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Assessing the acceptability of chocolate chip cookies formulated with fat substitutes

Marcel R. Gailes

FORMULATED WITH FAT SUBSTITUTES

A THESIS

Presented to the

Honors College at Southern University
Baton Rouge, Louisiana

In Partial Fulfillment of the Requirements for the
Honors College Degree

By

Marcel R. Gailes

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CERTIFICATE OF APPROVAL

HONORS THESIS

This is to certify that the Honors Thesis of
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has been approved by the examining committee for the thesis
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ABSTRACT

The purpose of this study was to investigate consumer acceptance of fat substitutes as replacements for butter in chocolate chip cookies. This experiment was designed with the aim to examine how fat substitutes affect the sensory and physical qualities that contribute to acceptability of chocolate chip cookies. The fat substitutes used in my investigation included flaxseed meal, tofu, nonfat plain yogurt, unsweetened applesauce, white bean paste and a shortening made of soy protein and canola oil known as Spectrum Spread. The fat content of the cookie dough consisted of 100% butter in the control and 25% butter and 75% substitute in each subsequent sample. The sensory analysis was conducted by sensory panelists, according to the testing procedures of IFT 1985 and Institutional Use of Humans in Research Guidelines.

The results of the sensory analysis suggest that the ideal substitutes would be tofu, Spectrum Spread and white bean paste. The 75% tofu cookies ranked in the top three for each parameter and were second in color and overall acceptability behind the control. The 75% Spectrum Spread cookies were in the top three of the moisture, texture, color and overall acceptability categories and ranked highest in moisture and texture overall. The 75% white bean paste cookies ranked in the top three of the texture, flavor and overall acceptability categories and ranked second in flavor behind the control. Data showed, flaxseed meal to be the least acceptable fat substitute in chocolate chip cookies.

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CHAPTER I
BACKGROUND OF STUDY

Introduction

In recent years, Americans have become increasingly obsessed with their diets. Diet-related metabolic disorders are rampant in the United States. Fats are the assumed culprits. Fat laden diets have serious health implications such as obesity and heart disease. With heart disease cited as the leading cause of death in the United States, consumers are constantly looking for ways to incorporate low-fat or no fat versions of their favorite foods into their diet.

Lipids consist of any group of organic compounds consisting of fats, oils, and related substances. Along with proteins and carbohydrates, they are the structural components of living cells. Lipids are an essential part of a healthy diet. They are a source of energy and have an important function in the absorption of fat-soluble vitamins A, D, E, K and carotenoids. Additionally, lipids are used as building blocks for the membranes of the body and have a role in several biological functions (Dietary Guidelines for Americans, 2005).

Classification of Lipids

Lipids can be divided into two major categories: saturated fats and unsaturated fats. Saturated fats consist of triglycerides containing only saturated fatty acids. Saturated fatty acids lack double bonds between the carbon atoms in the fatty acid chain and are named such because they are completely saturated with hydrogen atoms. Animals have an abundant source of this specific type of fat. The human body is capable of producing saturated fat

itself. It is for this reason that people must be aware of the amount of saturated fat they consume. Diets high in saturated fat correlate in some studies with an increased incidence of atherosclerosis and coronary heart disease. Some common examples of saturated fatty acids are butyric acid (butter), lauric acid (breast milk and cocoa butter), myristic acid (cow milk and dairy products), palmitic acid (meats) and stearic acid (meat). Stearic acid is the most common saturated fatty acid found in the diet. Non-animal sources of saturated fats include coconut, palm and palm kernel oils. Generally harder and more stable fats are more saturated, such as butter, stick margarine, shortening, and the fat in cheese and meat (Cyberlipid Center, 2006).

Unsaturated fat is a type of fat that contains fatty acids with one or more double bonds between carbon atoms of the fatty acid chain. These fats can be further divided into monounsaturated fats and polyunsaturated fats. Unsaturated fats with only one double bond along the fatty acid chain are called monounsaturated fatty acids. Monounsaturated fats are found in natural foods like nuts and avocados. They are also found in the main component of olive oil, oleic acid. Unsaturated fats with two or more double bond along the fatty acid chain are called polyunsaturated fatty acids. Common sources of polyunsaturated fatty acids are corn, safflower, soybean, and sunflower (Gropper, 2005).

Both types of unsaturated fats are a great substitute for saturated fats in the diet. Substituting saturated fats with unsaturated fats helps to lower levels of total cholesterol and low-density lipoproteins in the blood. High levels of both cholesterol and low-density lipoproteins are commonly associated with cardiovascular disease. Low density lipoproteins

(LDL) are responsible for carrying cholesterol from the liver to cells of the body. LDL deposits cholesterol in the artery walls, causing the formation of a hard, thick cholesterol plaque. Over time, the cholesterol plaque causes thickening of the artery walls and narrowing of the arteries resulting in atherosclerosis which increases the risk of heart disease. These lipoproteins are referred to as "bad" cholesterol. High density lipoproteins (HDL) help remove cholesterol from the blood, thereby reducing the risk for heart disease (atherosclerosis). They are sometimes referred to as the "good" cholesterol lipoproteins.

Usually saturated fats tend to be solid at room temperature, while unsaturated fats have a tendency to have lower melting points and therefore are not solid at room temperature. A prolonged diet consisting of high levels of saturated fats will often lead to harden fatty deposits in the blood vessels, which in turn may lead to cardiovascular disease.

Saturated fats are not the only source of trouble for American consumers. The more unsaturated an oil is the more vulnerable it is to oxidation. Oxidation of oils leads to rancidity. It is for this reason that solid fats have a longer shelf life than oils. Hydrogenation is the process during which unsaturated fats are converted into saturated fats. Hydrogen atoms attach to the fatty acids chains and break down doubles bond and convert them into single bonds. The complete or partial hydrogenation of oils produces trans fatty acids which are considered to be just as bad if not worse than saturated fats. Margarine is an example of a hydrogenated fat and is now one of the main sources of trans fat.

Essential Fatty Acids

Despite the overwhelming attention and concern with fat and cholesterol, fats still play an important role in good health and food preparation. Choosing the right kinds of fats is critical. Human metabolism requires particular essential fatty acids. Essential fatty acids are the polyunsaturated fatty acids, linoleic acid and alpha-linolenic acid. These are the parent compounds of the omega-6 and omega-3 fatty acid series respectively. They are essential in the human diet since they cannot be synthesized by the body. Humans can easily make saturated fatty acids and monounsaturated fatty acids with a double bond at the omega-9 position, but we do not have the enzymes to introduce a double bond at the omega-3 or omega-6 position. Omega-3 fatty acids are most abundant in cold water fish such as mackerel, salmon, albacore tuna, sardines and lake trout. Canola oil, soybean oil and some nuts and seeds also contain some omega-3 fatty acids. Omega-6 fatty acids are found abundantly in polyunsaturated vegetable oils.

Essential fatty acids are very important to the immune system as well as helping to regulate blood pressure, since they are used to make compounds such as prostaglandins. The brain is also highly enriched in derivatives of linoleic and alpha-linolenic acids. Linoleic acid is an omega-6 fatty acid that is found in vegetable oils and from animal sources such as fish oils, meat and milk. Alpha-linolenic acid is an omega-3 fatty acid found in fish, canola oil, leafy green vegetables, nuts, seeds, and soybeans. The essential fatty acids are adequately supplied by a varied diet.

