et al. 2000). Food Assistance and Nutrition Research Report found "On average, for each one ounce reduction in milk consumption, a child consumes 4.2 ounces of soft drinks, resulting in a net gain of 31 calories and a loss of about 34 milligram of calcium" (Oliveira et al. 2003). Harnack et al. (1999) reported overall energy intake to be related positively to consumption of sweetened beverages by children and adolescents. Children studied by Cullen et al. (2002) who drank the most sweetened beverages consumed 1390 kilo-joules more per day than those who did not drink sweetened beverages. Naturally sweet 100 % fruit juice is recommended by 2005 Dietary Guidelines for Americans (DGA), however to be limited to four to six ounces per day for children 1 to 6 years of age and eight to twelve ounces for older children and no more than one third of the total fruit group (HHS, 2005). Center for Disease Control's (CDC) "School Health Policies and Programs Study 2000" found far more schools offer soft drinks, sugary and salty snacks than 100% fruit/vegetable juice, bottled water, or milk, fruit or vegetable snacks outside the National

School Lunch Program (NSLP) (DASH, 2008). Children are exposed to many sources of sugary beverages, therefore nutrition education and understanding the products becomes very important to making healthy choices.

Most overweight and obese young people have poor eating habits especially those with increased fast food consumption (Thompson et al. 2004), portion sizes, and snacking (Nicklas et al. 2001). Making the appropriate food choices can be difficult since food has become more convenient, nutritionally dense, and good tasting (USDA, 2008). When price determines the purchase, larger sizes are found to be almost always cheaper than smaller sized packaged foods compared ounce to ounce (USDA, 2008). When nutrition labels are consulted, the portion size can lead to misunderstandings, since packages are not always one serving. Also, translating the nutrition labels using the Food & Drug Administration (FDA) baseline can be confusing to change to the United States Department of Agriculture (USDA) portion sizes of the Food Guide Pyramid (USDA, 2008). In many cases, the reference has changed in portion sizes. Bagels, muffins, cooked pasta, and chocolate chip cookies available are much larger than the portion size referenced in federal regulations for the FDA and USDA (USDA, 2008).

Food portions given to a child in early development form the food intake pattern used later on in life. At two years old, children develop the cognitive ability to make judgment of acceptability for certain foods (McConahy et al. 2002). In pre-school age children's consumption McConahy et al. (2004) found portion size alone accounted for 17 % to 19 % of the variance in energy intake, whereas body weight predicted only 4 %. The energy intake from food for children 12 to 18 months of age according to McConahy et al. (2002) was primarily the size of portions they eat rather than by the number of times they eat. Mrdjenovic et al. (2005) claims “the major determinant of energy intake in children appears to be the amount served to them by their caregivers”

1.6 Programs to address childhood obesity

Having information and resources available to the children, parents, and the community can begin to change children with poor nutrition and lack of physical activity. In schools many children and adolescents get their food and nutritional education by participating in the USDA’s National School Lunch Program (NSLP), School Breakfast Program, Summer Food Service Program, Child and Adult Care Food Program, Expanded Food and Nutrition Education Program and Special Milk Program. Coinciding with these programs in school is a state-based Local Wellness Policy that “at minimum includes goals for nutrition education, physical activity and other school-based programs to promote wellness, nutritional guidelines, guidelines for reimbursable meals not less restrictive than regulations of federal law, and community involvement.” (General Accounting Office (GAO), 2003).

Further help was needed to reach the nutritional education goals of the NSLP; therefore through a collaborative effort Team Nutrition was created (USDA, 2008; GAO, 2003). The initial step taken was the “Changing the Scene - Improving the School Nutrition Environment” tool kit that addressed the entire school nutrition environment from a commitment to nutrition and physical activity through “pleasant eating experiences, quality school meals, other healthy food options, nutrition education and marketing the issue to the public” (USDA, 2008). Second was “Getting It Started and Keeping It Going” a "how-to" guide for Team Nutrition School Leaders. Lastly, “Making

It Happen! School Nutrition Success Stories" gave guidance to students and the community in buying and consuming healthful foods and beverages, and schools making money from selling healthful options (USDA, 2008). Additionally, the USDA publishes nutritional resources for public education in formats of the Food Guide Pyramid at mypyramid.com and Dietary Guidelines, which are used by the schools to reference for the nutrition requirements of the school programs. Although, Dr. Paul Lachance, Professor Emeritus Rutgers University Department of Food Science, recommends a revised Food Guide Pyramid that is a food guide accounting for food groups to be at least two-thirds plant sourced, have nutrient content of foods and activity level of the person considered in the diet (Lachance, 2003). Along with the use of a food guide, Dr. Paul Lachance emphasizes the need for "classroom programs to help the young learn how to eat according to the pyramid" (Lachance, 2003).

