MUNGBEAN PASTE SUBSTITUTION FOR BUTTER

IN PEANUT BUTTER COOKIES

By

MELISSA ADAIR

Bachelor of Science

Oklahoma State University

Stillwater, Oklahoma

1998

Submitted to the Faculty of the
Graduate College of the
Oklahoma State University
in partial fulfillment of
the requirement of
the Degree of
MASTER OF SCIENCE
December, 1999

MUNGBEAN PASTE SUBSTITUTION FOR BUTTER

IN PEANUT BUTTER COOKIES

Thesis Approved:

Barbara J. Stoecker

Thesis Adviser

Gail Gates

Sue Knight

Patricia Rayas Duarte

Wayne B. Powell

Dean of the Graduate College

ACKNOWLEDGEMENTS

This thesis is the outcome of the efforts of many people. Every step of the way someone has come beside me to give guidance and encouragement.

Dr. Knight introduced Mr. Eckroat and his mungbeans to my Experimental Foods class three years ago. My life has been changed by this simple introduction.

Dr. Gates helped me interpret statistics. Analyzing statistics had been a great source of stress until Dr. Gates walked me through the process.

Dr. Stoecker always encouraged me. By allowing me to take communications courses while working on my master's degree, I was able to have an assistantship to help pay for my research. I appreciate her support and guidance during some important decisions in my life. I believe the professors in the nutrition department truly have a heart to help students. Thank you.

I am thankful to Dr. Rayas for serving on my committee. Her expertise in cereal chemistry and her contacts with the American Institute of Baking were very helpful in learning the qualities of a good cookie.

Thanks so much to Dr. Sangiah for her help with sensory evaluation. Dr. Sangiah met with me many times and introduced me to Langston University and a new world of sensory evaluation. My thanks for Dr. Sangiah's patience when I was very frustrated.

I am thankful to Dr. Arjmandi for stressing ethics as a top priority in my graduate course: research methods. When I faced an ethical decision while working on this thesis,

Dr. Arjmandi's words kept coming back. "It is better to be totally honest and be able to live with yourself then to compromise your integrity for a momentary gain".

Jen-Chieh Huang (Jack) was extremely helpful in answering my daily questions. I am so glad Jack was around to let me know that it is normal for a graduate student to feel stressed out. I consider Jack a dear friend and will always be thankful that our paths crossed.

I want to thank Dr. and Mrs. Alejandro Penaloza Encarnacion for their support during my college years. I learned a lot about the Mexcian culture over the past 6 years years. I also learned about some of the difficulties it takes to leave your family and friends in order to pursue your goals. Thank you.

Thank you to the seven dietitians who gave me advice while I was interning at Southern Progress Corporation. Each one of them encouraged me to get my master's degree while I was at college and had no spouse or children. Now I think I know why.

Thank you to my high school teachers who encouraged me that I could make it in a "big" college. They challenged me to dream big and encouraged me long after I had completed high school. The foundations they laid in my life as a youth were secure enough to help me withstand the pressures to give up along the way.

Thank you to my pastors David and Lynette Chapman, Brad and Julie Riley, Orville and Sherri White, and Sherri Smith. It would have been impossible for me to keep my priorities in order and my life in perspective without you constantly pointing me toward God.

A very special thanks to my aunt and uncle, Ruthie and Kenneth, and my cousins, Dustin and Ryan. They allowed me to live in their home during the past 2 ½ years. I am

thankful for their patience when I came home stressed out. They provided a lot of much needed support and guidance and a home that was a peaceful refuge.

I would like to thank my grandma, Betty. Her love of cookbooks and health books was passed on to me.

I would especially like to thank my parents, Dennis and Wanda Adair, and my brother, Cameron. Many phone conversations with me allowed them the opportunity to thank God that I lived with my aunt and uncle while writing this thesis. They have always been very supportive. They stressed the importance of getting a good education all my life, and were willing to taste most of my concoctions in the name of food science. Thank you for being an anchor in my life.

I would like to thank my savior Jesus Christ. I am thankful that he daily encourages me to persist. He picks me up when when I am hurting. He makes me laugh and encourages me through his word. Anytime I have felt overwhelmed, I could come to him and ask for help and he would give me peace. Nothing refreshes me like time in his presence. I am thankful he sticks with me in spite of my shortcomings.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

Mungbean (*Vigna radiata*) is a legume grown around the world as human food. Fifteen to twenty million pounds of mungbean are consumed annually in the United States (Oplinger et al., 1990). Domestic production of mungbean is estimated to be over 50 thousand hectares, with about 90 percent produced in Oklahoma (Cupka and Edwards, 1988) and the remainder in Texas and California (Poehlman, 1991). One hectare is 10,000 square meters or 2.47 acres. In Oklahoma, mungbean is grown as a short-season crop during the hot, dry summer often on post-harvest wheat land. The primary use of mungbean for a human food is as bean sprouts; however if the mungbean does not meet sprouting standards it may be used as a livestock food (Oplinger et al., 1990). In unfavorable seasons, a large portion of the crop in Oklahoma may be plowed under for green manure. Mungbean is widely perceived to be a low production and low income crop. Because yields fluctuate widely, production practices that require moderate investments of labor and capital are practiced less frequently than with staple crops (Poehlman, 1991).

The mungbean is rich in nutritional content. Mungbean cotyledon is high in protein (25%), carbohydrate (66%), phosphorus (290mg/100g), and calcium (70mg/100g). Mungbean averages about 24% protein, this is about two-thirds the protein content of soybean, twice that of wheat, and three fold that of rice (Poehlman, 1991). The protein in mungbean is rich in lysine, which is an amino acid deficient in cereal grains. Mungbean protein is deficient in methionine, cystine, and cysteine. These are sulfur-bearing amino acids found abundantly in cereal grains. A diet which combines mungbean and cereal grains, such as wheat or rice, compensates for the deficiencies in protein quality found in either food alone.

Lipids are present in small amounts in mungbean seeds. Mungbean has 1.15 g of fat per 100 g of edible seeds. This is around 20 times less fat than soybeans and 2 times less fat than wheat and rice. The major fatty acid in mungbean is linolenic, with oleic and linoleic acids also present (Salunkhe et al., 1982). Most of the research on legume seeds is conducted on soybean or oilseeds such as peanut. Very little research has been published utilizing the low-fat qualities of mungbean in human food products.

The School Meals Program plays an important role in the health and well-being of US children. The Federal Register (CFR, 1995) states that school lunches shall be provided based on the nutrition standards of several sources including the US Dietary Guidelines (USDA and DHHS, 1995). The Dietary Guidelines for Americans recommends choosing a diet low in fat, saturated fat, and cholesterol. The diet allows no more than 30 percent of total calories come from fat (USDA, 1995). Reducing fat content of menu items, either prepared in-house or purchased (Sneed, 1992), will help meet this nutrition standard (CFR, 1995). Childhood and adolescence are the two periods in life when consumption of saturated fat is the highest (above 12.5% of energy) (DHHS, 1994). One way to implement the current dietary guidelines and recommendations for reduced consumption of fat is to introduce modified foods with reduced fat and/or low saturated fat into the diet of children and adults (Lyle et al., 1992; Mattes, 1993; Sigman-Grant et al., 1993). In a survey of strategies to reduce fat intake in the long term, use of fat-modified foods was ranked as the easiest and most preferred strategy (Rolls, 1994). The success of this type of dietary intervention depends on the sensory acceptability of the fat-modified foods included in the diet (Mela, 1992), and how similar they are to their full-fat counterparts (Mattes, 1993). Most consumers are not ready to trade taste for health; therefore the reduced fat products need to be at least as acceptable as the regular ones, even though they may taste different, to be seen as full alternatives (Williams, 1992). The use of fat replacers is one way to modify recipes to reduce fat content. Although some students have been shown to accept some reduced-fat foods (Epstein, 1994), it is unclear if they will accept reduced-fat versions of their favorite baked products, such as cookies. Successful fat reduction in cookies is difficult to achieve (Pyler, 1988). Cookies are low moisture baked products. The type and amount of fat influence their quality attributes. However, if the amount of sweetness in the cookie is maintained, consumers will tolerate some deviations from the standard recipe in both texture and flavor (Drewnowski et al., 1998).

The most difficult quality attributes to emulate are those of the full-fat peanut butter cookie (Swanson and Munsayac, 1999). In a study by Swanson (1998), all peanut butter cookies were rated significantly less acceptable than the control when fat was reduced. Swanson concluded that cookies formulated with fat replacers and/or emulsifier combinations should be investigated.

Legumes are one type of food that has been studied as a fat-replacer. Rankin (1998) substituted canned, pureed, cannellini beans for fat in oatmeal chocolate chip cookies and concluded that beans appear to be an acceptable substitute for fat at low levels.

Mungbeans are a legume. They contain no cholesterol and very little fat. Cooking mungbeans softens their texture, improves flavor and palatability, destroys antinutritional factors and enzyme inhibitors, and increases nutritive value and digestibility (Poehlman, 1991). Traditional products produced from the mungbean are porridge, bean cake, confectionaries, noodles, and fresh green beans (Adsule et al., 1986). Cookies produced with mungbean have used mungbean flour or mungbean protein isolate to improve the nutritional value of cookies for Philippine school children (Payumo, 1978). Mungbean as a fat replacer in cookies has not been studied. In addition to nutritional aspects, mungbean incorporation into a traditionally accepted food, such as a cookie, could help increase the domestic usage of non-sprouting mungbeans.

Statement of Problem

In unfavorable seasons, a large portion of the mungbean crop in Oklahoma may be plowed under for green manure. If the harvested mungbean does not meet sprouting standards it may be used as a livestock food since the bean sprouts are the major use of the bean in this country. Utilization of mungbean seed in animal feed is uneconomical except where it makes use of beans unsuited for human food (Poehlman, 1991). Non-sprouting mungbeans are consumed in the rest of the world as a high protein human food. In America, food products utilizing non-sprouting mungbeans have been virtually non-existent. Mungbean product development catering to the needs of the American consumer is needed. Most Americans consume fat in excess of the US Dietary Guidelines. School lunch programs stress the importance of following the US Dietary Guidelines. It would be beneficial to improve a high-fat dessert that is currently being served in schools around the nation. This would increase the frequency of serving this popular dessert. It would also help create an economic boost for the non-sprouting mungbean, which has been an overlooked source of nutrition by most American consumers.