These essential fatty acids are often destroyed by the hydrogenation process. Trans fats behave like saturated fat in that they also raise the level of low-density lipoproteins found in the blood which in turn increases the risk of developing coronary heart disease. Additionally, trans fats decrease levels of high-density lipoproteins which help remove cholesterol from arteries.

Problem

Butter is arguably the most widely used fat in foods that are consumed by Americans. However, it contains saturated fat, a precursor to the occurrence of metabolic diseases. Americans are concerned about their fat intake. So it is understandable that people would like to know how to substitute butter in their recipes.

Butter creates flaky pastries and it provides flavor, tenderness, crispness, and a pleasing golden-brown color to many foods. It can be used when frying and sautéing food, as a spread for baked goods such as breads and rolls, and as a flavoring for cooked vegetables. When eaten, it does not leave a greasy feeling in your mouth because it melts at body temperature. It is an ingredient in hundreds of recipes including cookies, breads, pastries, cakes, entrees, and sauces (Hormel Foods, 2006).

In my research, I will test the effects various fat substitutes have on the physical and sensory qualities as well as the overall acceptability of homemade Nestle Toll House chocolate chip cookies. The fat substitutes I will use in my investigation include flaxseed meal, tofu, nonfat plain yogurt, unsweetened applesauce, white bean paste and a shortening made of soy protein and canola oil known as Spectrum Spread. The fat content of the cookie

dough will consist of 100% butter in the control and 25% butter and 75% substitute in each subsequent sample.

Purpose

The purpose of this study is to determine consumer acceptance of fat substitutes as replacements for butter in chocolate chip cookies.

Research Questions

This experiment is designed with the aim to answer certain research questions. One of the research questions that will be examined in this study is how do fat substitutes affect the physical qualities of chocolate chip cookies. The cookies with be weighed and measured to see the affects the substitutes have on their structure and spreadability. Another research questions that will be examined in this study is how do butter substitutes affect the sensory qualities of chocolate chip cookies. The cookies will be tested to see the effects the substitutes have on the moistness, texture, flavor, color, and overall acceptability. The final research question will examine which fat substitute had the highest overall acceptability rating in chocolate chip cookies.

Since the primary focus of this study is theory construction, a statement of specific hypothesis will not be offered. This study, therefore, will be exploratory rather than confirmatory.

REVIEW OF LITERATURE

Scientist are aware of the high caloric value of cookies and are experimenting with various fat alternatives to yield reduced fat cookies where texture and flavor is not compromised. Through research, one can determine that fat replacements in baked goods; must be carefully planned.

In a study conducted in Spain, the sunflower oil in a standard muffin recipe was replaced with hydrated peach dietary fiber. Fat was replaced in increments of 0%, 2%, 3%, 4%, 5% and 10%. The replacement of peach dietary fiber made a difference in both caloric value and the fat content. The muffins with the 10% peach fiber had the lowest fat content and the least amount of calories and were considered to be moister than the control recipe. The muffins with a replacement of up to 4% of the fat did not have a significant change in acceptability, but the muffins with hydrated peach dietary fiber replacing 5% or more of the sunflower oil were less acceptable than the control sample (Grigelmo, 2001).

In a later experiment conducted at Idaho State University by Keller et al (2002), fudge was prepared using pureed, soft silken tofu as a substitute for margarine in increments of 0%, 50%, 75% and 100%. The fudge samples were evaluated by a sensory panel on the parameters of appearance, flavor, texture and overall acceptability. Approximately 89% of the panelists gave the 50% tofu sample acceptable scores for all parameters, 91% gave the 75% tofu sample acceptable score for all parameters, while approximately 89% of the panelists gave the 100% tofu sample acceptable score for all parameters.

In 2002, Rankin, from Idaho State University, prepared oatmeal cookies using pureed white bean paste at levels of 0%, 25%, 50%, and 75%. In terms of acceptability, the sensory panelists liked the control and 25% pureed white bean cookies very much. The panelists liked the 50% pureed white bean cookies moderately. The 75% pureed white bean cookies had a significantly lower overall acceptability rating than the control and was only liked slightly.

Scientists at Oklahoma State University prepared cookies with mungbean paste as a substitute for butter at levels of 0%, 25%, 50%, 75% and 100%. Reducing the butter content by 25% had no significant effect on the overall acceptability of the cookies. Samples utilizing 50% or more mungbean paste were met with decreasing overall acceptability (Adair, 2001).

In 1999, Swanson replaced butter and shortening in peanut butter, oatmeal, and chocolate chip cookies with prune puree, or unsweetened, non-chunky applesauce. The fat element was replaced in increments of 75% for the applesauce and increments of 25% and 50% for the prune puree. Generally, the reduced fat cookies were less acceptable than their full-fat counterparts in varying degrees. The chocolate chip cookies prepared with prune puree were liked moderately, while the cookies prepared with applesauce were liked slightly. There was no significant reporting of an off flavor in the chocolate chip cookies prepared with applesauce and prune puree.

In baked goods, fats add moisture, flavor and provide tender texture to cookies, cakes, quick breads and muffins. The use of fruit purees, such as prune, banana or applesauce, and

nonfat dairy products like nonfat yogurt or nonfat sour cream, provide some of the fat-like characteristics in homemade baked goods without the addition of fat. By modifying recipes to include fruit purees instead of fat, there is a slight boost of vitamins, minerals and fiber. It is important to remember however that not all fruit purees are equal.

Pureed prunes provide a rich flavor as well as a moist and tender texture. Additionally, naturally occurring elements that are found in prunes work to enhance the other flavors that may be found in recipes such as chocolate, cinnamon and orange. This results in baked goods that are flavorful, moist and lower in fat. Of course, an element of common sense is required when using fruit purees as substitutes. It would be ill-advised to use a prune puree in place of fat for a light colored cake. In this instance applesauce or peach puree may work better. Unlike prune puree, applesauce would contribute to a moist and tender texture without changing the color. Another benefit of applesauce is the lack of fat, cholesterol and sodium as well as the fact that apples are a rich source of antioxidants.

The use of fat replacements has more significance than just reducing the level of fat in a given food. Some replacements may be fortified or enriched with vitamins. Yogurt, for instance, is filled with calcium, potassium, and magnesium. Studies have shown that these three nutrients have been shown to reduce hypertension. Studies have also shown that a diet rich in calcium could help regulate blood pressure in women during and after pregnancy as well as reduce the risk of osteoporosis (Yogurt's Healthy Benefits, 2002).

The proportion of fruit puree or nonfat yogurt to use in baked goods usually varies. Sometimes all of the fat can be replaced with an equal portion of fruit puree or yogurt. Other

times only a portion of the fat can be replace in order to ensure that a high quality product is obtained.

Flaxseed may also be used to replace butter in cookie recipes. Flaxseeds are the tiny hard seeds of the flax plant, *Linum usitatissimum*. Flax has been widely used as a source of food and clothing for thousands of years. To this point, scientists have isolated at least three flaxseed components with potential health benefits (Flaxseed, 2006). Flaxseed is extremely high in omega-3 essential fatty acids, lignins and fiber. Lignins have the ability to act as both phytoestrogens and antioxidants. The fiber that is contained in the flaxseed is of both the soluble and insoluble type of dietary fiber (Sorgen, 2003).