Creating more innovative programs improves the nutrition education of students according to the Institute of Medicine (IOM) (2005). More recently, the creative approach to provide resource materials and interactive tools for parents, educators, and children, such as USDA's "Eat Smart. Play Hard", CDC's Division of Adolescent and School Health (DASH) and Healthy Youth's VERB, Kids Walk to School, Body and Mind (BAM), Powerful Bones, Powerful Girls and Fruit and Veggiesmatter.gov address physical activity, healthy lifestyle and diet (CDC, 2008). Furthermore, collaborative efforts of the (American Dietetics Association) ADA, CDC, USDA, National Institutes Health (NIH), International Life Science Institute, established Healthy Weight for Kids Initiative in 2001, which continues to spearhead parental, school and community-linked programs such as "Action for healthy kids" (ADA, 2008)

Programs with nutrition and physical activity as the focus have been attempted in many different capacities in and outside the school setting. Approaches to the intervention and prevention of childhood obesity are varied considering individual, family, school, or community-based programs. Resources vary broadly depending on dietary counseling, nutrition education, physical activity education, sedentary education, behavior counseling, family/parent training and involvement, physical activity environment, and school food environment. In many of the cases improvements are made to the environment. Yet, a measurable significant change in obesity must be found to rate the success of the children in the programs. Overweight interventions with multicomponent family interactions through nutrition education and physical activity have the best results for children ages 5 to 12 years old (ADA, 2006a) Multicomponent school based programs worked best for adolescences ages 12 to 19 years old (ADA, 2006a). Participation in the school food programs helped girls with food insecurities decrease their risk of overweight and all children by having no association with obesity (Linz et al. 2005, Hofferth et al. 2005, Jones et al. 2003).

APPENDIX II

1.0 National School Lunch Program

The National School Lunch Program (NSLP) started in 1946 after a health investigation found connections between physical deficiencies and childhood malnutrition (Gunderson, 1971). The National School Lunch Act was enacted as a

> "measure of national security, to safeguard the health and well-being of the Nation's children and to encourage the domestic consumption of nutritious agricultural commodities and other food, by assisting the States, through grants-in aid and other means, in providing an adequate supply of food and other facilities f or the establishment, maintenance, operation and expansion of nonprofit school lunch programs" (Gunderson, 1971).

Through agreement with the State education agency, the program provided lunches meeting minimum nutritional requirements set by the Secretary of Agriculture. In the beginning meals of the Type A meal pattern were set to meet one third to one half of the minimum daily nutritional requirements of a child 10 to 12 years of age and adjusted for different ages (Gunderson, 1971). The program has grown by changes in nutrition, acceptability, cost, availability and other factors to what it is today (Gunderson, 1971).

1.1 Nutrition requirements for the National School Lunch Program

The NSLP in school year 2007 served 5,071.8 million lunches to a total of 30.5 million participating students (National School Lunch Annual Summary NSLAS, 2008). The school lunches are federally required by Code of Federal Regulations (7 CFR Part 210.10) to meet one third of the Recommended Daily Allowances (RDA) for protein, calcium, iron, vitamin A and vitamin C in the appropriate levels for the ages/grades and be consistent with the most current Dietary Guidelines of America (DGA) (2005), which are updated every five years (NSLP, 2005). The current NSLP lunchtime energy allowances (calories) in the appropriate levels recommended are referenced by the 1989 DGA (Hirschman, 2006). The requirements of the NSLP also currently come from the 1995 DGA:

> (i) Eat a variety of foods; (ii) Limit total fat to 30 percent of total calories; (iii) Limit saturated fat to less than 10 percent of total calories; (iv) Choose a diet low in cholesterol; (v) Choose a diet with plenty of grain products, vegetables, and fruits; and (vi) Choose a diet moderate in salt and sodium (Hirschman, 2006).

Using these guidelines, federal law requires lunch meals to limit percent total calories from fat to 30 % and saturated fat to less than 10 % but still meet the total calories, protein, calcium, iron, vitamin A and vitamin C levels for the age group served. The nutritional values are calculated and reported on a weekly average of reimbursable meals offered (NSLP, 2005). The NSLP funds schools for each lunch based on a reimbursable lunch which must include an entrée and fluid milk as a beverage to create a meal of at least three menu items. An entrée is a combination of foods or is a single food item offered as the main course. An entrée can also be offered as part of a menu item in a reimbursable lunch.