Purpose and Objectives

The main purposes of this study were: to develop an acceptable peanut butter cookie using mungbean paste in place of butter, to determine its characteristics through objective and subjective (sensory evaluation) tests, and to test its acceptability through consumer preference testing.

The objectives of this study were:

1. To determine if mungbean paste used in place of butter in a peanut butter cookie would produce a taste and texture similar to the peanut butter cookie recipe provided by the USDA for use in national school lunch programs (USDA: Quantity Recipes for School Foodservice, 1988).
2. To determine whether the use of emulsifying agents in the mungbean peanut butter cookie would provide texture attributes similar to those of the control peanut butter cookie.
3. To compare sensory characteristics of control peanut butter cookies against peanut

butter cookies made with different levels of mungbean paste in place of butter. Comparison of the sensory characteristics will be measured by two texture indicators (hardness, fracturability) and three flavor indicators (peanut flavor, butter flavor, different flavor).

4. To compare objective tests among all experimental and control cookies as measured by calculations of specific gravity, average weight before baking, average weight after baking, average width (as-is), average thickness (as-is), adjusted width, adjusted thickness, width/thickness ratio (as-is), adjusted width/thickness ratio, and spread factor.
5. To compare consumer preferences between a control peanut butter cookie and a peanut butter cookie made with mungbean paste.
6. To correlate objective and subjective data obtained in this study.
7. To make recommendations for further studies in this area.

Hypotheses

The following hypotheses were postulated for this research.

H_1: There would be no significant difference in the control peanut butter cookies and peanut butter cookies made with 50% mungbean paste in place of butter as measured by:

1. Sensory attributes of two texture indicators (hardness, fracturability) and three flavor indicators (peanut flavor, butter flavor, different flavor).
2. Objective tests measured by calculations of specific gravity, average weight before baking, average weight after baking, average width, average thickness,

adjusted width, adjusted thickness, width/thickness ratio, adjusted width/thickness ratio, and spread factor.

H_2: There would be no significant difference among the peanut butter cookies containing mungbean paste for the sensory attributes: hardness, fracturability, peanut flavor, butter flavor, different flavor as measured by:

1. Sensory attributes of two texture indicators (hardness, fracturability) and three flavor indicators (peanut flavor, butter flavor, different flavor).
2. Objective tests measured by calculations of specific gravity, average weight before baking, average weight after baking, average width (as-is), average thickness (as-is), adjusted width, adjusted thickness, width/thickness ratio (as-is), adjusted width/thickness ratio, and spread factor.

H_3: There would be no significant difference in the overall consumer acceptability of the control peanut butter cookie and the 25% mungbean paste cookie.

H_4: There would be no significant difference in the overall consumer acceptability of the control peanut butter cookie and the 50% mungbean paste cookie.

Assumptions

The following assumptions were made by the author at the beginning of this study:

1. Adding an emulsifier to the peanut butter cookie containing mungbean paste improves its texture.
2. The emulsifiers tested were chosen from among those widely used by manufacturers of baked products, and the levels listed were those recommended by the manufacturer.
3. The consumer panel is representative of a large population.
4. The data produced by a semi-trained panel is adequate in determining the attributes tested.
5. After completion of the training, the panel used their developed skills to accurately evaluate the attributes of the cookies, and the data generated reflected the ratings of the panel, not preference.
6. Conventional ovens were used rather than commercial ovens.

Limitations

The limitations of this study are:

1. The recipe selected for preparation yields an acceptable cookie to serve as the control.
2. Due to the scope of the study it was not possible to test every commercially available emulsifier or to test every allowable level of each emulsifier used.
3. Consumer panel subjects may not represent a true random sample of the total population.

4. Though the protocol for baking the cookies in the conventional oven was identical, a large convection oven where all cookies could have baked at once would have reduced the chances for human error.
5. The trained taste panel received a limited amount of training and cannot be considered as a fully trained panel.
6. All the attributes of the peanut butter cookies containing mungbean paste could not be studied in sensory evaluation.

Format of Thesis

The study discussed in this thesis was outlined and written according to the Style Guide for Research Papers of the Institute of Food Technologists.

CHAPTER II

REVIEW OF LITERATURE

The purpose of this study was to develop a peanut butter cookie using mungbean paste in place of butter. Once this cookie was developed, objective, sensory, and consumer evaluations were conducted. The review of literature begins with an overview of past research conducted on mungbeans, mungbean composition, health benefits of mungbean consumption, overview of cookies, emulsifiers, and objective testing methods.

Overview of Mungbeans

Mungbean is a pulse crop grown principally for its protein rich edible seeds. Mungbean and other pulse crops are also referred to as grain legumes. Pulse crops do not include grain legumes such as the soybean, groundnut, or peanut, because they are species that are grown for their high seed oil content and are generally classified as oilseed crops (Poehlman, 1991). Mungbean has been grown in India since ancient times and is still grown widely in Southeast Asia, Africa, South America, and Australia. It was grown in the United States as early as 1835 as the Chickasaw pea. It is closely related to the adzuki and cowpea (Oplinger et al., 1990). Mungbean may be called mung, mung bean, green gram (India), liewdow (China), nokdu (Korea), ryokuto (Japan), landek bay (Cambodia), tou kiew (Laos and Thailand), kajang hijang (Indonesia and Malaysia), mungobohne (Germany), moong (Bangladesh), Jerusalem pea (Jamaica), or mat-pe (Burma)

(PCARR,1977).

Mungbean Production

The production of mungbean constitutes about five percent of the world production of all pulses (Poehlman, 1991). Fifteen to twenty million pounds of mungbean are consumed annually in the United States (Oplinger et al., 1990). About 75% of the mungbean used in the U.S. is imported. Mungbean imports into the U.S. average five to seven thousand metric tons (mt) annually with Thailand and Australia supplying about 60 percent of the total (Poehlman, 1991). The United States imports of mungbean are summarized in Table 1. The area planted to mungbean in the United States is estimated to be in excess of 50 thousand hetares with about 90 percent in the state of Oklahoma (Cupka and Edwards, 1988) and the remainder in Texas and California (Poehlman, 1991). Mungbean production for selected countries is summarized in Table 2.

Mungbean seeds vary in weight from 15 to 85 milligrams and generally average 25 to 30 thousand seeds per kilogram (Poehlman, 1991). In Oklahoma, mungbean is grown as a short-season crop during the hot, dry summer months. Low soil moisture and high temperatures during flowering cause flower abortion and reduce pod setting. The portion of the crop that is not plowed under is mechanically-harvested for seed that is marketed for sprouting and planting (Poehlman, 1991).

Table 1. United States imports of mungbean[a]

Country of origin	Quantity imported 1985-86 mt[b]	1986-87 mt[b]	1987-88 mt[b]
Angola	21	0	0
Australia	2,670	1,875	1,425
Chile	0	63	59
China (PRC)	465	564	496
Dominican Republic	19	0	0
Hong Kong	147	362	217
India	348	447	270
Kenya	28	163	98
Korea, South	17	0	0
Malawi	30	10	7
Mexico	0	18	37
Nepal	36	0	0
Peru	749	441	268
Philippines	1	21	6
Republic of South Africa	0	4	0
Singapore	216	0	0
Taiwan (ROC)	77	27	128
Thailand	2,933	2,291	1,195
Venezuela	0	44	0
Other[c]	96	470	305
Total	7,853	6,800	4,511

[a] Data from USDA (1988).

[b] September 1 to August 31 period

[c] Includes transhipment from non-mungbean producing countries with country of origin not specified

Table 2. Mungbean production: area planted, yield, and production for selected countries

Country	Year[a]	Area 1000 ha	Yield kg/ha	Production	Source of information
Thailand	1986	434.3	606	262.0	Chainuvati et al. (1988)
U.S.A.	1988	50.0		2.5	Cupka and Edwards (1988)
India	1984-85	2725.0	409	1115.0	Sandhu et al. (1988)
China	1987	500.0	675	337.5	Ling et al. (1988)

[a] The latest year for which production figures are available is used.

Mungbean Research

Due to fluctuation in mungbean yield and its perception as a low income crop, biotechnological research with legumes has been largely directed largely towards forage legumes or soybean. Relatively little research has been devoted to mungbean. Biotechnological research is expensive and the attainment of practical benefits is long term. Considering the economic status of the mungbean crop, it does not appear likely that it will be the focus of a major biotechnology research effort (Poehlman, 1991). Therefore, it is important to focus on different approaches to mungbean research.

Several nutritional studies have been conducted on mungbeans. Mungbeans lower cholesterol in the serum, liver, and aorta of rats (Adsule et al., 1986). Mungbean usually usually has the least flatulence potential when compared with other legumes (Fleming, 1981; Murphy, 1975; Rachie and Roberts, 1974). Mungbean flour and protein isolates have been utilized to fortify many types of food products. In the Philippines, 80% of preschool children were below the normal weight range, with nutritionally inadequate food during infancy and at weaning time being cited as the cause (Payumo, 1978). This prompted the development of high protein food supplements made with mungbean and other vegetable protein flours for use as weaning foods and for school feeding programs (Morton et al., 1982). A product called Nutripac was one of the weaning foods developed. Nutripac is made from mungbean grits, rice, skim milk powder, and oil. Dried flakes are made utilizing mungbean flour with various combinations of rice flour protein isolate, fish protein concentrate, or dried milk (Morton et al., 1982). Other studies using mungbean as a protein fortifier have been successful. A promising area of mungbean research consists of nutritional enhancement of food products.

Nutritional Quality of Mungbean

Mungbean has six main constituents: water, 9.1%; protein 22.9%; fat 1.2%; carbohydrates 62.6%; crude fiber 5.3%, and ash 3.3% (Poehlman, 1991). The caloric value of mungbeans is 334 kcal/100g. The nutritional quality of mungbean is relatively better than most legumes, but lower than that of animal proteins (Adsule et al., 1986).