Insoluble fiber is basically bulk that changes little as it passes through the body. Soluble fiber, in contrast, forms a soft gel in aqueous solutions. While most foods provide a mixture of both soluble and insoluble fiber, they are listed as mostly one or the other. Soluble fiber has been shown to be able to bind bile salts. The binding of these bile salts may reduce blood cholesterol levels. The process may also slow down the absorption of glucose from the intestine, requiring less insulin to be secreted in so doing (ADA, 2002).

Tofu makes an acceptable fat replacement because it is high in protein and calcium, low in salt and free of cholesterol. Tofu is a soft food with no particular flavor that is made from coagulated soybean extract that is pressed into the form of a cake that is easily digested. Soy contains all the amino acids essential to human nutrition, which must be supplied in the diet because they cannot be synthesized by the human body. Despite the fact that tofu is actually very high in fat, it happens to be high in unsaturated fat which is much better than

saturated fats found in butter. Furthermore, documentation of the nutritional benefits of tofu continues to amass. It has been stated that the more tofu there is in the diet, there are fewer cases of cancer and heart disease and a lower risk of osteoporosis. As for women, eating a lot of tofu translates to an escape from the symptoms that are traditionally associated with menopause (U.S. Soyfoods Directory, 2006). Because of its texture range from soft to firm, tofu is very versatile and can easily be used in many types of dishes, such as soups, casseroles, sandwiches, salads, dips, sauces, and stir-fries.

There are three main types of tofu that are available in American grocery stores: firm, soft and silken tofu. The firm variety is dense and solid. It works well in any dish that would require the tofu to retain its shape. Firm tofu also is higher in protein, fat and calcium than other forms of tofu. Soft tofu, on the other hand, is better for recipes that call for blended tofu, such as Oriental soups. Silken tofu is made by a slightly different process than the other two types. This results in a creamy, custard-like consistency. Silken tofu functions well in pureed or blended dishes (U.S. Soyfoods Directory, 2006).

In addition to tofu, some baked goods may use an isolated soy protein, soy protein concentrates and soy flour or soy grits. Soy protein is a cost-effective way to reduce fat. It also increases the protein content and improves overall baking characteristics of baked goods such as breads, rolls, doughnuts, cookies, cakes, pies, batters and breading, muffins and pasta. Soy protein can in addition be used to enhance the nutritional profile of many cereal-based products such as hot cereal mixes, cold cereals and cereal bars. Soy protein concentrate comes from defatted soy flakes. The concentrate contains approximately 70%

protein. At the same time, it retains most of the bean's dietary fiber. On the other hand, when protein is removed from defatted flakes the result is soy protein isolates or isolated soy protein. Soy protein isolates is the most highly refined soy protein and contains the greatest amount of protein of all soy products, at approximately 92% protein (U.S. Soyfoods Directory, 2006).

Spectrum Spread is blend of canola oil and soy protein isolate. It is free of trans fats and is mainly composed of monounsaturated and polyunsaturated fatty acids (Spectrum Organic Products, 2003). This additive could impart monounsaturated fatty acids, which could have useful implications for heart disease and isoflavones, which could ease menopausal symptoms, reduce the risk of cancer and heart disease, protect against prostate problems and improve bone health. Isoflavones are found in virtually all soy products (Isoflavones.info, 2003).

Legumes have long been used as one of the main sources of protein in vegetarian diets. White bean puree could be an effective replacement for fat in cookies because beans as a whole are beneficial to the diet. Beans are completely free of cholesterol, are high in protein, dietary fiber and complex carbohydrates and are low in fat, calories and sodium (Chretien, 2006).

CHAPTER III
METHODOLOGY

Materials

Various materials were used during the preparation of the cookies. The ingredients and brands names used are listed in Table 1. A metric scale was used to measure the weights of the majority of the ingredients, while measuring spoons were used for the vanilla extract. The cookie dough was mixed using a KitchenAid® stand mixer. The cookies were scooped with a #40 scoop and baked on a cookie sheet lined with an 11-5/8 inch by 16-1/2 inch SILPAT® silicone non-stick baking sheet. All of the cookies were scooped with a #40 scoop to ensure that they shard an identical pre-baked height and diameter. The cookies were measured with a ruler before and after baking.

Recruitment of Participants

Ethical approval and access approval from the Institutional Review Board for projects involving human subject at Southern University and A&M College were obtained prior to advertising the study. The participants used in this experiment were selected by a convenient sample. The first one hundred people who showed interest were recruited. Of the one hundred participants, one was dismissed due to a food allergy, eight withdrew on their own accord, and seven applicants' forms were voided because they did not fill out their paperwork properly.

Preparation of Cookies

The standard Nestle® Toll House® Chocolate Chip Cookie recipe was used as the control for this experiment. This recipe utilized 100% butter. Fat substitutes used were tofu, nonfat plain yogurt, flaxseed meal, Spectrum Spread, unsweetened applesauce, and white bean paste. Fat replacements for each cookie were made in the following order: Control (100% butter); Fat Substitution 1 (25% butter, 75% tofu); Fat Substitution 2 (25% butter, 75% nonfat plain yogurt); Fat Substitution 3 (25% butter, 75% flaxseed meal); Fat Substitution 4 (25% butter, 75% Spectrum Spread); Fat Substitution 5 (25% butter, 75% unsweetened applesauce); and Fat Substitution 6 (25% butter, 75% white bean puree). [See Table 1]. The recipe was scaled from the original sixty servings to yield one-hundred servings. The flaxseed cookies had an extra egg added to the batter to make the dough more pliable.

The white bean paste was made by boiling the Great Northern variety of white beans. The beans were drained of liquid and allowed to cool. Once the beans were cool they were pureed in a food processor until a smooth paste formed.

The control called for 380 grams of butter. The other samples were adjusted to use only 25% butter and include 75% of a substitute. Thus, each subsequent sample included 95 grams of butter and 285 grams of the designated substitute. All of the ingredients except the eggs and vanilla extract were weighed out for accuracy.

The flour, baking soda and salt were combined by hand in a small bowl, while the butter, fat substitutes, granulated sugar, brown sugar and vanilla extract were mixed using

a standing electrical mixer. The eggs were added one at a time, making sure to beat the mixture well after each addition. The flour mixture was gradually incorporated in stages. At this stage the bowl was removed from the mixer and the chocolate chip morsels were stirred in by hand. The dough was then poured onto wax paper, wrapped, placed in a zip lock bag and stored in a refrigerator overnight.

Table 1: Ratio of cookie ingredients by recipe.