Foods of Minimal Nutritional Value (FMNV) are not included in the nutrient analysis as part of the NSLP. FMNV are foods with less than five percent of the Reference Daily Intakes (RDI) for each specified nutrient protein, vitamin A, vitamin C, niacin, riboflavin, thiamine, calcium, and iron per serving if artificially sweetened. All other foods require a greater than five percent RDI of the nutrients listed above per 100 calories to not be considered a FMNV (NSLP, 2005). The categories of FMNV are soda water or carbonated beverages, water ices, chewing gum, hard candy, jellies and gum, marshmallow candies, fondant, licorice, spun candy, and candy coated popcorn. However, products that are FMNV can be exempted if petitioned by including a statement of the percent of RDI for the eight nutrients the food provides per serving and per 100 calories (NSLP, 2005).

Students, parents and the public are informed on improvements made by the schools to meet the nutritional standards for school lunches (NSLP, 2005). The School Food Authority (SFA) and State Department of Agriculture Child Nutrition agency are in charge of reviewing nutritional information reported in all the menu plans submitted by schools. If the analysis shows that the menu(s) are not meeting these standards, the school needs to take action to make sure that the lunches meet the nutrition standards and the calorie, nutrient, and dietary component levels. Actions may include technical assistance and training and may be taken by the State agency, the SFA or by the school as needed.

Schools are advised to follow the current 2005 DGA for creating a well-balanced meal. Consistent with federal requirements the 2005 DGA lists the total fat for ages 4 to 18 years to equal 25 to 35 % of calories and consuming fats mostly from fish, nuts and vegetable oils (HHS, 2005). Continued further than the NSLP regulations, more nutrient dense foods and beverages are encouraged including fat-free or low free or low-fat milk about two cups per day for (ages 2 to 8), three cups per day for (ages 9 to 18), whole grains at least half of bread or grain consumption, and four and a half cups fruits and vegetables for a 2,000 calorie diet (HHS, 2005). Additionally, the 2005 DGA recommends levels of cholesterol less than 300 milligrams per day, sodium less than 2,300 milligrams per day, and fiber 14 grams per 1,000 calories, although these values are not required to be calculated or reported in NSLP (HHS, 2005). The 2005 DGA also provides calorie ranges with more detail than the NSLP based on activity level (sedentary, low active, active, very active) at each age (HHS, 2005).

Schools participating in the NSLP serve the food items selected by the school prepared on site or provided by a food service company. The four menu planning options are Traditional Food-Based Menu Planning (TFBMP), Enhanced Food-Based Menu Planning, Nutrient Standard Menu Planning (NSMP), and Assisted Nutrient Standard Menu Planning (ANSMP) (NSLP, 2005). Traditional Food-Based menu at a minimum must offer five food items in the quantities listed according to age group (Table 1) to meet calorie and Recommended Daily Allowance (RDA) levels of that age group (Table 2) (NSLP, 2005). Enhanced Food-Based Menu Planning must at least offer five food items in the quantities listed according to age group (Table 3) to meet calorie and RDAs of that age group (Table 4) (NSLP, 2005). Enhanced Menu Plan has one and a half more servings of vegetables or fruit and grains or bread for Grades K-3 and Grades 7-12 when compared to Traditional Menu Planning. Enhanced Menu Plan also has one and a half servings less of all items listed under “Meat or Meat Alternate” for Grades 7-12 when compared to Traditional Menu Planning. The ages and grade levels of the Enhanced and Traditional differed for Grades K-6 and Grades 4-12 respectively though the serving sizes are the same except the Enhanced has a little more vegetables or fruit and one and half more servings of grains or breads.