Mungbean consists of three parts: seedcoat, germ, and cotyledon. Each part has been evaluated separately for nutritional quality. The chemical composition of different seed lots of all species will vary due to the production environment, genetic factors, and the analytical procedures used to determine the composition. The pulse and soybean data, from the USDA Handbook No. 8-16 (Haytowitz and Matthews, 1986), and the cereal data from Souci et al. (1986) are mean values from the analysis of many different seed lots reported in their studies.

The seedcoat of mungbean is high in crude fiber (48%), carbohydrate (46%), phosphorus (23mg/100g), iron (8mg/100g), and calcium (1g/100g); nutrients that are removed when the seed coat is dehusked (Araullo, 1974). The germ constitutes two to five percent of the dry grain weight. Mungbean germ is high in protein (37%), carbohydrate (42%), phosphorus (744mg/100g), iron (11mg/100g), and calcium (110mg/100g). When seeds are split, the germ is often lost, leaving only the cotyledon. Mungbean cotyledon is high in protein (25%), carbohydrate (66%), phosphorus (290mg/100g), and calcium (70mg/100g) (Poehlman, 1991). Mungbean sprouts are high in protein (21%- 28%), calcium, phosphorus and certain vitamins. Because they are easily digested, they replace scarce animal protein in human diets in tropical areas of the world. If the mungbean does not meet sprouting standards it can be used as a livestock food (Oplinger et al., 1990).

Protein in Mungbean

Mungbean averages about 24% protein, this is about two-thirds the protein content of soybean, twice that of wheat, and three times that of rice (Poehlman, 1991). A major problem in utilization of this information is that the protein content of mungbean is affected greatly by environmental factors such as soil fertility, soil moisture, temperature, plant disease, maturity of pod, and other factors (Morton et al., 1982). Among the commonly cultivated pulses, mungbeans are relatively better balanced in their amino acid composition (Adsule et al., 1986). Mungbean protein is deficient in methionine, cystine, and cysteine. These are sulfur-bearing amino acids found abundantly in cereal grains.

Methionine, cystine, and tryptophan are the limiting amino acids in the pulse species and lysine is the limiting amino acid in wheat and rice (Vijayaraghavan and Srinivasan, 1953).

In animal proteins, the amino acids are generally present in proportions to satisfy human nutritional needs. In vegetable proteins, one or more amino acids are deficient so that the protein is not balanced as required for the human diet. The amino acids important in human nutrition which may be imbalanced in vegetable proteins are lysine, methionine, cystine, threonine, and tryptophan. A general rule is that the amino acids be supplied in the diet in a ratio of 4 parts lysine: 2 parts methionine: 2 parts threonine: 1 part tryptophan. When an amino acid is so low in the total diet that the ratio is affected, it becomes the limiting factor in the nutritive value of the protein (Morton et al., 1982).

Lipid in Mungbean

Lipid is a term chemists use to describe a group of compounds that are fat soluble, such as fats, oils, phospholipids, sterols, and vitamin D. Fat is composed of the same basic elements as carbohydrates: carbon, hydrogen, and oxygen. The amount of energy that fat provides, however, is 2 ½ times greater than the energy found in the same weight of carbohydrates or protein. The difference is that fat molecules contain a much smaller amount of oxygen, so there is more space for oxygen molecules to be added to the carbon chain. Because food energy is released when oxygen is added, this capacity to add oxygen molecules accounts for the high energy value of fats. Some types of lipids may have a few atoms of phosphorous, nitrogen or sulfur (Freeland-Graves and Peckham, 1987b).

Fat in food is known as triglycerides (triacylglycerols). Triglycerides comprise approximately 95% of the lipids in foods. Triglycerides are called neutral fats because they do not contain exposed acid or basic groups. A triglyceride is formed from three fatty acids and one molecule of glycerol. Glycerol is a water soluble, three-carbon molecule that forms the backbone of a molecule of triglyceride. The hydrogens of each of the three hydroxyl (OH), or alcohol groups, can react with a fatty acid to form an ester linkage to the fatty acid. An ester linkage is formed from the reaction of an acid and an alcohol. The molecule of glycerol linked to three fatty acids is called a triglyceride. The fatty acids may or may not be the same. If only one fatty acid is attached, it is called a monoglyceride. If two fatty acids are attached, it is called a diglyceride. The actual percentage of monoglycerides and diglycerides in foods is small. They are often added to fats because of their emulsifying properties, or ability to keep fats suspended in a watery medium (Freeland-Graves and Peckham, 1987b).

Lipids are present in small amounts in mungbean seeds. Mungbean averages about 1.2% lipid (Poehlman, 1991). The lipid in mungbean is 72.8% unsaturated and 27.7% saturated fatty acid (Adsule et al., 1986). The saturated fatty acids include palmitic (14.1%), stearic (4.3%), and behenic (9.3%) acids, while unsaturated fatty acids include oleic (20.8%), linoleic (16.3%), and linolenic (35.7%) acids (Adsule et al., 1986). Linoleic and linolenic acids are required for growth, physiological functions, and maintenance of the body, and are called essential fatty acids.

From the proximate composition reported in Table 3, mungbean does not differ importantly from the mean of other pulse species for all constituents, except lipids.

(Poehlman, 1991). Table 3, 4, and 5 compare nutritional information on the composition of seeds of some pulses, oilseeds, and cereal species. Most of the research on legume seeds is conducted on soybean or oilseeds such as peanut. Very little research could be found utilizing the low-fat qualities of the mungbean in human food.

Food Products Utilizing Mungbean

Mungbean is grown widely as a human food. Mungbean seeds are sprouted for fresh use or canned for shipment to restaurants. Traditional products produced from the mungbean include porridge, bean cake, confectionaries, noodles, and fresh green beans (Adsule et al., 1986). Mungbean composite flours are also being used to replace wheat flour in biscuits and noodles. Some products are nutritionally superior in many respects to the equivalent products made with wheat flour alone (Mabesa et al., 1983). The Philippine Government published a variety of ways to prepare mungbean (PCARR, 1977).

Nutritional Effects of Heat Processing on Mungbean

Heat processing improves flavor and palatability of cotyledons of mungbean while destroying antinutritional factors and enzyme inhibitors. This increases nutritive value and digestibility of mungbean (Poehlman, 1991). Heat processing has a significant

Table 3. Proximate composition of seeds of some pulse, oilseed (soybean), and cereal (wheat and rice) species, amounts in 100 grams edible portion [a,b]

Species	Water g	Food energy k cal	Protein (N x 6.25) g	Lipids (fat) g	Carbohydrate (total) g	Crude Fiber G
Mungbean	9.05	347	23.86	1.15	62.60	5.27
Blackgram	8.58	351	25.06	1.83	61.00	4.43
Cowpea	11.95	336	23.52	1.26	60.00	4.58
Dry bean	11.75	333	23.58	0.83	60.00	6.23
Chickpea	11.53	364	19.30	6.04	60.70	4.09
Pigeonpea	10.59	343	21.70	1.49	62.80	3.12
Lentil	11.19	338	28.06	0.96	57.10	5.20
Soybean	8.54	416	36.48	19.94	30.20	4.96
Wheat (whole grain)	13.20	309	11.50	2.00	59.40	10.60
Rice (unpolished)	13.10	353	7.40	2.20	74.60	4.00

[a] Pulse and soybean data adapted from Haytowitz and Matthews (1986).
[b] Cereal data adapted from Souci et al. (1986).

Table 4. Mineral composition of seeds of some pulse, oilseed (soybean), and cereal (wheat and rice) species, amounts in 100 grams edible portion[a,b]

Species	Ca mg	Fe mg	Mg mg	P mg	K mg	Na mg	Zn mg	Cu mg	Mn mg
Mungbean	132	6.74	189	367	1246	15	2.68	0.941	1.035
Blackgram	196	6.84	260	575	1025	26	3.08	0.659	1.614
Cowpea	110	8.27	184	424	1112	16	3.37	0.845	1.528
Dry bean	143	8.20	140	407	1406	24	2.79	0.958	1.021
Chickpea	105	6.24	115	166	875	24	3.43	0.847	2.204
Pigeonpea	130	5.23	183	367	1392	17	2.76	1.057	1.791
Lentil	51	9.02	107	454	905	10	3.61	0.852	1.429
Soybean	277	15.7	280	704	1797	2	4.89	1.658	2.517
Wheat (whole grain)	44	3.30	147	406	502	8	4.10	0.630	3.400
Rice (unpolished)	23	2.60	157	325	150	10		0.240	1.100

[a] Pulse and soybean data adapted from Haytowitz and Matthews (1986).
[b] Cereal data adapted from Souci et al. (1986).

Table 5. Vitamin composition of seeds of some pulse, oilseed (soybean), and cereal (wheat and rice) species, amounts in 100 grams edible portion[a]

Species	Ascorbic acid mg	Thiamin mg	Riboflavin mg	Niacin mg
Mungbean	4.8	0.621	0.233	2.251
Blackgram	4.8	0.355	0.280	1.800
Cowpea	1.5	0.853	0.226	2.075
Dry bean	4.5	0.529	0.219	2.060
Chickpea	4.0	0.477	0.212	1.541
Pigeonpea	0.0	0.643	0.187	2.965
Lentil	6.2	0.475	0.245	2.621
Soybean	6.0	0.874	0.870	1.623

[a] Pulse and soybean data adapted from Haytowitz and Matthews (1986).

Species	Pantothenic acid mg	B_6 mg	Folacin mcg	A IU[b]
Mungbean	1.910	0.382	624.9	114
Blackgram	1.920	0.275	628.2	114
Cowpea	1.496	0.357	632.6	50
Dry bean	0.780	0.397	394.1	8
Chickpea	1.588	0.535	556.6	67
Pigeonpea	1.266	0.283	456.0	36
Lentil	1.849	0.535	432.8	39
Soybean	0.793	0.377	375.1	24

[a] Pulse and soybean data adapted from Haytowitz and Matthews (1986).
[b] International units.

beneficial effect in improving the protein quality of mungbean (Chandrasekhar and Jayalakshmi, 1978; Devadas et al., 1964). Jyothi and Reddy (1981) reported improvement in the starch digestibility of mungbean after heat processing.