	Control	75% Tofu	75% Yogurt	75% Flaxseed Meal	75% Spectrum Spread	75% Unsweetened Applesauce	75% White Bean Paste
Ingredient	**Amount**						
All-Purpose Flour	470 g	470 g	470 g	470 g	470 g	470 g	470 g
Baking Soda	5 g	5 g	5 g	5 g	5 g	5 g	5 g
Salt	10 g	10 g	10 g	10 g	10 g	10 g	10 g
Butter	380 g	95 g	95 g	95 g	95 g	95 g	95 g
Granulated Sugar	250 g	250 g	250 g	250 g	250 g	250 g	250 g
Dark Brown Sugar	275 g	275 g	275 g	275 g	275 g	275 g	275 g
Vanilla Extract	10 ml	10 ml	10 ml	10 ml	10 ml	10 ml	10 ml
Eggs	3	3	3	4	3	3	3
Semi-Sweet Chocolate Morsels	560 g	560 g	560 g	560 g	560 g	560 g	560 g
Plain Nonfat Yogurt	-	-	285 g	-	-	-	-
White Bean Puree	-	-	-	-	-	-	285 g
Tofu	-	285 g	-	-	-	-	-
Flaxseed Meal	-	-	-	285 g	-	-	-
Unsweetened Apple Sauce	-	-	-	-	-	285 g	-
Spectrum Spread	-	-	-	-	285 g	-	-

The next day the cookies were scooped onto a standard sized cookie sheet lined with a nonstick silicone pad and baked in an oven preheated to 375 degrees Fahrenheit. The cookies were baked for approximately twelve minutes per batch and allowed to cool before being stored in airtight containers until serving time.

Sensory Evaluation

Sensory analysis was conducted by sensory panelists, according to the testing procedures of IFT 1985 and Institutional Use of Humans in Research Guidelines. At the beginning of the sensory evaluation session, the participants were given a packet that included two copies of a consent form, a demographical survey and a scorecard. The participants were instructed to sign both copies of the consent form before the beginning of the experiment. One copy was returned to the principal investigator and the other was for the participants' records. Each cookie was cut in half for sampling. Cookie samples were coded with letters (from A to G) to ensure that the panelists would not know the identity of the samples. Bottled water was provided to cleanse the palate between samples. Tasters were instructed to taste a sample, rate it, and then cleanse the palate before going to the next sample. Cookies were evaluated for moistness, flavor, texture, color and acceptability to determine their overall quality using a 9-point hedonic scale where a score of 9 represents excellent and a score of 3 or below indicates unacceptable quality.

Sensory analysis is a vital part of the product development process. If a product does not taste good, consumers will not make repeat purchases. When it comes to developing a new product, sensory evaluation helps direct development to a more clear-cut goal and can

save money. The main purpose of sensory evaluation in product development is to minimize the chance of putting a product in the market that is not going to be well-liked. Secondly, sensory analysis steers developers in the direction of what marketing has requested.

Statistics

Statistical Analysis System (SAS, 1999) was used to perform the statistical computation of all data. General Linear Model (GLM) procedures and Duncan's Multiple Range Test were used to determine the association among these variables: fat substitution, sensory palatability traits (moistness, texture, flavor, color, and acceptability), gender, race, age, preference of sources, and frequency of consumption. Correlations, interactions, and differences were determined among dependent variables. All tests were conducted at the 95% level of confidence.

CHAPTER IV
RESULTS

Demographics

Eighty-four panelists participated in this study. About 66% of the participants were females and 34% were males. In terms of race, approximately 95% of the participants were African American, 1% was Hispanic and 4% were Caucasian. About 84% of the participants ranged in age from 18 to 24 years old, 8% ranged in age from 25 to 34 years old, 6% ranged in age from 35 to 49 years old and 2% of the participants were at least 50 years old.

Cookie Diameter and Height

The scoop produced cookies that were 4.3 centimeters in diameter and 2.5 centimeters in height. Yogurt-enhanced and control cookies gave the highest yield ($P<.05$) in terms of diameter of baked cookies. All other cookies had similar diameter after baking. In terms of height, the control cookies were the flattest of all the samples with a baked height of 0.8 centimeters. Cookies with white bean puree, flaxseed meal and tofu yielded cookies with increased height ($P<.05$) over the control. This might suggest that these additives contributed some leavening effect (Table 2).

Table 2: Cookie dimensions.

	Diameter (cm)			Height (cm)		
Sample	**Pre-baked**	**Baked**	**Change**	**Pre-baked**	**Baked**	**Change**
Control (100% Butter)	4.3	9.6^{a}	+ 5.3	2.5	0.8^{d}	- 1.7
75% Tofu	4.3	7.1^{c}	+ 2.8	2.5	1.7^{ab}	- 0.8
75% Yogurt	4.3	8.3^{b}	+ 4.0	2.5	1.2^{c}	- 1.3
75% Flaxseed Meal	4.3	7.3^{c}	+ 3.0	2.5	1.7^{ab}	- 0.8
75% Spectrum Spread	4.3	7.5^{c}	+ 3.2	2.5	1.1^{c}	- 1.4
75% Applesauce	4.3	7.7^{bc}	+ 3.4	2.5	1.3^{c}	- 1.2
75% White Bean Paste	4.3	7.1^{c}	+ 2.8	2.5	2.0^{a}	- 0.5

Values with the same letter in a column are not significantly different ($P<0.05$).

Fats differ in composition, with shortening and lard essentially 100% fat, butter around 81% fat, margarines by law exceed 80% fat and fat substitutes contain as much as 60% water. As the fat-to-water balance shifts, so does the functionality. The more water present in a fat or fat substitutes, the more steam is produced during baking. This release of steam causes a cookie to puff, increase the height of cookies (McWilliams, 2005).

Different factors affect if a fat is solid or liquid at certain temperatures, therefore affecting its behavior. These factors include: the composition, arrangement and length of its fatty acids as well as the source of fat and the effect of processing conditions on crystalline structure. Butter melts over a narrow temperature range. It begins to liquefy soon after being placed in an oven. At the same time, shortenings and lard remain solid at higher temperatures. This characteristic allows the oven to set a cookie's structure to some extent. The quicker a fat melts the more it spreads and flattens the cookie. It also does not aerate well either, resulting in flatter, poorly textured cookies (McWilliams, 2005).

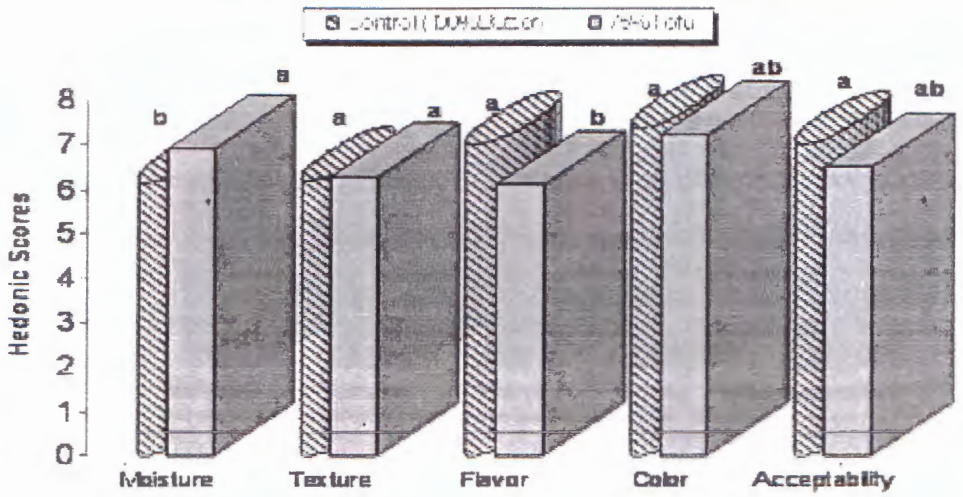
Effect of Fat Substitution on Moisture

Moisture scores for tofu and spectrum spread-enhanced cookies were significantly higher than control. Cookies made with yogurt, applesauce, and white bean puree had similar moisture scores to control, and those made with tofu and spectrum spread. Flaxseed cookies received the lowest scores (Figures 1-6).