Table 1. Traditional Food-Based Menu Planning Food Components per age group

TRADITIONAL FOOD-BASED MENU PLANNING APPROACH–MEAL PATTERN FOR LUNCHES	MINIMUM QUANTITIES				RECOMMENDED QUANTITIES
FOOD COMPONENTS AND FOOD ITEMS	GROUP I AGES 1-2 PRESCHOOL	GROUP II AGES 3-4 PRESCHOOL	GROUP III, AGES 5-8 GRADES K-3	GROUP IV AGES 9 AND OLDER GRADES 4-12	GROUP V AGES 12 AND OLDER GRADES 7-12
Milk (as a beverage)	6 fluid ounces	6 fluid ounces	8 fluid ounces	8 fluid ounces	8 fluid ounces
Meat or Meat Alternate (quantity of the edible portion as served):					
Lean meat, poultry, or fish	1 ounce	1 ½ ounces	1 ½ ounces	2 ounces	3 ounces
Alternate Protein Products[1]	1 ounce	1 ½ ounces	1 ½ ounces	2 ounces	3 ounces
Cheese	1 ounce	1 ½ ounces	1 ½ ounces	2 ounces	3 ounces
Large egg	½	¾	¾	1	1 ½
Cooked dry beans or peas	¼ cup	3/8 cup	3/8 cup	½ cup	¾ cup
Peanut butter or other nut or seed butters	2 tablespoons	3 tablespoons	3 tablespoons	4 tablespoons	6 tablespoons
Yogurt, plain or flavored, unsweetened or sweetened	4 ounces or ½ cup	6 ounces or ¾ cup	6 ounces or ¾ cup	8 ounces or 1 cup	12 ounces or 1 ½ cups
The following may be used to meet no more than 50% of the requirement and must be used in combination with any of the above:					
Peanuts, soynuts, tree nuts, or seeds, as listed in program guidance, or an equivalent quantity of any combination of the above meat/meat alternate (1 ounce of nuts/seeds = 1 ounce of cooked lean meat, poultry, or fish)	½ ounce = 50%	¾ ounce = 50%	¾ ounce = 50%	1 ounce = 50%	1 ½ ounces = 50%
Vegetable or Fruit: 2 or more servings of vegetables, fruits or both	½ cup	½ cup	½ cup	¾ cup	¾ cup
Grains/Breads: (servings per week): Must be enriched or whole grain. A serving is a slice of bread or an equivalent serving of biscuits, rolls, etc., or ½ cup of cooked rice, macaroni, noodles, other pasta products or cereal grains	5 servings per week[2] -- minimum of ½ serving per day	8 servings per week[2] -- minimum of 1 serving per day	8 servings per week[2] -- minimum of 1 serving per day	8 servings per week[2] -- minimum of 1 serving per day	10 servings per week[2] -- minimum of 1 serving per day

[1] Must meet the requirements in appendix A of this part.

[2] For the purposes of this table, a week equals five days.

Table 2. Minimum nutrient and calorie content for Traditional Food-Based Menu Plan averaged over a week per age group.

MINIMUM NUTRIENT AND CALORIE LEVELS FOR SCHOOL LUNCHES TRADITIONAL FOOD-BASED MENU PLANNING APPROACH (SCHOOL WEEK AVERAGES)				
	MINIMUM REQUIREMENTS			RECOMMENDED
NUTRIENTS AND ENERGY ALLOWANCES	GROUP II PRESCHOOL AGES 3-4	GROUP III GRADES K-3 AGES 5-8	GROUP IV GRADES 4-12 AGES 9 AND OLDER	GROUP V GRADES 7-12 AGES 12 AND OLDER
Energy allowances (calories)	517	633	785	825
Total fat (as a percentage of actual total food energy)	[1]	[1, 2]	[2]	[2]
Saturated fat (as a percentage of actual total food energy)	[1]	[1, 3]	[3]	[3]
RDA for protein (g)	7	9	15	16
RDA for calcium (mg)	267	267	370	400
RDA for iron (mg)	3.3	3.3	4.2	4.5
RDA for Vitamin A (RE)	150	200	285	300
RDA for Vitamin C (mg)	14	15	17	18

[1] The Dietary Guidelines recommend that after 2 years of age "...children should gradually adopt a diet that, by about 5 years of age, contains no more than 30 percent of calories from fat."

[2] Not to exceed 30 percent over a school week

[3] Less than 10 percent over a school week

Table 3. Enhanced Menu Planning Food Components per age group.

ENHANCED FOOD-BASED MENU PLANNING APPROACH-MEAL PATTERN FOR LUNCHES					
	MINIMUM REQUIREMENTS				OPTION FOR
FOOD COMPONENTS AND FOOD ITEMS	AGES 1-2	PRESCHOOL	GRADES K-6	GRADES 7-12	GRADES K-3
Milk (as a beverage)	6 fluid ounces	6 fluid ounces	8 fluid ounces	8 fluid ounces	8 fluid ounces
Meat or Meat Alternate (quantity of the edible portion as served):					
Lean meat, poultry, or fish	1 ounce	1 ½ ounces	2 ounces	2 ounces	1 ½ ounces
Alternate protein products[1]	1 ounce	1 ½ ounces	2 ounces	2 ounces	1 ½ ounces
Cheese	1 ounce	1 ½ ounces	2 ounces	2 ounces	1 ½ ounces
Large egg	½	¾	1	1	¾
Cooked dry beans or peas	¼ cup	3/8 cup	½ cup	½ cup	3/8 cup
Peanut butter or other nut or seed butters	2 tablespoons	3 tablespoons	4 tablespoons	4 tablespoons	3 tablespoons
Yogurt, plain or flavored, unsweetened or sweetened	4 ounces or ½ cup	6 ounces or ¾ cup	8 ounces or 1 cup	8 ounces or 1 cup	6 ounces or ¾ cup
The following may be used to meet no more than 50% of the requirement and must be used in combination with any of the above:					
Peanuts, soynuts, tree nuts, or seeds, as listed in program guidance, or an equivalent quantity of any combination of the above meat/meat alternate (1 ounce of nuts/seeds equals 1 ounce of cooked lean meat, poultry or fish).	½ ounce =50%	¾ ounce =50%	1 ounce =50%	1 ounce =50%	¾ ounce =50%
Vegetable or Fruit: 2 or more servings of vegetables, fruits or both	½ cup	½ cup	¾ cup plus an extra ½ cup over a week[2]	1 cup	¾ cup
Grains/Breads (servings per week): Must be enriched or whole grain. A serving is a slice of bread or an equivalent serving of biscuits, rolls, etc., or ½ cup of cooked rice, macaroni, noodles, other pasta products or cereal grains	5 servings per week[2] – minimum of ½ serving per day	8 servings per week[2] – minimum of 1 serving per day	12 servings per week[2] – minimum of 1 serving per day[3]	15 servings per week[2] – minimum of 1 serving per day[3]	10 servings per week[2] –minimum of 1 serving per day[3]