Fat in the Diet

The Dietary Guidelines for Americans recommends choosing a diet low in fat, saturated fat, and cholesterol (USDA, 1995). The recommendation is for no more than 30 percent of total calories from fat.

There seems to be a relationship between dietary factors and the incidence of heart disease. Persons who suffer heart attacks almost always have above-normal levels of blood cholesterol. Cholesterol, a fat-related compound present in many animal foods and one which the body can synthesize, is a major constituent of the atherosclerotic plaques that form on the inside of blood vessels. Plaques eventually narrow the blood vessel passages to the point that if a clot forms, it closes the vessel entirely. Since diet can affect serum cholesterol, some health organizations recommend diet modifications to achieve lower cholesterol levels (ACSH, 1995). These diet modifications include reducing consumption of total fat, saturated fat, and cholesterol (Giese, 1996).

Studies have shown that reductions in fat intake can result in a 10% reduction of the risk for heart disease, and if people who are overweight lose weight in addition to modifying their diet, they can lower their risk of cardiovascular heart disease by 20% (Latta, 1990).

School Lunch

The School Meals Program plays an important role in the health and well-being of U.S. children. The Federal Register (CFR, 1995) states that school lunches shall be provided based on the nutrition standards of several sources including the US Dietary Guidelines (USDA, 1995). The Dietary Guidelines for Americans recommends choosing a diet low in fat, saturated fat, and cholesterol. The diet recommended is for no more than 30 percent of total calories from fat. Reducing fat content of menu items, either prepared in-house or purchased (Sneed, 1992), will help meet this nutrition standard (CFR, 1995).

The use of fat replacers is one common way to modify recipes to reduce fat content. Although some students accept some reduced-fat foods (Epstein, 1994), it is unclear if they will accept reduced-fat versions of their favorite baked products, such as cookies. Resemblance to a familiar food reduces the initial negative responses to new foods. The fear of new foods decreases the liking for new foods at all levels of sensory input (visual, smell, and taste) (Tuorila et al., 1994b). It is difficult to achieve successful fat reduction in low-moisture baked products such as cookies, in which type and amount of fat influence quality attributes (Pyler, 1988).

Cookies

Cookies have long shelf-lives, making large-scale production and widespread distribution possible, and they are generally well liked bakery products (Vratanina and Zabik, 1980). Cookies are widely consumed, exhibit good eating qualities, and are acceptable to many sections of the population. The excellent eating quality helps in promoting their inclusion in children's feeding programs and in low-income market segments (Chavan and Kadam, 1993).

Since early in this century, the cookie industry has been dominated by three leading firms: Nabisco, Keebler, and Sunshine Biscuits. Together, they represent almost two-thirds of the industry's total production. Nabisco is the largest cookie producer in the world. Its sales exceed $2.5 billion or about 37% of the total volume of the entire industry. Keebler, a second major manufacturer of cookies has an estimated 17% or $1.2 billion in sales. With over $500 million in annual sales, Sunshine ranks third in the industry and controls about 7% of the market share (Hess, 1994).

The cookie industry will remain a solid segment within both the food and snack industries. It is unlikely cookie consumption will increase significantly unless the cookies cease to be considered as sweet desserts and are formulated to become a more broadly based food snack. This could be accomplished, as a response to the general diet requirements, by reformulation (Hess, 1994).

Cookie reformulation to improve nutritional value of cookies has been attempted. Cady et al. (1987) mixed navy bean flour in a master mix at the 35% level to prepare oatmeal drop cookies. The blending of bean flour did not cause an adverse effect on the sensory characteristics of the product. Cady et al. determined that the incorporation of bean flour into a master mix is a feasible way to produce a quality product.

Diwan et al. (1982) used black gram and mungbean flours in amounts of 5-10% to prepare biscuits (cookies). The products were of acceptable quality and had 1.5 times more protein than the control biscuits. A similar study by Naikare et al. (1986) indicated that acceptable cookies could be produced with improved protein content by incorporating 10% mung bean flour in blends of wheat maida: pearl millet. Pearl millet is a cereal grass that is rich in protein. It is used as a staple food for almost one-third of the world's population.

Cookie Formulation

There are two methods used to express the amount of each ingredient used in a recipe: true percent (formula percent) and bakers' percent. When a formula is expressed in true percent, the total ingredient percentages will always equal 100%. This method is generally used when formulating dry mixes. Bakers' percent is generally used in bakery production. It expresses the individual formula ingredients where the total flour weight is taken as 100% and all other ingredients are calculated as a percent of the flour. The flour is always 100 and thus, the sum of all formula ingredients always exceeds 100. To find the bakers' percent of individual ingredients, the weight of each ingredient is divided by the total flour weight and the result is multiplied by 100. The major advantage of using "bakers' percent" is that the amount of any one ingredient can be altered without recalculation of all other ingredient percentages (Lehmann et al., 1994).

All cookie batters and doughs bear some similarities to cake batters. The main difference is the decreased amount of liquid in the cookie dough. Other differences that distinguish a cookie batter or dough may be increased amounts of fat and egg and the smaller amounts of leavening- all of which give cookies a crisp, rather than light, texture.

Generally, cookies can be classed as meringue or sponge cookies, sheet or bar cookies, drop cookies, rolled cookies, refrigerator or icebox cookies, and pressed or bagged cookies (Freeland-Graves and Peckham, 1987a). Cookies usually contain a large proportion of fat.

Fat in Cookies

Butter is a water-in-oil emulsion containing approximately 80-81% milk fat (butterfat), and 14% water. One to five percent air is incorporated into butter during its processing. Butter is considered to be the best of all shortenings from a flavor standpoint. The fat globules are surrounded by a phospholipid membrane, which contains lecithin, that helps to keep the globules emulsified in the water phase (Lorenz, 1994).

Margarine is a water-in-oil emulsion, containing approximately 80% fat plus water, milk solids, salt, emulsifiers, and certain other ingredients. Margarine is comprised of eight major ingredients: fat 80%, milk 16.5%, water 15%, salt 3%, milk solids 1.5%, emulsifier 0.5%, artificial flavor, and artificial color. Margarines are intended to simulate butter (Lorenz, 1994).

Shortenings are fats used in the preparation of many foods. Because they impart a "short" or tender quality to baked goods, they are called shortenings. For many years, lard and other animal fats were the principal edible fats used in shortenings in this country. Today, many hydrogenated vegetable oils including soybean, cottonseed, corn, sunflower, and palm are used in shortening products. Shortenings have four primary functions in cookies: lubrication, aeration, eating quality, and spread (Lorenz, 1994).

Fats and oils are two of the most expensive major ingredients used in cookie production. Vegetable shortenings, although generally more expensive than animal products, are favored shortenings in cookies. Butter is used in specialty products only. Margarines are rarely used since they do not carry the premium quality image of butter. Less expensive vegetable shortenings perform as well as margarine in cookie production, so they are often the preferred fat. Lorenz (1994) recognized how cookie manufacturers can help Americans meet the U.S. Dietary Guidelines:

> The manufacturer of cookies can help consumers to meet the U.S. Dietary Guidelines by using the lowest possible level of fat in his products without sacrificing quality, by using more highly unsaturated fats, and by substituting fat replacers for part of the fat in cookie formulations (p. 147).

Fat-Replacers in Cookies

The use of fat replacers is one common way to modify recipes to reduce fat content. Research to produce fat replacers has been in progress for 30 years. Many food companies have patents on artificial fats and fat replacers. The main reason for the development of such fats is to reduce fat and calories in foods. Fat replacers contain between zero and seven calories per gram whereas fats contain nine calories per gram. Most of the fat replacers are carbohydrate-based (Lorenz, 1994). Although fat substitutes of various types have been used as a means of reducing total fat content in different kinds of foods, acceptance by the general population has not been enthusiastic. One of the reasons may be that food products made with some fat replacers are judged to be less than optimal in taste (Charlton and Sawyer-Morse, 1996). Reducing the fat component in food products alters appearance, flavor, aroma, and texture. The textural attributes, in particular, that are provided by fat are difficult to achieve with fat replacers (Armbrister and Setser, 1994).

When a baker starts to look at low-fat, challenges emerge and options multiply. The baker today has three major choices: 1- rebalance formulas using "conventional" ingredients; 2 - go to ingredient suppliers for their help in using items specifically designed for fat replacement; or 3 - use a low-fat/no-fat mix from a bakery supply company (Stockwell, 1995). Successful fat reduction in cookies is difficult to achieve since the type and amount of fat influence quality attributes (Pyler, 1988).

Additional work is recommended to explore consumer acceptability of the shortening-reduced cookies with fat replacers. It is important to keep in mind that difference from the control does not automatically imply that cookies would be unacceptable by consumers (Armbrister and Setser, 1994). In cookies which tend to be high in fat and low in moisture, it is probably unrealistic to expect reduced-fat products that are indistinguishable from their full fat counterparts (Swanson, 1998).

One problem with sensory evaluation of fat content is that the presence of fat in foods is associated with a wide range of textural characteristics. Fats provide texture and bulk to foods, hold water, provide a mechanism for heat transfer at high temperatures, and act as a carrier for fat-soluble flavor molecules. Therefore, no single textural attribute can be associated with the fat content of foods (Drewnowski, 1987).

Some consumers today are placing an increased importance on consuming healthy foods. Since 1989, the number of persons consuming "healthy" cookies has increased (Sigman-Grant, 1997). The food industry has risen to the challenge and produced many low-fat and reduced-fat cookies. For the most part, the oral sensation of fat in these products has been provided by a variety of other ingredients such as modified starches and gels, fibers and gums, maltodextrins, and sugars (Drewnowski et al., 1998).

One concern in using low-fat or low-sugar foods has been that a caloric deficit at one meal would be compensated for at the next meal, or later on during the day. Studies in which subjects consumed either high- or low-fat preloads showed that active young males compensated for the missing energy by consuming extra carbohydrates, with a resulting shift in the carbohydrate to fat ratio (Rolls and Hammer, 1995). In contrast, young women presented with low-sugar breakfasts compensated for only a fraction of the missing calories, while overweight and dieting women failed to compensate altogether (Drewnowski, 1995). In general, studies on sugar substitutes (Aspartame) and on fat replacements (Olestra) showed that there was a net advantage to using lower-energy foods (Rolls and Hammer, 1995).