Effect of Fat Substitution on Texture

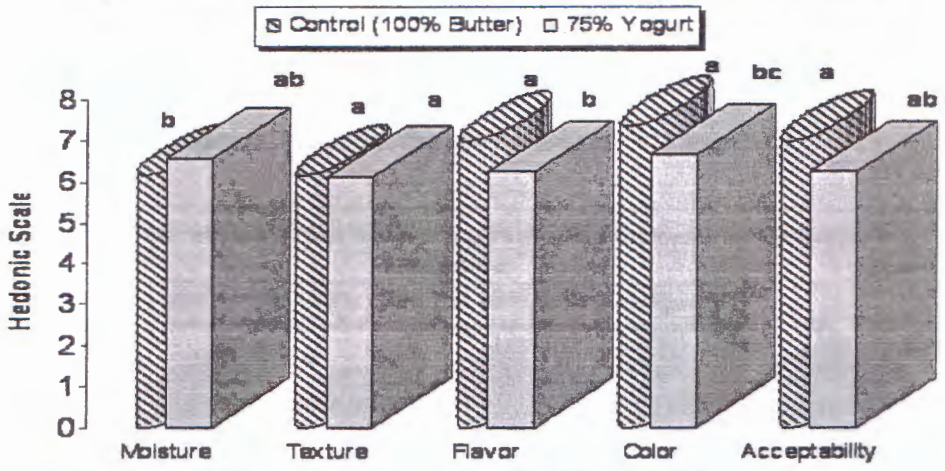
The texture of all cookies was not affected by fat substitutes, except for flaxseed, which received the lowest scores (Figures 1-6).

Fig. 1: Effect of tofu substitution on palatability traits in cookies



Values with the same letter in a column are not significantly different at P<0.05

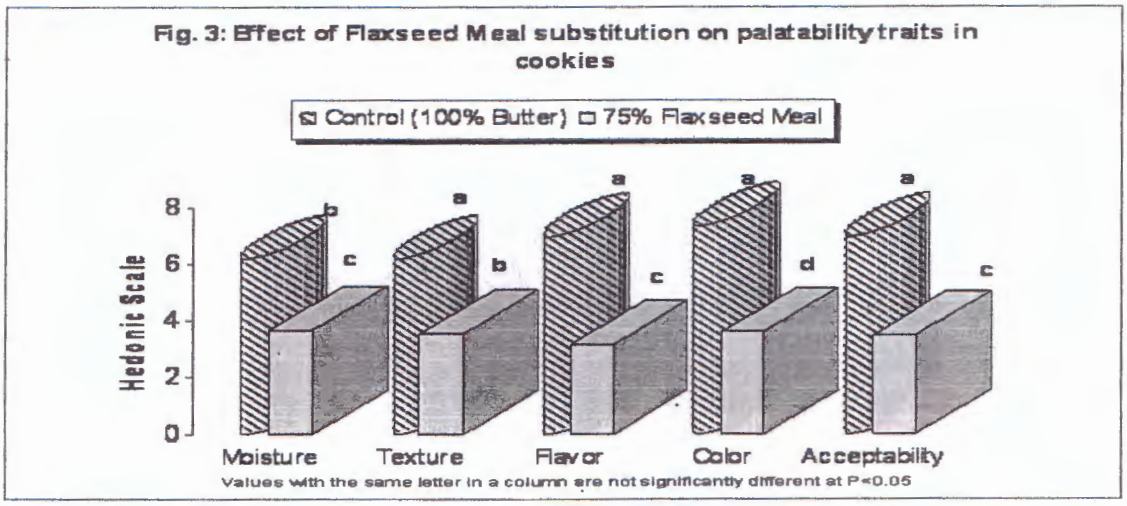
Fig. 2: Effect of yogurt substitution on palatability traits in cookies



Values with the same letter in a column are not significantly different at P<0.05

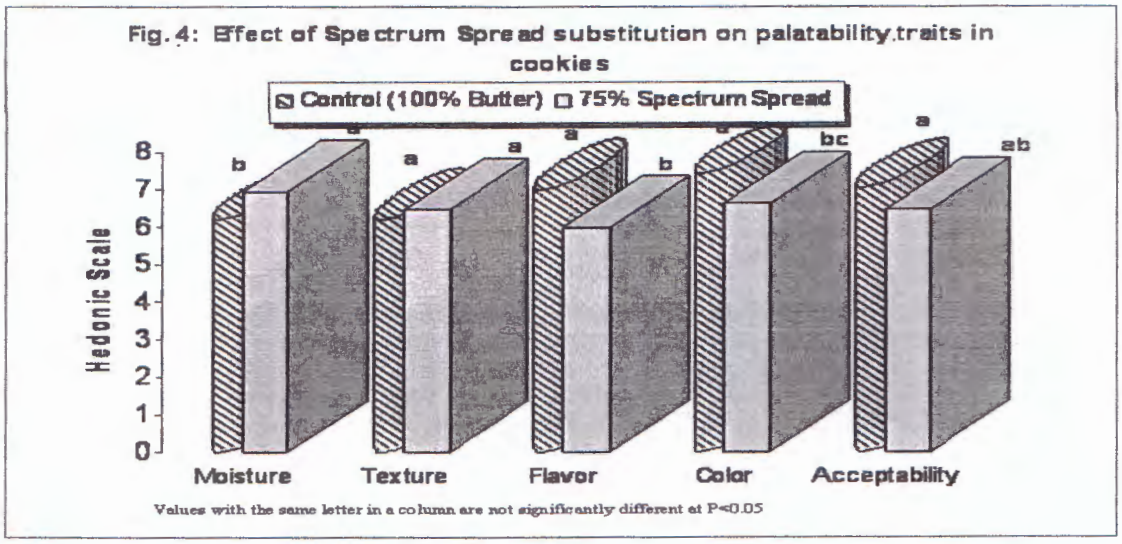
Effect of Fat Substitution on Flavor

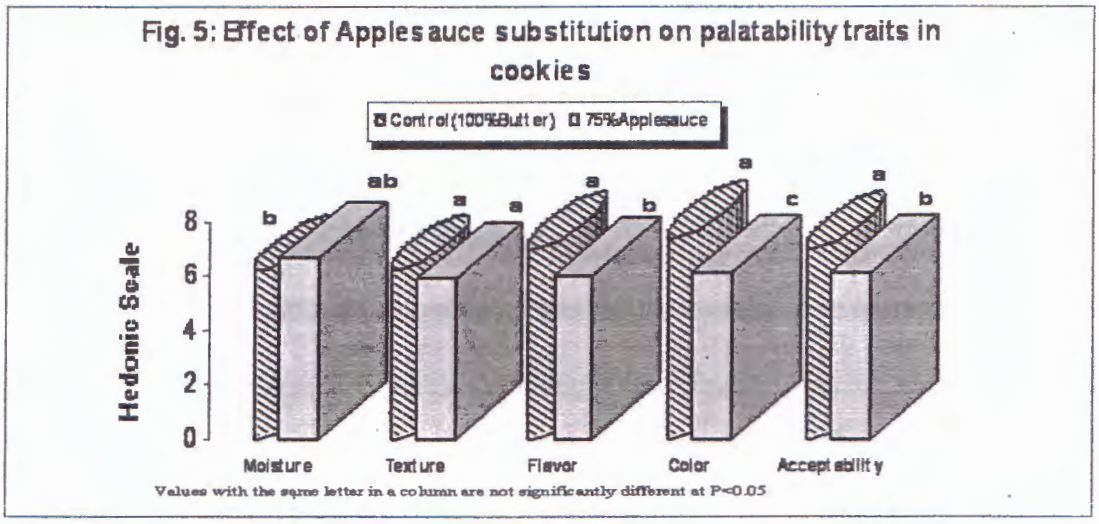
The control cookies had a significantly higher flavor score than all cookies. The flavor score for flaxseed was significantly lower than all cookies (Figures 1-6).