[1] Must meet the requirements in appendix A of this part.
[2] For the purposes of this table, a week equals five days.
[3] Up to one grains/breads serving per day may be a dessert.

Table 4. Minimum nutrient and calorie content for Enhanced Food-Based Menu Plan averaged over a week per age group.

MINIMUM NUTRIENT AND CALORIE LEVELS FOR SCHOOL LUNCHES ENHANCED FOOD-BASED MENU PLANNING APPROACH (SCHOOL WEEK AVERAGES)				
	MINIMUM REQUIREMENTS			OPTIONAL
NUTRIENTS AND ENERGY ALLOWANCES	PRESCHOOL	GRADES K-6	GRADES 7-12	GRADES K-3
Energy allowances (calories)	517	664	825	633
Total fat (as a percentage of actual total food energy)	[1]	[1, 2]	[2]	[1,2]
Saturated fat (as a percentage of actual total food energy)	[1]	[1, 3]	[3]	[1,3]
RDA for protein (g)	7	10	16	9
RDA for calcium (mg)	267	286	400	267
RDA for iron (mg)	3.3	3.5	4.5	3.3
RDA for Vitamin A (RE)	150	224	300	200
RDA for Vitamin C (mg)	14	15	18	15

[1] The Dietary Guidelines recommend that after 2 years of age "...children should gradually adopt a diet that, by about 5 years of age, contains no more than 30 percent of calories from fat."

[2] Not to exceed 30 percent over a school week

[3] Less than 10 percent over a school week

The Nutrient Based and Assisted Nutrient Based Menu Planning approach creates a meal pattern based on nutritional content not serving size of food items. The Child Nutrition Database is a software program providing nutritional information for standardized recipes used to create menus that meet federal nutritional requirements (USDA, 2008a). The School Food Authority (SFA) may also contract with a food management company to create a menu meeting federal nutritional requirements. In a 1999 to 2000 school year survey schools reported "one-quarter of all districts were using nutrient-based menu planning systems while most of the remaining three-quarters used a food-based system." (Food Nutrition & Service (FNS), 2008). NSMP is more likely to be used by the largest districts (35.8 %) and by districts operated by food service management companies (42 %) (FNS, 2008). Reported in 1999 to 2000 school year, 64 % of the food-based systems did not intend to adopt a NBMP, while 20.7 % were working on changing and 14.8 % were planning to switch (FNS, 2008).

In the NSLP a variety of food sources can be used to meet the nutritional requirements of the FBMP. As shown in Table 1 all or part of the meat or meat alternate requirement can be met by four ounces (weight) or half cup (volume) of yogurt, plain or flavored, unsweetened or sweetened equal to one ounce of the meat or meat alternate (NSLP, 2005). Not included are noncommercial and or non-standardized yogurt products, such as frozen yogurt, homemade yogurt, yogurt flavored products, yogurt bars, yogurt covered fruit and/or nuts or similar products. To meet no more than one-half of the meat or meat alternate component nuts and seeds may be used with another meat or meat alternate to meet the full requirement. Acorns, chestnuts, and coconuts must not be used because of their low protein and iron content. Full strength vegetable or fruit juice may be used to meet no more than one-half of the vegetable or fruit requirement. Cooked dry beans or peas may be counted as either a vegetable or meat alternate but not as both in the same meal. All grains or breads must be enriched, whole grain, or made with enriched or whole grain meal or flour. The servings for biscuits, rolls, muffins, and other grain or bread varieties are specified in the Food Buying Guide for Child Nutrition Programs (PA 1331), an FNS publication (NSLP, 2005). According to the Enhanced Food-Based Menu Planning approach schools may count up to one grain-based dessert per day for children in grades kindergarten to 12th towards meeting the grains/breads component (NSLP, 2005). Schools must offer students pasteurized fluid milk which meets State and local standards for such milk. Although, if a certain type of milk is consumed less than 1 % of the total amount of milk consumed in the previous year, a school does not need to offer this type of milk, but the school can offer additional types of milk (NSLP, 2005).