Engell et al. (1998) studied the effects of information about fat content on food preferences in pre-adolescent children. In this study the butter content of oatmeal cookies was reduced. The study showed that fat-content labeling can affect the food preferences and choices of pre-adolescent children. The subjects in Engell's study viewed the low-fat label positively. When asked which cookie they liked best in a forced-choice situation, preference shifted from the standard recipe cookie when fat-content was not available to the reduced-fat cookie when the cookies were labeled appropriately.

Legumes have had limited study as a fat substitute. Rankin (1998) substituted canned, pureed cannellini beans for fat in oatmeal chocolate chip cookies. The beans were substituted for fat in varying percentages: 25, 50, and 75 (percent by weight). Results showed that there was no significant difference in overall acceptability between cookies prepared using 25% beans and control cookies. There was no significant difference for overall acceptability between cookies prepared using 50% beans and cookies prepared using 25% beans, and between cookies prepared using 50% beans and cookies prepared using 75% beans. Additionally, no significant differences were found between cookies prepared using 25% beans and the control cookies, for appearance, color, flavor, and texture. Rankin concluded that beans appear to be an acceptable substitute for fat at low levels. Information on other types of bean purees or pastes used as fat replacers in cookies were not found. Specifically, research on mungbean as a fat replacer in cookies could not be found.

Table 6 shows a nutritional comparison of butter and mungbean. Mungbean contains many more components than butter. According to Table 6 mungbean is much higher than butter in protein, carbohydrate, fiber (especially insoluble), and water. These components must be considered when objective tests on the cookie are conducted. More detailed nutrition comparisons of butter and mungbean are provided in Appendices A-C.

Table 6. Comparison of nutrients in 100g salted butter and 100g mature blanched mung bean seeds without salt[a].

Nutrients (in grams)	Butter	Mungbean
Calories	717.0	105.0
Protein	0.9	7.0
Carbohydrates	0.6	19.1
Fiber	0.0	7.6
Fiber (soluble)	0.0	1.4
Fiber (insoluble)	0.0	6.2
Sugar	0.1	2.0
Other carbohydrates	0.0	9.5
Fat	81.1	0.4
Fat (monounsaturated)	23.4	0.1
Fat (saturated)	50.5	0.1
Fat (polyunsaturated)	3.0	0.1
Water	15.9	72.7

[a] ESHA Research, 1993.

Kissell and Yamazaki (1975) reported that addition of ingredients to a cookie system with increased water retention properties results in an increased competition for the limited amount of free water present in the cookie dough. The rapid partitioning of water to these extra sites of hydrophilicity result in a greater internal dough viscosity. Yamazaki (1955) showed that the competition for the limited amount of water in the cookie dough system reduces cookie spread and limits the top grain formation.

In the mungbean cookie system competition for water occurs between the sugar, fiber, carbohydrates, and protein. Mungbean flour has a high water absorption capacity. Though mungbean flour was not be used in this study, the components of mungbean flour are similar to the components of mungbean cotyledon, therefore it is important to note that mungbean flour has about double the water absorption capacity of wheat flour (Mabesa and Novero, 1983).

Emulsifiers in Cookies

An emulsifier is any ingredient used to bind together normally noncombinative substances, such as oil and water. Emulsifiers are considered as safe food additives (GRAS) by the United States Food and Drug Administration (FDA), but their level of usage is controlled. Egg yolks contain a natural emulsifier (lecithin) and are used to thicken and bind sauces (such as hollandaise), as well to bind ingredients in baking. Lecithin is one of the most important phospholipids.

The structure of phospholipids is similar to triglycerides in that they both have a backbone of glycerol. In both, fatty acids are attached at carbons 1 and 2. But in phospholipids, a molecule of a compound containing phosphate and a nitrogenous base are attached at carbon 3. In lecithin, the nitrogenous base is a molecule of choline (Freeland-Graves and Peckham, 1987b).

Some commercial emulsifiers inhibit baked goods from going stale (Herbst, 1995). The eating quality of soft cookies as well as their keeping quality can be enhanced by the use of emulsifiers.

Emulsifiers manage the oil/water interface: one end of the emulsifier molecule is polar and attracted to water, while the other end is lipophilic with an attraction to oil (Stockwell, 1995). Emulsifiers increase the aerating (creaming) properties of fats thus increasing volume and lightness of a product. Emulsifiers complex with flour components which makes cookies softer. Cookies that are softer initially should be softer at each stage in their shelf life (Lorenz, 1994). In low-fat products, the choice and use of emulsifers are very important. Mono- and diglycerides, including glycerol monostearate (GMS), are the emulsifiers used most commonly to replace fats in bakery foods (Pyler, 1988).

When shortening in cookie dough is reduced, the incorporation of certain emulsifiers at levels between 0.125% and 0.75% (based on flour weight) during the creaming phase of mixing produce a considerably softer cookie (Hutchinson et al., 1977). Although emulsifiers are not used routinely in cookies, Rusch (1981) stated that they are capable of increasing cookie spread.

Objective Tests

Tests that do not depend on the observation of an individual and can be repeated using an instrument are described as objective tests (IFT, 1964). They are reproducible and less subject to error than sensory methods (Penfield and Campbell, 1990).

Specific Gravity

The determination of specific gravity is calculated by dividing the weight of food packed in a small, even rimmed cylindrical container by the weight of the water held by the same container (Lee et al., 1982). Specific gravity indicates the amount of air in the batter. Handlemen et al. (1961) reported that specific gravity dropped as emulsifier was added and moderate air was incorporated. But Carlin (1944) reported that with the addition of an emulsifier, the specific gravity of the batter increased

Cookie Quality

A method outlined by the American Association of Cereal Chemists (AACC, 1995) involves measuring the width of six cookies laid side by side, rotating each cookie 90 degrees, measuring the width again, and averaging the two readings. The cookies are then stacked on top of each other and measured and then restacked in a different order so they can be remeasured. The height is measured each time in millimeters and an average of those two measurements is determined. From these measurements, the width/thickness ratio (W/T ratio) is calculated and a correction factor applied. Spread ratios may be measured as indicators of cookie dough quality (Penfield and Campbell, 1990). The procedures outlined in method 10-50D of the AACC Manual have been followed in a variety of cookie studies. Method 10-50D has been used as a procedure for cutting cookies (Sanchez et al., 1995), screening the effects of emulsifier levels in cookies (Hutchinson et al., 1977), determining cookie spread as an objective indicator of uniformity across sensory sessions (Swanson, 1998), and calculating the spread factor as an objective measure to determine the feasibility of producing high fiber cookies (Vratanina and Zabik, 1978).

According to the equations in Method 10-50D, calculations can be made for cookie width (as-is), adjusted width, thickness (as-is), adjusted thickness, spread factor (as-is), and adjusted spread factor. The following are equations that are used to make the necessary calculations.

Width (W) divided by thickness (T) = W/T ratio (as-is)

W/T (as-is) x correction factor (CF) = adjusted W/T

Adjusted W/T x 10 = spread factor

W (as-is) x CF = adjusted W

T (as-is) x CF = adjusted T

Sensory Evaluation

Sensory evaluation is a scientific discipline used to evoke, measure, analyze, and interpret reactions to those characteristics of foods and materials as they are perceived by the senses of sight, smell, taste, touch, and hearing (IFT, 1975). Failure of a product in the market may relate to differences in perceived quality by the manufacturer and the consumer. Due to an increase in the awareness of consumers, manufacturers are turning towards sensory evaluation as a means to determine "quality" as perceived by the consumer (Stone et al., 1991).

Sensory tests can be classified into two major categories: analytical tests and affective tests. Analytical tests are used to evaluate differences or similarities between products and identify and quantify sensory characteristics. Affective tests are used to evaluate preference and/or acceptance of products. Analytical tests are further divided into discriminative and descriptive tests, both of which employ trained panelists to generate reproducible results (IFT Sensory Evaluation Division, 1981). For analytical testing the primary goal is to use the sensory abilities of human beings, as complex laboratory instruments, to measure characteristics of food. Trained panelists should never be asked the question of preference as their perception of analyzing a product completely changes due to the training. They cease to be an untrained consumer. On the other hand, unlike analytical testing, affective testing panelists, such as consumers, should not be over familiarized with the product or they cease to be untrained (Rutledge and Hudson, 1990; Mancini, 1992; Lawless, 1994; O'Mahony, 1995). The number of samples that can be presented in a given session is a function of both sensory and mental fatigue in the subject. With cookies, eight or ten may be the upper limit (Meilgaard et al., 1987). It is important to give panelists the orientation and time to feel comfortable with the test protocols, and to provide them with enough information to respond properly to the variables under study (Meilgaard et al., 1987).

Project Design for Sensory Evaluation

Having clearly set objectives is very important before starting sensory evaluation. The type of test is selected according to the objectives of the study. Panelists are used as human instruments and are screened on the basis of their ability to use their senses. Since there is a high variability in these measuring devices, they are trained by repeated familiarization with standards, to calibrate them (Lawless and Claassen, 1993; O'Mahony, 1995). The size of the panel depends on various factors. The British Standard suggests that at least five panelists are necessary and the larger the panel the greater the probability of revealing difference in ranks. King et al. (1995) concluded that a panel of 20 was justified in explaining treatment effects, but a panel of five would be adequate to indicate sample relationships.

Analytical panelists are trained to focus and identify the individual attributes of a product. They are trained to agree on what the sensory terms mean and what the high and low ranges on a scale are. They should not be used for testing acceptability of products combined with the analytical testing. Selection of appropriate objectives, test methods, panelists, and careful planning are the keys to successful application of sensory evaluation (Lawless and Claassen, 1993).

Consumer Sensory Evaluation

The precision of the consumer testing is low and the variability is high due to the uncontrolled sources of error. Therefore, consumer tests are performed on large numbers of people to maintain the statistical balance (Lawless, 1994).

A consumer test should involve not less than 50 people. The questionnaire should be as brief as possible asking just the amount of information required (ASTM, 1986; Lawless and Claassen, 1993).