Effect of Fat Substitution on Color

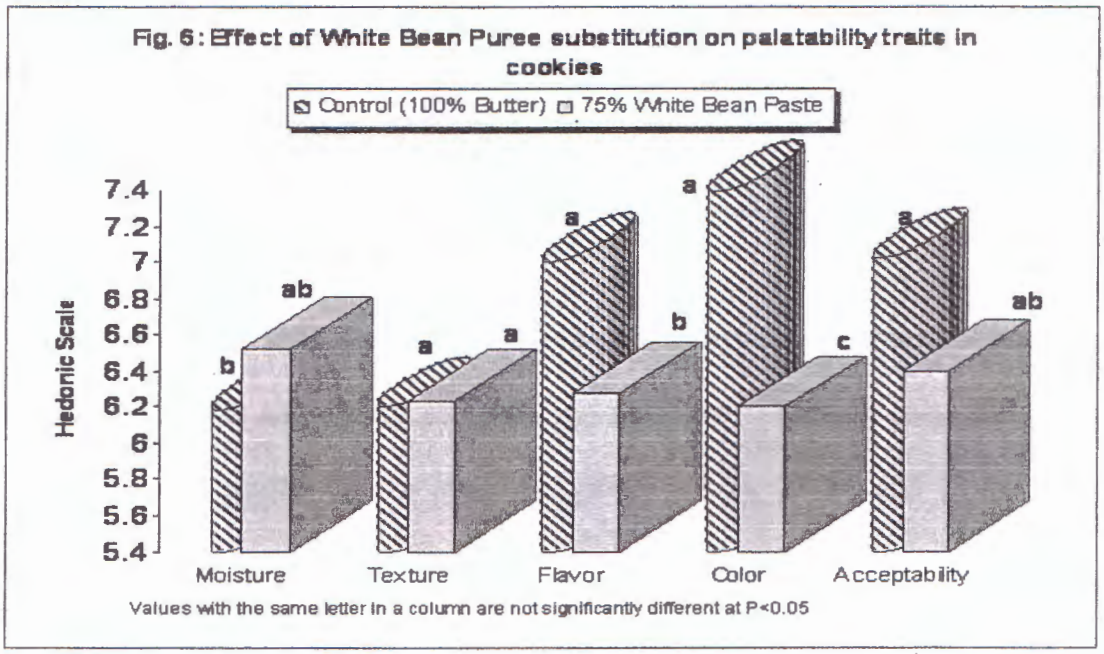
Color scores were extremely varied. Control and tofu-enhanced cookies had significantly higher scores on color than all cookies. However, values were not significantly different among tofu, yogurt, and spectrum spread cookies. Applesauce, spectrum spread, white bean puree and flaxseed received the lowest scores (Figures 1-6).





Effect of Fat Substitution on Overall Acceptability

Overall acceptability scores of cookies made with tofu, spectrum spread, and white bean puree were significantly higher than other cookies but were similar to control. Flaxseed received the lowest acceptability scores (Figures 1-6).



Palatability Traits as Affected by Gender

Gender had no significant affect on the general perception of moisture, texture, color, flavor and overall acceptability.

Palatability Traits as Affected by Race

African American and Caucasians perceived the cookies to be more moist, flavorful, have better color and more acceptable than Hispanics. Texture was not significant among races (Table 3).

Table 3: Comparison of attributes on the basis of race.

	Attributes				
Race	Moisture	Texture	Flavor	Color	Overall Acceptability
Hispanic	4.42[b]	4.29[a]	4.29[b]	4.14[b]	4.14[b]
Caucasian	5.86[ab]	5.66[a]	5.90[a]	6.76[a]	5.90[a]
African American	6.25[a]	5.85[a]	5.86[a]	6.28[a]	6.07[a]

Cookies were rated according to a 9-point Hedonic scale: 1=dislike extremely, 2=dislike very much, 3=dislike moderately, 4=dislike slightly, 5=neither like nor dislike, 6=like slightly, 7=like moderately, 8=like very much and 9=like extremely.

Values with the same letter in a column are not significantly different ($P<0.05$).

Palatability Traits as Affected by Age

Participants 35 to 49 years old gave the highest scores for all parameters (moisture, texture, flavor, color and overall acceptability) measured. Texture, color and overall acceptability were similar for the other age groups (18-24, 25-34, and 50 and over). However, panelists aged 50 and over rated flavor significantly lower than the other age

groups. Moistness was rated significantly higher for consumers aged 35-49 than in other groups (Table 4).

Table 4: Comparison of attributes on the basis of age.

	Attributes				
Age	Moisture	Texture	Flavor	Color	Acceptability
18-24	6.10^{b}	5.72^{b}	5.76^{a}	6.14^{b}	5.94^{b}
25-34	6.51^{ab}	5.80^{b}	5.84^{a}	6.34^{b}	6.11^{b}
35-49	7.51^{a}	7.31^{a}	7.06^{a}	7.97^{a}	7.43^{a}
50+	5.86^{b}	5.86^{b}	5.64^{b}	6.29^{b}	5.93^{b}

Cookies were rated according to a 9-point Hedonic scale: 1=dislike extremely, 2=dislike very much, 3=dislike moderately, 4=dislike slightly, 5=neither like nor dislike, 6=like slightly, 7=like moderately, 8=like very much and 9=like extremely.

Values with the same letter in a column are not significantly different ($P<0.05$).

Preference of Source

Preference of source is whether the participants prefer store bought cookies or homemade cookies. This factor did not appear to have a significant effect on the rating of the samples.

Frequency of Consumption and its Effects on Palatability Traits

In terms of cookie preferences, only 15.5% of the participants reported that they ate cookies on a regular basis (two or more times a week). Thirty-three and three-tenths percent reported eating cookies often (once a week), 38.1% reported eating cookies once in awhile (one to three times a month) and 13.1% reported eating cookies rarely (less than once a month). In choosing a source, 84.5% preferred homemade cookies and 15.5% preferred store

bought cookies. Seventy-five percent prefer chocolate chip cookies, while the remaining 25% of the participants prefer another flavor (Table 5).

Table 5: Cookie preference by frequency of consumption, source and flavor.