Classification of school food products is important to identify the nutritional quality of the meals served. Various modifications are made to school foods for optimizing the nutrients, such as protein content.

> "Products or dishes containing more than 30 parts fully hydrated alternate protein products to less than 70 parts beef, pork, poultry or seafood on an uncooked basis, in a manner which does not characterize the product or dish solely as beef, pork, poultry or seafood must be identified" (NSLP, 2005).

The edible portion of the meat or meat alternate component as served is measured but if the portion size is excessive, the school must reduce that portion and supplement it with another meat or meat alternate to meet the full requirement. For example a meal with a large portion of peanut butter might meet the meat alternate requirement but be too excessive a portion size that would be unaccepted. Therefore reducing the portion size of peanut butter and added with another meat or meat alternative would be more acceptable. The meat or meat alternate component must be served in a main dish or in a main dish with only one other food item. If this component is not served daily with choices then schools should not serve any one meat alternate or form of meat (for example, ground, diced, pieces) more than three times in the same week (NSLP, 2005).

Additionally, some portion of the non-protein constituents of the food can be removed and supplemented with a protein. The enriched product's biological quality must be at least 80 % of casein by Protein Digestibility-Corrected Amino Acid Score (PDCAAS) method, and 18 % protein by weight when fully hydrated or "a dry alternate protein product and the amount of water, fat, oil, colors, flavors or any other substances which have been added" (NSLP, 2005). Documentation for the product is needed to meet the criteria on the percent protein contained in the dry alternate protein product and prepared basis. For an alternate protein product mix, manufacturers should provide information on the amount by weight of dry alternate protein product in the package, hydration instructions, and instructions on how to combine the mix with meat or other meat alternate (NSLP, 2005). The alternate protein product may be used alone or in combination with other food ingredients such as beef patties, beef crumbles, pizza topping, meat loaf, meat sauce, taco filling, burritos, and tuna salad either in the dry form (non-hydrated), partially hydrated or fully hydrated form. Alternate protein products may be combined with commercially prepared meat or meat alternate products or a commercially prepared product that contains only alternate protein products.

Another alternative is enriched macaroni with fortified protein though it may not be used as both grain or breads and meat or meat alternate in the same lunch. The enriched macaroni products with fortified protein must meet the meal requirements that one ounce (28.35 grams) of a dry product be used to meet not more than one-half of the meat or meat alternate requirements when served in combination with one or more ounces (28.35 grams) of cooked meat, poultry, fish, or cheese adjusted for various age groups with a label or a legend acceptable to both the State or local authorities and Food and Nutrition Services (FNS) (NSLP, 2005). New product acceptance mandates a chemical analysis reported to the FNS (NSLP, 2005). Enriched macaroni products with fortified protein are not Dietary Supplements, but must have one or more of the milled wheat ingredients designated in 21 CFR 139.110(a) and 139.138(a) larger than the proportion of any other ingredient used to meet protein standard (NSLP, 2005). Each such finished food, when tested the Official Methods of Analysis of the AOAC International will have protein content not less than 20 % by weight (on a 13 % moisture basis), protein quality not less than 95 % that of casein as determined on a dry basis by the PDCAAS method, and the total solids content not less than 87 % by weight (NSLP, 2005). Each pound of food shall contain 5 milligrams of thiamine, 2.2 milligrams of riboflavin, 34 milligrams of niacin or niacinamide, and 16.5 milligrams of iron and may also contain 625 milligrams of calcium (NSLP, 2005).