Preference testing allows a panelist to choose one sample over another, and a ranking test requires panelists to rank products in an order either of preference or based on a particular attribute. Paired-preference, ranking and rating tests are appropriate methods for consumer panel testing (IFT Sensory Evaluation Division, 1981).

Summary

Butter replacement with mungbean paste in peanut butter cookies would not only improve the nutritional balance of the cookies, but it would also create a new market for the non-sprouting mungbeans that are grown in the United States primarily in Oklahoma. Mungbean is very low in total fat and has no cholesterol, unlike butter. Non-sprouting mungbeans do not have many food uses that are suited to American consumers' tastebuds. Attempts should be made to include mungbean paste in a variety of products in place of butter.

CHAPTER III

METHODOLOGY

The primary objective of this study was to develop a cookie with the substitution of mungbean paste in place of butter. The second objective was to evaluate sensory attributes of the cookies made with different amounts of mungbean paste in place of butter. The sensory attributes were evaluated by a semi-trained sensory panel. The cookies that were used for the sensory panel were also used to obtain objective data. The third objective of this study was to use an untrained consumer panel to compare the overall acceptability of cookies made with mungbean paste. The following sections will cover the process of product development, sample preparation for data collection, data collection through objective tests, sensory evaluation participant selection training, data collection through sensory and consumer testing, experimental design, and statistical analysis of the data.

Materials and Methods

Product Development

Step 1: Formula selection. Initial experiments were conducted to determine the properties of fat in cookies. Peanut butter cookies were baked with varying percentages of fat. Two commercial brands of peanut butter cookies were prepared to examine the qualities of commerical peanut butter cookie mixes. Quality attributes of full-fat peanut butter cookies were the most difficult to achieve according to studies in which fat substitutes such as fruit purees were used in peanut butter, oatmeal, and chocolate chip reduced-fat cookies (Swanson and Munsayac, 1999). Similar results have been reported when commercially available fat substitutes were used in peanut butter cookies. The USDA peanut butter cookie recipe was used as the control in these studies (USDA: Quantity Recipes for School Foodservice, 1988). The recipe for each level of mungbean paste used is in Appendix D. The ingredients are listed as bakers' percent and true percent in Appendix E. The recipe used in this study was reduced to bakers' percent so it would be easier to alter ingredients based on the flour weight during product development.

The ingredients used in this study were all-purpose flour, baking soda, iodized salt, dry milk, granulated sugar, light brown sugar, Land O' Lakes Salted Butter, imitation vanilla, Peter Pan Smooth Peanut Butter, and Grade A large eggs. All ingredients were purchased from Wal-Mart Supercenter. All the cookies made throughout the preliminary study were weighed on a Fisher Scientific XT top loading balance (Model 115/230 VAC, Denver, CO).

A Rival high performance mixer (Model 455, Rival Company, Kansas City, MO) was used for mixing. Butter, peanut butter, sugar, brown sugar, eggs, and vanilla were mixed for 30 seconds on speed one. The sides of the bowl were scraped and then the same ingredients were mixed for 30 seconds on speed two. The sides of the bowl were scraped. After sifting twice, the dry ingredients were added to the butter, peanut butter, sugar, brown sugar, egg, and vanilla mixture. All of these ingredients were mixed for 30 seconds on speed one and then the sides of the bowl were scraped. The ingredients were mixed again on speed two for 30 seconds and the sides of the bowl were scraped.

The cookies were baked in a Maytag Model CRG9700CAE conventional gas oven at 350°F for 17 minutes. Baking time and temperature were kept consistent throughout the study.

Step 2: Preparation of Mungbean Paste. The paste that would serve as a butter replacement was developed by reviewing literature on mungbean preparation (PCARR, 1977). All mungbeans used in this study were obtained in one batch from a mungbean farmer in Hennessey, Oklahoma. The outer green coat had been removed and the beans split in half when they were obtained for this research.

Mungbean paste was made by blanching the mungbeans in sodium bicarbonate. The blanching process involved heating deionized water to 210°F and dipping the beans into the hot water for 10 seconds so the temperature of the beans could be brought to 180-190°F throughout. This allowed the outer enzymes to be denatured and therefore reduced the likelihood of an off-taste in the finished paste. After the mungbeans were removed from the hot water, they were immediately rinsed with cold water to stop the blanching process. The mungbeans were then weighed and covered in deionized water for 12 hours in a covered container in the refrigerator. After 12 hours, the water was drained off of the mungbeans. The mungbeans were weighed again and put into a pan to be boiled. The weight of deionized water added to mungbeans before boiling was equal to the weight of the mungbeans in grams plus 31%. The mungbeans and deionized water were simmered over low heat for 30 minutes. They were stirred frequently. At the end of the boiling process, the mungbeans were soft and pliable and had a paste-like consitency. The mungbeans were allowed to cool for five minutes and then transferred to a Robot Coupe

(Model R-2, Robot Coupe U.S.A. Inc., Ridgeland, MS). The bean paste was mixed in the Robot Coupe for three minutes. The machine was turned off and the contents were stirred. The Robot Coupe was turned back on, and the paste was allowed to mix for three more minutes. After removing the mungbean paste from the Robot Coupe, the paste was formed into balls and refrigerated in an airtight container. The mungbean paste had the consistency of soft warm play-dough and it was a dull yellow color when it went into the refrigerator.

Step 3: Introduction of Mungbean Paste. Peanut butter cookies were prepared with varying amounts of mungbean paste as a butter replacer in order to determine what level of mungbean paste should be used in sensory testing. To determine optimum levels of butter replacement, the cookies were tasted by undergraduate students, graduate students, and nutrition professors. It was determined by preliminary tasters in the nutrition department that mungbean paste was acceptable as a butter replacement for sensory testing in levels up to 100%. Based on input from the preliminary panelists it was determined to test mungbean paste as a butter replacement at four levels: 25%, 50%, 75%, 100%. The control cookie contained no mungbean paste. A copy of the preliminary score sheet is in Appendix F.

The following procedures were used in making all cookies:

1. Combine flour, baking soda, dry milk, and salt.
2. Sift flour, baking soda, dry milk, and salt two times. Set aside.
3. In separate bowl blend butter and/or mungbean paste, peanut butter, sugar, brown sugar, eggs, and vanilla for 30 seconds in mixer on speed one.

4. Scrape sides of bowl, mix on speed two for 30 seconds.
5. Scrape sides of bowl. Add dry ingredients from step 2 to creamed mixture.
6. Blend mixture for 30 seconds on speed one. Scrape sides of bowl. Blend for 30 seconds on speed two.
7. Conduct specific gravity test.
8. Record weight of 3 separate No. 40 scoops of cookie dough.
9. Portion cookie dough with a level No. 40 scoop in rows of 4 down and 3 across onto Air Bake Insulated Bakeware 14" x 16" Baking Sheet.
10. Flatten cookies to 7 mm (0.275 in.) thick in accordance with AACC Method 10-50D. To flatten cookies uniformly, place two 7 mm thick wooden strips onto baking sheet between each cookie row. Press flat metal sheet onto cookie dough until the metal is stopped by the wooden strips. Remove metal sheet and wooden strips.
11. Bake for 17 minutes at 350°F with the cookie sheet in the middle of the center rack of the oven.
12. Allow cookies to cool 2 minutes on baking sheet after removing from the oven. Transfer cookies from cookie sheet to cooling rack with a spatula.

Step 4: Use of emulsifiers. The cookies made with mungbean paste were smaller, had more height, and had a chewier texture than the control cookies. To overcome this problem, the use of emulsifiers was explored. Emulsifier samples were received from three different ingredient companies. Each company shipped their most popular emulsifier for reduced-fat cookies. The three emulsifiers received were Emplex 254, Polysorbate 60 F240050, and Surfax™.

Incorporation of emulsifiers began by following the manufacturers' recommended ranges of incorporation of the emulsifiers, and the recommended levels of emulsifier usage as noted in the review of literature. Polysorbate 60 was listed as an ingredient in the emulsifier Surfax™. Testing began with the incorporation of Emplex in the 100% mungbean paste cookie. Emplex was was tested at three levels 0.25%, 0.44%, and 0.50%. These levels were determined by manufacturer's information and emulsifier studies by Hutchinson et al. (1977). Usage levels were based on flour weight. All emulsifiers were incorporated into the cookie dough during the first step or creaming phase of mixing.

Based on the manufacturer's instruction, Surfax™ was tested at 0.75%. The optimum levels of emulsifier were 0.50% Emplex and 0.75% Surfax™. Cookies were made with 100% mungbean paste and taken to an Oklahoma Agriculture Teachers Food Science Workshop to determine which cookie emusifier provided the most pleasant eating qualities according to a group of untrained consumers. The teachers chose the cookie made with Surfax™ as their favorite. They noticed more of an oily mouthfeel in the cookie made with Surfax™, and they liked this over the dry mouthfeel of the Emplex cookie. This input contributed to the decision to use the emulsifier Surfax™ at the 0.75% level in all of the fat-reduced cookies in the semi-trained sensory panel. See the nutritional composition of Surfax in Appendix G.

<u>Sample Preparation for Data Collection.</u>

The ingredients used for the final experimental cookies were all-purpose flour, baking soda, idiozed salt, dry milk, granulated sugar, light brown sugar, imitation vanilla, Land O'Lakes Salted Butter, Grade A large eggs, Peter Pan Creamy Peanut Butter, mungbean paste, and Surfax™. The ingredients for each test were obtained from the same batch and weighed on a Fisher Scientific XT top loading balance. Cookies were made fresh 18 hours prior to sensory testing. Objective data were obtained on the cookies the same day the cookies were prepared. The cookie dough was portioned with a level No. 40 scoop in rows of 4 down and 3 across onto an Air Bake Insulated Bakeware 14" x 16" Baking Sheet. Cookies were flattened to a thickness of 7mm (0.275 in.) in accordance with AACC Method 10-50D (AACC, 1995). The cookies were baked in a Maytag Model CRG9700CAE conventional gas oven at 350°F for 17 minutes in the center of middle rack in the oven. After baking, cookies were cooled for 2 minutes on a baking sheet and then transferred to a cooling rack.