Preference	Number of Panelists	Percentage of Panelists
Frequency of Consumption:		
Regularly (2 or more times/wk)	13	15.5%
Often (Once a week)	28	33.3%
Once in Awhile (1-3 times/mo)	32	38.1%
Rarely (Less once a month)	11	13.1%
	Total: 84	
Source:		
Store Bought	13	15.5%
Homemade	71	84.5%
	Total: 84	
Flavor:		
Chocolate Chip	63	75%
Other	21	25%
	Total: 84	

Panelists who consumed cookies "regularly" scored the sensory attributes measured (moistness, texture, flavor, color, overall acceptability) significantly higher than those who consumed them "often," "once in awhile," or "rarely." Flavor values were not affected by frequency of consumption. Consumers who consumed cookies "rarely" had significantly lower acceptability scores then those who consumed it "regularly," "often" or "once in awhile" (Table 6).

Table 6: Comparison of attributes on the basis of frequency of consumption.

Frequency of Consumption	Attributes				
	Moisture	Texture	Flavor	Color	Overall Acceptability
Regularly (2 or more times/week)	6.80[a]	6.52[a]	6.23[a]	6.79[a]	6.48[a]
Often (Once a week)	5.88[b]	5.46[b]	5.78[a]	6.20[b]	6.17[ab]
Once in Awhile (1-3 times/month)	6.29[ab]	5.83[b]	5.67[a]	6.17[b]	6.00[ab]
Rarely (Less than once a month)	6.10[b]	5.82[b]	6.03[a]	6.06[b]	5.82[b]

Cookies were rated according to a 9-point Hedonic scale: 1=dislike extremely, 2=dislike very much, 3=dislike moderately, 4=dislike slightly, 5=neither like nor dislike, 6=like slightly, 7=like moderately, 8=like very much and 9=like extremely.

Values with the same letter in a column are not significantly different (P<.05).

CHAPTER V
DISCUSSION

Control cookies containing 100% butter were the largest in diameter ($P<.05$) after baking, but were the flattest of all the cookies with a baked height ($P<.05$) of 0.8 centimeters. This might suggest that the fat substitutes in the other cookies contributed some leavening effect resulting in their increased height over the control (Table 2). Fats differ in composition, with shortening and lard essentially 100% fat, butter around 81% fat, margarines by law exceed 80% fat and fat substitutes contain as much as 60% water. As the fat-to-water balance shifts, so does the functionality. The more water present in a fat or fat substitutes, the more steam is produced during baking. This release of steam causes a cookie to puff, increase the height of cookies (McWilliams, 2005).

Different factors affect if a fat is solid or liquid at certain temperatures, therefore affecting its behavior. These factors include: the composition, arrangement and length of its fatty acids as well as the source of fat and the effect of processing conditions on crystalline structure. Butter melts over a narrow temperature range. It begins to liquefy soon after being placed in an oven. At the same time, shortenings and lard remain solid at higher temperatures. This characteristic allows the oven to set a cookie's structure to some extent. The quicker a fat melts the more it spreads and flattens the cookie. It also does not aerate well either, resulting in flatter, poorly textured cookies (McWilliams, 2005).

My study revealed that the use of tofu as a substitute for fat in chocolate chip cookies yielded acceptable results. My findings were in agreement with the study conducted by

Keller et al. (2002) using tofu as a fat-ingredient substitute in fudge. Keller et al. (2002) found that fudge formulated with 75% tofu garnered acceptable scores for all of the parameters measured (appearance, texture, flavor, and overall acceptability). Thereby, it could be concluded from this study that pureed tofu could be used as a partial replacement for fat in chocolate chip cookie might yield a similar acceptability rating.

In this study, cookies formulated with 75% applesauce fared well for each parameter measured, but the flavor, color and overall acceptability were significantly lower than the control. Swanson and Munsayac (1999) measured the parameters for liking, hardness, chewiness, flavor acceptability, presence of off-flavor and freshness in peanut butter, oatmeal, and chocolate chip reduced-fat cookies formulated with fruit purees. For the chocolate chip recipe, the cookies with prune puree were liked more than the applesauce and were rated higher on all of the parameters measured except the presence of off-flavor. The prune cookies fared better than the applesauce and the control recipe for oatmeal cookies in all parameters with the exception of the presence of off-flavor. The applesauce cookies were rated higher than the prune and the control peanut butter cookies in terms of softness and tenderness. Off-flavors were detected the least for applesauce peanut butter cookies (Swanson, 1999). Overall, the applesauce performed well as a partial fat replacement in cookies so it could be concluded that both applesauce and prune puree would be acceptable fat substitutes in a variety of cookie flavors because the yield a tender, moist and fresh product.

The cookies formulated with 75% white bean puree in this study received high rating for each parameter measured. These results contradicted the findings of Rankin and Bingham (2000). The difference may be attributed to the fact that Rankin and Bingham used oatmeal chocolate chip cookies in their study analyzing the acceptability of cookies prepared using pureed white beans as a fat ingredient substitute for butter. There was not a significant difference in texture rating for all samples (0%, 25%, 50% and 75% white bean puree). The sample using 75% pureed white beans was liked slightly. The most significant difference in ratings between control and 75% sample was for the parameters of flavor and overall acceptability (Rankin, 2000).

CONCLUSION

Tofu cookies (75% level) received high scores for moistness, flavor and texture and ranked highest for color and overall acceptability after the control. Spectrum Spread cookies (75% level) received high scores for the moisture, texture, color and overall acceptability categories and ranked highest for moisture and texture overall. White bean puree cookies (75% level) received high scores for texture, flavor and overall acceptability and ranked highest for flavor after the control. The use of these fat substitutes yielded wholesome cookies that could be utilized by consumers aged 35 to 49 who consume cookies "regularly" and are on a reduced-fat diet. Furthermore, tofu and white bean puree are rich protein sources, additives which could enhance the protein content of the vegetarian diet and provide isoflavones for menopausal women. My study revealed that, tofu, Spectrum Spread or white bean puree at the 75% level of formulation would make acceptable substitutes for for butter in a chocolate chip cookie recipe. Availability of these reduced-fat cookies in the marketplace may lower excess fat consumption associated with chronic diseases while allowing retention of some favorite foods in the diet.

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APPENDIX A

1. Gold Medal® All-Purpose Flour (General Mills Sales, Inc., Minneapolis, MN)
2. Arm & Hammer® Baking Soda (Church & Dwight Co., Inc., Princeton, NJ)
3. Morton's ® Iodized Salt (Morton International, Inc., Chicago, IL)
4. Mid-America Farms® Butter (Keller's Creamery, Kansas City, MO)
5. Domino® Granulated Sugar (Domino Foods, Inc., Yonkers, NY)
6. Domino® Dark Brown Sugar (Domino Foods, Inc., Yonkers, NY)
7. Tone's® Pure Vanilla Extract (Tone Brothers, Inc, Ankeny IA)
8. Eggland's® Best Eggs (Eggland's Best, Inc., King of Prussia, PA)
9. Nestle® Toll House® Semi-Sweet Chocolate Morsels (Nestle USA, Inc., Solon, OH)
10. Dannon® Plain Nonfat Yogurt (Allentown, PA)
11. Camellia Brand® White Beans (L.H. Hayward & CO., L.L.C., Harahan, LA)
12. Mori-Nu® Soft Silken Tofu (Morinaga Nutritional Foods, Inc., Torrance, CA)
13. Spectrum Essentials Organic Ground Premium Flaxseed (Spectrum Organic Products, Inc., Petaluma, CA)
14. Mott's® Unsweetened Apple Sauce (Mott's Inc., Rye Brook, NY)
15. Spectrum Spread (Spectrum Organic Products, Inc., Petaluma, CA)

APPENDIX B

Informed Consent for Participation in Sensory Evaluation

Title of Project: Assessing the Acceptability of Chocolate Chip Cookies Formulated with Fat Substitutes

Principal Investigator: Marcel R. Gailes

PURPOSE OF THE PROJECT

You are invited to participate on a sensory evaluation panel that involves assessing the various sensory characteristics pertaining to a particular formulation of a chocolate chip cookie. Establishing such information will be correlated with objective measurements to evaluate the efficacy of butter substitutes as a replacement for 75% of the fat content in the standard Toll House chocolate chip cookie recipe. A student in the Department of Human Nutrition and Food is conducting this project. Your participation is voluntary.