1.2 Meeting nutritional requirements

On average schools nationally report not meeting the levels limiting fat and saturated fat as required by federal nutritional regulations of the NSLP. The USDA reported in 1994 to 1996, intakes were above the limit for fat and saturated fat for 67 % and 72 % respectively of students' ages 6 to 19 years old (USDA, 1998). In the SNDA-II 1998 to 1999, elementary schools lunches on average were about 33 % of calories from fat and about 12 % of calories from saturated fat (Fox et al. 2001). Reported in the SNDA-II limits were met for fat and saturated fat in 1998 to 1999 by 82 % of elementary schools and 91 % of secondary schools although overall more than three-quarters of schools did not (Fox et al. 2001, GAO, 2003). In 2000, according to national studies (Fox et al. 2001, GAO, 2005, CDC, 2001), lunches met requirements for nutrients such as protein, vitamins, calcium, and iron, but do not meet the required 30 % limit for calories from fat. In a 2004 study of Texas school lunches, 90 % of 122 child nutrition programs in this study used FBMP with total fat 34.3 % and saturated fat 12.6 % (Connors, et al. 2004). However, the programs using the NSMP or ANSMP were over the limit for fat by less than the FBMP and had greater energy, protein, iron, and vitamins A and C (Connors et al. 2004). Although, schools continue to make changes to better meet the federal standards to limit meals on a weekly average to 30 % calories from fat and 10 % calories from saturated fat. In a 2000 survey of SFAs 94 % of the FBMP schools said changes were being made in a variety of ways to better follow the federal nutrition standards while having a positive to neutral effect on the acceptability of school lunches (CDC, 2001).

SFA or State agencies can make specific modifications or major changes to the standard menu planning approach. State agencies may or may not require prior approval or may establish guidelines for using these modifications. Adjustments can be made for menu planning if only one grade or age group is outside the established levels, so that schools may follow the levels for the majority of the children. Another modification is the "'offer versus serve' option for senior high (as defined by the State educational agency) students" (NSLP, 2005). Under this plan students must select at least two menu items and are allowed to decline a maximum of two menu items out of the at least three menu items offered (NSLP, 2005). A student must always take the entree. The price of a reimbursable lunch does not change if the student does not take a menu item or requests smaller portions. If the SFA chooses the "offer versus serve" option, they must indicate the affected age or grade groups, the number and type of items (and, if applicable, the quantities for the items) that constitute a reimbursable lunch under offer versus serve, how it will reduce plate waste; and how a reasonable level of calories and nutrients will be provided for the lunch as taken (NSLP, 2005). A major change is to have an alternate menu planning approach tailored to the schools choice. The alternate menu plan must offer fluid milk, include offer versus serve for senior high students, meet the RDA, lunchtime energy allowances (nutrient levels) for indicated age or grade groups served reporting how the nutrient levels are met for those age or grade groups, follow the requirements for competitive foods, count food items and products towards the meal patterns in a FBMP approach), and identify a reimbursable lunch at the point of service (NSLP, 2005).

Schools' budget pressures and competing time demands compound the problem to provide nutritious meals. Responses of a national 2003 report on the NSLP stated improvements made to create a healthier environment were attempted by lowering the fat content of recipes, conducting taste tests, establishing food policies to restrict unhealthy choices, enlist help from "businesses", and change the cafeteria layout (GAO, 2003). Processing techniques for school food choices to make them more nutritious include baking rather than frying, reducing salt usage, and substituting low-fat ingredients wherever possible, such as in gravies, cheese sauces, and salad dressings (GAO, 2003).

Several SFA directors said that they worked with vendors of prepared food to provide items that had healthier nutritional specifications and lower fat content (GAO, 2003). SFA in Washington State negotiated with a vendor to supply French fries with less fat and sodium (GAO, 2003). In Kentucky, an SFA worked with vendors to provide low-fat pizza and chicken nuggets (GAO, 2003). Students must choose to eat nutritious meals as well as limit the other less healthful food they may eat during the day.

1.3 Competitive foods

Extra disadvantage to the nutrition integrity of the NSLP are the competitive foods in schools according to a 2001 USDA report to Congress (GAO, 2005). Neumark-Sztainer et al. (2005) reported food availability was one of the strongest correlates of food choices in adolescents. Kramer-Atwood et al. (2002) compared schools with and without competitive foods and found students consumed 50 % less fruit and 25 % less total fruit juice, and vegetables when schools sold competitive foods. The percentage of middle schools offering competitive foods through a la carte lines, vending machines, or school stores increased from 83 to 97 % from 1998 to 2003 respectively (FNS, 2008). American Dietetic Association (ADA) (2006) found adolescents selecting a la carte items in addition to or instead of school meals increased intake of energy but decreased intake of certain nutrients. Furthermore, the ADA reported exposure to a la carte programs lowered intakes of fruits and vegetables and increased the percentage of calories from total and saturated fat (ADA, 2006). SNDA-II found weekly a la carte revenue was inversely related to overall NSLP participation and another study found an inverse association between soft drink consumption and milk and fruit consumption (Fox et al, 2001). Kramer-Atwood et al. (2002) studied a la carte foods less than half met “low-fat”