Data collection

Objective tests

Pre-bake batch weight. After mixing the cookie dough, all the dough for one recipe was weighed on a Fisher Scientific XT top loading balance (Model 115/230 VAC, Denver, CO). This was done in order to determine the differences in total weight of cookie dough as mungbean paste increased. Even though one scoop of cookie dough and one baked cookie might weigh the same, the weight of the total batch told if more cookies were being made per recipe. The butter contained a lower percentage of water than the mungbean paste, and this test helped determine if the water difference effected the dough weight.

Pre-bake scoop weight. After mixing and weighing the entire batch of cookie dough, a #4 scoop was used to obtain three cookie dough samples. Each sample was weighed on the Fisher Scientific XT top loading balance, and the numbers were averaged to give the pre-bake scoop weight average for each recipe.

Weight after baking. After the cookies were baked and cooled on a cooling rack, six cookies were chosen randomly. These six cookies were weighed on a Fisher Scientific XT top loading balance. The individual weights were recorded in grams. The six weights were then averaged to determine the average cookie weight. This test helped determine the moisture loss for each cookie when the weight after baking was compared with the pre-bake scoop weight.

Specific gravity. Specific gravity was determined by dividing the weight of the batter in a one-ounce souffle cup by the weight of the water measured in the same container.

Baking Quality. Methods for calculating baking quality were based on Method 10-50D of the Approved Methods of the American Association of Cereal Chemists (AACC, 1995). Calculations were made for cookie width (as-is), adjusted width, thickness (as-is), adjusted thickness, spread factor (as-is), and adjusted spread factor.

Width (as-is) and Adjusted Width. After cooling for 30 minutes, six cookies were laid edge to edge and width was measured in millimeters. The measurements were read to the nearest ½ millimeter. The six cookies were then rotated 90 degrees and remeasured. The average of these two measures was divided by six to obtain width (as-is). The adjusted width was calculated by multiplying the width (as-is) times a correction factor provided by the American Association of Cereal Chemists (AACC, 1995). The correction factor adjusted width to constant atmospheric pressure. The constant atmospheric pressure was determined by the barometeric pressure on the day of baking and the elevation of Stillwater, Oklahoma, corrected to sea level.

Thickness (as-is) and Adjusted Thickness. After cooling for 30 minutes, six cookies were stacked on top of each other and their thickness was measured in millimeters. The measurements were read to the nearest ½ millimeter. The six cookies were then restacked in a different order and remeasured. The average of these two measures was divided by six to obtain thickness (as-is). The adjusted thickness was calculated by multiplying the thickness (as-is) times a correction factor provided by the American Association of Cereal Chemists (AACC, 1995). The correction factor adjusted the thickness to constant atmospheric pressure. The constant atmospheric pressure was determined by the barometeric pressure on the day of baking and the elevation of Stillwater, Oklahoma, corrected to sea level.

Width/Thickness Ratio (as-is) and Adjusted Width/Thickness Ratio. The width/thickness ratio (as-is) was calculated by dividing the adjusted width by the adjusted thickness. The adjusted width/thickness ratio was determined by multiplying the width/thickness ratio (as-is) times a correction factor. The correction factor was determined by using a chart provided by the American Association of Cereal Chemists (AACC, 1995).

Spread Factor. The spread factor was determined by multiplying the adjusted width/thickness ratio by 10.

Sensory Evaluation

Sensory Evaluation Participant Selection and Training. Twelve panelists were selected from among the students, faculty, and staff of Langston University. They were questioned for any allergic reactions to peanuts and were informed that the product to be tested would contain peanuts. A consent form was signed agreeing that participation was voluntary. Participants were informed of all the ingredients in the product to be tested. The consent form for sensory participation is in Appendix H.

All panelists received a 15-page sensory panelist training packet. A copy of the sensory packet is in Appendix I. The contents of the sensory packet were covered with all panelists. The training packet consisted of a taste acuity exercise in which panelists identified four basic tastes: sweet, sour, salty, bitter. Panelists then participated in a scaling excercise. Terminology related to this particular type of panel testing was reviewed. Once panelists were familiar with the terminology, they assigned intensity values to the reference standards through discussion and consensus. The reference standards for the two texture attributes, hardness and fracturability, were obtained from Spectrum Intensity Scales (Meilgaard et al., 1987). The three flavor attributes (peanut flavor, butter flavor, and different flavor) were determined from the reference standards noted in the sensory packet. The intensity values were assigned to the control by marking a horizontal line on a numerical scale (0-10) as shown in Fig.1. Panelists practiced evaluating the intensity of the sample and assigning numerical values to intensities using reference standards. Once the panelists had evaluated the intensity of the samples, they were given a control cookie so they could discuss and come to a consensus on where the control cookie should fall on the intensity scale for each of the five attributes. The control

EVALUATION OF USDA PEANUT BUTTER COOKIES

Instructions. Evaluate the cookie for texture and taste by placing a mark on each line below:

Texture

Hardness

|____|____|____|____|____|____|____|____|____|____|

0 (soft) 5 (hard) 10

Fracturability

|____|____|____|____|____|____|____|____|____|____|

0 (crumbly) 5 (brittle) 10

Taste

Peanut Flavor

|____|____|____|____|____|____|____|____|____|____|

0 (none) 5 (strong) 10

Butter Flavor

|____|____|____|____|____|____|____|____|____|____|

0 (none) 5 (strong) 10

DifferentFlavor

|____|____|____|____|____|____|____|____|____|____|

0 (none) 5 (strong) 10

Panelist code number ____________________

Date____________________

Fig. 1. Sensory evaluation sheet used by the semi-trained panelists.

cookie helped to serve as a reference point for panelists throughout sensory evaluation.

Analysis of Sensory Data. Cookies were baked on a 14" x 16" baking sheet for sensory evaluation. Cookies were made according to bakers' percent with each batch yielding approximately 15 cookies. New cookies were baked the day before each sensory evaluation. After the cookies were cooled and used to obtain objective measures, each cookie was cut into four pieces. Bite size cookie pieces were 7 mm (0.275 in.) thick. The cookies were then transferred into number coded gallon size plastic bags and stored overnight at a constant temperature in the product development laboratory.

Each panelist evaluated the cookies three times. Sessions were held in a room with ambient temperature and lighting with environmental sounds and odors minimized. The procedure and definitions were available during each testing session. The reference USDA peanut butter cookie was kept available for panelist use as needed. The intensity values determined by panelists during sensory training were marked on the scoresheet for easy reference during testing. Each panelist was given four testing samples and a control. They tested each of the test samples against the control and marked their rating on the hedonic scale in Fig. 2. The hedonic scale was divided into equally marked lines to make it easier for the panelists to identify the numbers on the scale. For each session the panelists had an unlimited supply of distilled water to cleanse their palate. Spit cups were also provided.

Twelve panelists completed the sensory training. Three panelists were dropped from the study. Two of these panelists were dropped because they did not attend the three sensory sessions required to participate in this study, and one panelist had missing data on

EVALUATION OF USDA PEANUT BUTTER COOKIES

Instructions. Evaluate the cookie for texture and taste by placing a mark on each line below:

Texture

Hardness Control Cookie = 6.5

|____|____|____|____|____|____|____|__x__|____|____|____|

0 (soft) 5 (hard) 10

Fracturability Control Cookie = 4.5

|____|____|____|__x__|____|____|____|____|____|____|____|

0 (crumbly) 5 (brittle) 10

Taste

Peanut Flavor Control Cookie = 6.0

|____|____|____|____|____|____|____x|____|____|____|____|

0 (none) 5 (strong) 10

Butter Flavor Control Cookie = 2.0

|____|____x|____|____|____|____|____|____|____|____|____|

0 (none) 5 (strong) 10

Different Flavor Control Cookie = 0.0

x|____|____|____|____|____|____|____|____|____|____|____|

0 (none) 5 (strong) 10

Panelist code number ____________________
Date____________________

Fig. 2. Sensory evaluation sheet used by the semi-trained panelists. This sheet contains the reference points determined by panelists in training.

the score sheet on several of the sensory testing days. The data of the remaining nine panelists were analyzed for this study.

Consumer Testing

The consumer testing involved 181 volunteers. The testing was conducted midmorning on the Langston University Campus. The panelists varied in age and ethnicity. No training was given to these panelists. The questionnaire was kept brief (See Fig. 3).

Consumer Flavor Acceptability Test

Circle the number that most closely describes the flavor acceptability of each cookie.

Blue	1 dislike extremely	2 dislike very much	3 dislike	4 like	5 like very much	6 like extremely
Red	1 dislike extremely	2 dislike very much	3 dislike	4 like	5 like very much	6 like extremely

Comments:

____

____

Fig. 3. Consumer acceptability score sheet.

Consumer tests were conducted on two days with two separate experimental cookies being tested. Both days had a different set of consumers testing the cookies for acceptability. Each consumer received and rated two cookies, one experimental and one control. Panelists rated the degree of like or dislike on a six point scale on the scorecard.

On day one of consumer testing, the control peanut butter cookie was tested with a peanut butter cookie containing 25% of mungbean paste. On day two of consumer testing, the control peanut butter cookie was tested with a peanut butter cookie containing 50% of mungbean paste. Both cookies were prepared one day before service and stored overnight in the product development laboratory. The sample presentation was randomized. Half of the color coded scorecards listed the control cookie first and the other half listed the experimental cookie first. Consumers were asked to refrain from participation if they had any type of peanut allergy or did not like peanut butter cookies.

Experimental Design and Statistical Analysis

The semi-trained panel data were analyzed using SPSS General Linear Model (GLM) procedure for repeated measures (SPSS Institute, Inc., 1997). Objective data were collected for 11 measurements: pre-bake batch weight, pre-bake scoop weight, specific gravity, width (as-is), thickness (as-is), width/thickness ratio, spread factor, adjusted width, adjusted thickness, adjusted width/thickness ratio, and weight after baking. A Least Significant Difference (LSD) pairwise comparison test was performed on objective data for all cookies used in the semi-trained taste panel in order to identify significant differences ($p \leq 0.05$) in each objective measure

Because the semi-trained panel rated cookies 3 out of 4 days, the subjective data obtained from this sensory panel was subjected to one-way Analysis of Variance (ANOVA) on the five characteristics that panelists rated: hardness, fracturability, peanut flavor, butter flavor, and different flavor. This test was conducted to determine if the testing day had a significant influence on the scores of each attribute. Sensory ratings were not significantly different ($p \leq 0.05$) between days for any of the attributes.