PROCEDURES

There will be only one session involving a convenient sample of 100 subjects. The session will be approximately 20 minutes long. You will be presented with 7 samples during the test session. As a panelist, it is critical to the project that you give a truthful answer. Panelist will also be required to complete an informed consent form, a demographic sheet and record sample ratings on a scorecard. Certain individuals are sensitive to some foods such as milk, eggs, wheat gluten, strawberries, chocolate, artificial sweeteners, etc. If you are aware of any food or drug allergies, please list them in the following space and immediately inform the principal investigator prior to consuming any samples: _____.

BENEFITS/RISKS OF THE PROJECT

Your participation in the project will provide useful information that can be used in the further development of a high quality low-fat chocolate chip cookie. There are no food additives involved and this study and all ingredients used have been approved by the Food and Drug Administration, so there are minimal risks involved, provided you do not have any unknown food allergies. You may receive the results or summary of the panel when the project is completed.

EXTENT OF ANONYMITY AND CONFIDENTIALITY

The results of your performance as a panelist will be kept strictly confidential. The demographics will be used for statistical purposes only. Individual panelists will be referred to by code for analyses and in any publication of the results.

COMPENSATION

No compensation will be provided for panelists involved in this study.

FREEDOM TO WITHDRAW

It is essential to sensory evaluation projects that you complete the session. However, there may be conditions preventing the completion of the session. If after reading and becoming familiar with the sensory project, you decide not to participate as a panelist, you may withdraw at any time without penalty. If a participant's safety is at risk due to a possible allergy or food drug-interaction then participation may be terminated by the principal investigator without regard to the participant's consent.

APPROVAL OF THE RESEARCH

This research project has been approved by the Institutional Review Board for projects involving human subjects at Southern University and A&M College. If you have questions or concerns about your rights as a participant in this research study or to report a research-related injury contact:

Jimmy D. Lindsey, Ph.D., Chairperson

Institutional Research Oversight Committee

P. O. Box 11241, Southern University-Baton Rouge, Baton Rouge, LA 70813-1241

Voice: 225-771-3950

Facsimile: 225-7715652

E-mail: Jimmy_Lindsey@CXS.SUBR.edu

SUBJECT'S RESPONSIBILITIES

I know of no reasons I cannot participate in this study, which will require which will require participating in one session lasting approximately 20 minutes.

Signature _____ Date _____

SUBJECT'S PERMISSION

I have read the information about the conditions of this sensory evaluation and give my voluntary consent for participation in this project. I know of no reasons I cannot participate in this study, which will require which will require participating in one session lasting approximately 20 minutes.

Signature _____ Date _____

Should I have any questions about this research or its conduct, I may contact:

Marcel R. Gailes

(225) 802-0784

Investigator

Senior

Department of Human Nutrition and Food

Southern University and A&M College

MRGailes@yahoo.com

Janet Gager, M.S.

(225) 771-2242 Ext. 266

Faculty Advisor

Instructor and Research Associate

Department of Human Nutrition and Food

Southern University and A&M College

janetg@subr.edu

APPENDIX C

Panelist No: _____

ASSESSING THE ACCEPTABILITY OF CHOCOLATE CHIP COOKIES FORMULATED WITH FAT SUBSTITUTES

Demographical Survey

The following questions will be used for statistical reasons only.

1. Age: _____
2. Gender: _____

Circle the answer that applies to you.

3. How often do you eat sweets in general?

Regularly Often Once in awhile Rarely Never

4. How often do you eat cookies?

Regularly Often Once in awhile Rarely Never

5. What is your cookie preference?

Chocolate Chip Cookie

Sugar/Shortbread

Oatmeal/Oatmeal Raisin

Peanut Butter

White Chocolate Macadamia

Fudge/Double Chocolate

Other: _____

APPENDIX D

Panelist No: _____

ASSESSING THE ACCEPTABILITY OF CHOCOLATE CHIP COOKIES FORMULATED WITH FAT SUBSTITUTES

Scorecard

Samples must be rated according to a 9-point Hedonic scale:

1) Dislike extremely
2) Dislike very much
3) Dislike moderately
4) Dislike slightly
5) Neither like nor dislike
6) Like slightly
7) Like moderately
8) Like very much
9) Like extremely

Sample	Moistness	Texture	Flavor	Color	Overall Acceptability
A					
B					
C					
D					
E					
F					
G					

Marcel R. Gailes
5324 Lennox Street
Zachary, Louisiana 70791
225-654-2190
MRGailes@yahoo.com

Career Objective: To acquire a research position in a laboratory setting or as a sensory analyst that would utilize my experience in Food Science towards the development of new food products.

EDUCATION

Southern University and A&M College, Baton Rouge, LA
Major: Human Nutrition and Food, Bachelor's of Science
Minor: French
GPA: 3.6/4.0
Expected date of graduation: July 2006
Honors College Thesis: Assessing the Acceptability of Chocolate Chip Cookies Formulated with Fat Substitutes
Defense date – April 2006

HONORS AND AWARDS

Chancellor's Scholar
College of Agricultural, Family and Consumer Sciences Academic Excellence Award, Spring 2003
College of Agricultural, Family and Consumer Sciences Student of the Year, Spring 2005
Dean's List
Highest GPA in the College of Agricultural, Family and Consumer Sciences, Spring 2006
Meritorious Scholarship Award in the Department of Foreign Languages, Spring 2004
Outstanding French 201 Student, Spring 2003
Outstanding French Student, Fall 2003

PROFESSIONAL ASSCOIATIONS

Alpha Mu Gamma Honor Society, Member Since 2003
Honors Student Association, Member Since 2001
National Scholars Honor Society, Member Since 2006
Phi Upsilon Omicron Honor Society, Member Since 2003

LEADERSHIP/SOCIAL ACTIVITIES

Alpha Mu Gamma Honor Society

- President, Spring 2003 – Spring 2006

Dietetics Club

- Secretary, Spring 2005 – Spring 2006

French Club

- President, Fall 2003 – Spring 2006

Phi Upsilon Omicron Honor Society

- Publicity Chair, Fall 2004 – Spring 2006

SKILLS

Computer literate
Can operate cash register
Knowledge of Microsoft Office Suite and Microsoft Works
Knowledge of the PrintMaster series and Adobe PageMaker
Able to read, write and speak French
Minimal fluency in American Sign Language
Minimal competency in HTML programming

REFERENCES

Upon Request

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Author Marcel R. Gailes

Date 7/20/06