FDA criteria out of the 33 options offered. The sample of school stores researched by Kramer-Atwood et al. (2002) showed 89 % of snacks sold each day were high in fat and/or added sugars and more than 40 % of beverages were soft drinks. Of the sales in these same stores the highest were cookies, nondairy drinks, vegetables (especially French fries), milk, and entrees (especially pizza) (Kramer-Atwood et al. 2002). Of the school stores studied by Kramer-Atwood et al. (2002) 80 % sold candy or candy bars but very few sold lower-fat snack options. Students snack food purchases were significantly associated with both the number of snack machines at schools and policies about the types of foods sold according to Neumark-Sztainer et al. (2005). In this study creating a school policy for competitive foods such as closing vending machine usage at lunch time, especially to limit soft drink purchases and other types of foods sold in vending machines was found to have a significantly inverse association with frequency of student snack food purchases (Neumark-Sztainer et al. 2005).

The total eating environment in schools, types of food available throughout school, nutrition information in cafeteria and around school, nutritional quality, variety, and acceptability of program meals, meal scheduling, and nutrition education will affect the choices made by students (USDA, 2001). The a la carte items in the cafeteria, vending machines, and school stores are sources of foods known as competitive foods. Second servings as part of the school meal and foods that are sold in addition to or in place of reimbursable school meals are considered competitive foods. Although, sold during the school day, competitive foods are not part of the federal school meal program they compete with the nutritionally regulated school meal programs.

An American Dietetics Association (ADA) study on competitive foods found nine of ten schools had food and beverages available a la carte (ADA, 2006). An increase percentage of schools from elementary, middle, and high schools (9, 35, 44 % respectively) had food at school stores and snack bars and (15, 55, 76 % respectively) had vending machines (ADA, 2006). Between school years 1998 to 1999 and 2003 to 2004, the availability of competitive foods increased in middle schools, and the volume and variety of a la carte foods sold increased in many schools (Bhattacharya, et al. 2004). Vending machines are contracted with vendors with incentive from the school to consume a certain quota to receive an award (ADA, 2006). Nearly half of all schools in school year 2003 to 2004 had an exclusive beverage contract (Bhattacharya, et al. 2004). In over a third of schools with exclusive beverage contracts, the contracts covered 5 years or more, with some covering at least 10 years (Bhattacharya, et al. 2004). Motivating SFAs to have contracts is the money, because when competitive foods and reimbursable meals combine profit and cost one can support the other yet while still a nonprofit. An ADA report suggests having "registered dietitians actively involved in negotiating contracts to make sure nutrition is given consideration" (ADA, 2006).

1.4 Local Wellness Policy

Persuaded by the attention to competitive foods and beverages; school food policy has resulted in nutritional standards, restricted sales, and banning or limiting vending machine sales of poor nutritional foods. A new federal policy was introduced beginning School year 2006 to 2007 for each local education agency participating in USDA's school meals programs had to establish a Local Wellness Policy in accordance with Section 204 of the Child Nutrition and WIC Reauthorization Act of 2004 (GAO, 2003).

Requirements for local policies came without funding, so resources and energy from the local communities will be needed. Coalitions for action have been forming at the local and state level, some by public health departments changing the community environments to support healthier eating and activity.

1.5 New Jersey Model School Nutrition Policy

The state of New Jersey Department of Agriculture Child Nutrition Bureau and Department of Education developed nutritional standards for competitive foods in New Jersey schools as part of their Local Wellness Policy. FMNV are not to be sold in school lunches, in New Jersey this includes all food and beverage with sugar as first ingredient, and all forms of candy. All products labeled containing trans fats are discouraged in New Jersey schools. According to the New Jersey Model School Nutrition Policy all competitive foods during the school day or in the After School Snack Program are restricted by fat content and serving size. First, competitive foods are limited to eight grams total fat per serving and two grams of saturated fat per serving but this does not count fat sources from nuts and seeds (NJDA, 2006). Second, whole milk is limited to 8 ounces, while all other beverages are limited to 12 ounces except water and milk with two percent or less fat (NJDA, 2006). No other beverages can be offered in elementary schools other than milk, water or 100 % fruit or vegetable juices (NJDA, 2006). For middle and high schools the rules are more flexible. Milk, water, and other beverages with at least 60 % of the “other” beverages to be 100 % fruit or vegetable juices are offered (NJDA, 2006). Also, 40 % of the total desserts are allowed to exceed eight grams of fat per serving, two grams of saturated fat per serving, and have sugar as the first ingredient in middle and high schools (NJDA, 2006). Additionally, the standards do no apply during special school celebrations or during curriculum related activities with the exception of foods of minimal nutritional value as defined by USDA regulations (NJDA, 2006).

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