Since ratings for each day were not significantly different for any of the sensory attributes, all data were analyzed using the GLM procedure for repeated measures. The GLM test compared the variability in the ratings of each experimental cookie against the other experimental cookies and determined their significance levels. A Least Significant Difference (LSD) pairwise comparison test was performed on subjective data for all cookies in order to determine which cookies were significantly different ($p \leq 0.05$) from the others in each subjective measure.

Once the experimental cookies' sensory attributes were compared against each other, they were compared individually against the control using a one sample t-test. The one sample t-test determined if the ratings for each cookie were significantly different from the control.

Two paired t-tests were performed on the consumer panel data to test differences between preferences for the experimental cookies and control on the days of consumer tests. Day 1 compared the control to the 25% mungbean paste cookie, and day 2 compared the control to the 50% mungbean paste cookie.

CHAPTER IV

RESULTS AND DISCUSSION

This study compared peanut butter cookies with different levels of butter replaced with mungbean paste. The objective data depicted differences among the cookies in pre-bake scoop weight, specific gravity, width (as-is), thickness (as-is), width/thickness ratio, spread factor, adjusted width, adjusted thickness, adjusted width/thickness ratio and weight after baking.

Sensory evaluation showed no differences among the experimental cookies in hardness, fracturability, or different flavor. Sensory evaluation comparing each experimental cookie with the control showed no difference in fracturability between the control and experimental cookies.

Two different consumer studies were conducted to compare the acceptability of mungbean paste cookies. The first study compared the control peanut butter cookie to the 25% mungbean paste cookie. Results of this study showed no significanct difference between the acceptability of the two cookies. The second consumer study compared the control peanut butter cookie to the 50% mungbean paste cookie. Results of this study showed a significant difference between the acceptability of the cookies. The control peanut butter cookie was significantly more acceptable than the 50% mungbean paste cookie, however both cookies were liked by consumers according to the hedonic scale on which they were measured.

Objective Data

General Linear Model (GLM) repeated measures procedures were performed on the cookie data for all objective tests: pre-bake batch weight, pre-bake scoop weight, specific gravity, width (as-is), thickness (as-is), width/thickness ratio, spread factor, adjusted width, adjusted thickness, adjusted width/thickness ratio, and weight after baking. (See Table 7).

Significant differences from the control were found for 10 of the 11 objective measurements. Pre-bake scoop weight was significantly higher ($p \leq 0.05$) than the control in the 50% ($p = 0.012$) and 75% ($p = 0.010$) mungbean paste cookies.

Specific gravity was significantly higher ($p \leq 0.05$) than the control in the 50% ($p = 0.011$), 75% ($p = 0.003$), and 100% ($p = 0.004$) mungbean paste cookies.

Width was significantly lower ($p \leq 0.05$) than the control in the 100% ($p = 0.009$) mungbean paste cookie.

Thickness was significantly higher ($p \leq 0.05$) than the control in the 25% ($p = 0.021$), 50% ($p = 0.007$), 75% ($p = 0.004$), and 100% ($p = 0.002$) mungbean paste cookies.

Width/thickness ratio was significantly lower ($p \leq 0.05$) than the control in the 25% ($p = 0.034$), 50% ($p = 0.011$), 75% ($p = 0.006$), and 100% ($p = 0.002$) mungbean paste cookies.

Spread was significantly lower ($p \leq 0.05$) than the control in the 25% ($p = 0.034$), 50% ($p = 0.011$), 75% ($p = 0.006$), and 100% ($p = 0.002$) mungbean paste cookies.

Table 7. Means of objective tests and standard error on experimental cookies and the control peanut butter cookie

	Control	**25% Mungbean Paste**	**50% Mungbean Paste**	**75% Mungbean Paste**	**100% Mungbean Paste**
Pre-bake batch weight (g)	434.28 ± 1.30	437.63 ± 0.57	441.93 ± 3.17	433.53 ± 3.13	435.55 ± 1.01
Pre-bake scoop weight (g)	$25.59^{b} \pm 0.50$	$26.34^{b} \pm 0.43$	$27.69^{a} \pm 0.45$	$28.00^{a} \pm 0.27$	$26.97^{ab} \pm 0.39$
Specific gravity	$1.07^{c} \pm 0.02$	$1.12^{bc} \pm 0.03$	$1.15^{a} \pm 0.03$	$1.18^{ab} \pm 0.02$	$1.19^{a} \pm 0.03$
Width (as-is) (mm)	$78.65^{ab} \pm 0.59$	$77.77^{a} \pm 1.02$	$77.09^{ab} \pm 1.20$	$75.13^{b} \pm 1.25$	$70.67^{c} \pm 0.94$
Thickness (as-is) (mm)	$9.75^{d} \pm 0.07$	$10.46^{c} \pm 0.17$	$11.02^{b} \pm 0.19$	$11.84^{b} \pm 0.20$	$13.33^{a} \pm 0.28$
Width/Thickness ratio	$8.07^{a} \pm 0.09$	$7.45^{b} \pm 0.20$	$7.01^{bc} \pm 0.23$	$6.35^{c} \pm 0.16$	$5.31^{d} \pm 0.18$
Spread factor	$78.00^{a} \pm 0.78$	$72.00^{b} \pm 1.92$	$67.75^{bc} \pm 2.16$	$61.45^{c} \pm 1.66$	$51.38^{d} \pm 1.78$
Adjusted width (mm)	$77.63^{ab} \pm 0.56$	$76.99^{a} \pm 0.94$	$76.08^{ab} \pm 1.18$	$74.15^{b} \pm 1.26$	$69.75^{c} \pm 0.96$
Adjusted thickness (mm)	$9.97^{d} \pm 0.06$	$10.70^{c} \pm 0.18$	$11.27^{b} \pm 0.19$	$12.11^{b} \pm 0.21$	$13.64^{a} \pm 0.30$
Adjusted width/thickness ratio	$7.80^{a} \pm 0.08$	$7.20^{b} \pm 0.19$	$6.78^{bc} \pm 0.22$	$6.15^{c} \pm 0.17$	$5.14^{d} \pm 0.18$
Weight after baking (g)	$23.57^{c} \pm 0.11$	$24.18^{bc} \pm 0.51$	$25.90^{a} \pm 0.13$	$25.75^{ab} \pm 0.49$	$24.29^{abc} \pm 0.74$

[a,b,c,d] The means are significantly different ($p < 0.05$) from each other for each category unless they have one of the same superscripts beside them.

Weight after baking was significantly higher ($p \leq 0.05$) than the control in the 50% ($p = 0.001$) and 75% ($p = 0.025$) mungbean paste cookies.

The pre-bake batch weight measurements were not significantly different at the 0.05 level for any of the cookies compared to the control.

Pre-Bake Batch Weight

LSD pairwise comparisons indicated that, for the total weight in grams of one batch of cookie dough, the control cookie was not significantly different ($p \leq 0.05$) from the 25% ($p = 0.122$), 50% ($p = 0.126$), 75% ($p = 0.816$), or 100% ($p = 0.154$) mungbean paste cookies.

In addition to comparisons made between the control and experimental cookies, comparisons were also made among the experimental cookies. LSD pairwise comparisons between experimental cookies indicated that pre-bake batch weight was not significantly different ($p \leq 0.05$) between any of the experimental cookies.

Each cookie batch weighed about the same. When dough was weighed individually with a No. 40 scoop, however, the dough weights were different.

Pre-Bake Scoop Weight

LSD pairwise comparisons indicated that, for one No. 40 scoop weight of cookie dough, the control cookie was significantly lower ($p \leq 0.05$) than the 50% ($p = 0.012$), and 75% ($p = 0.010$) mungbean paste cookies. The scoop weights were lowest for the control cookie. This may be due to the fact that butter helps aerate the dough during mixing. Aeration produces a dough that is less dense.

Scoop weights of experimental cookies were significantly different ($p \leq 0.05$) among some of the experimental cookies: the 25% mungbean paste cookie weighed significantly less than the 50% ($p = 0.002$) and 75% ($p = 0.046$) mungbean paste cookie dough.

Weight After Baking

LSD pairwise comparisons indicated that two cookies were significantly heavier ($p \leq 0.05$) than the control: the 50% ($p = 0.001$) and 75% ($p = 0.025$) mungbean paste cookies.

LSD pairwise comparisons between experimental cookies indicated that weight of cookie after baking was significantly different ($p \leq 0.05$) between some of the experimental cookies: the 25% mungbean paste cookie was significantly different than the 50% ($p = 0.043$) mungbean paste cookie. The cookie containing 25% mungbean paste weighed significantly less than the cookie containing 50% mungbean paste. One would expect that increasing the amount of mungbean paste in the cookie recipe would increase the cookie's weight because mungbean paste is more dense than butter. The 75% and 100% mungbean paste cookies, however, weighed the same as the 50% mungbean paste cookies. Surprisingly, the addition of mungbean paste did not always increase the cookie's weight.

Perhaps when butter and mungbean paste are in the same food product, the aerating effects of butter are reduced by the density of the mungbean paste.

<u>Specific Gravity</u>

Dough consistency can be followed by measuring specific gravity. Specific gravity is the weight of a given volume of material divided by the weight of the same volume of water. Water has a specific gravity of 1.00. Specific gravity gives an indication of the density of the batter resulting from the incorporation of the air or release of the leavening gas during the mixing stage (Lehmann et al., 1994).

LSD pairwise comparisons indicated that, for specific gravity, the control cookie was significantly lower ($p \leq 0.05$) than the 50% ($p = 0.011$), 75% ($p = 0.003$), and 100% ($p = 0.004$) mungbean paste cookies.

Specific gravity was also significantly different ($p \leq 0.05$) when the experimental cookies were compared with each other. The 25% mungbean paste cookies had significantly lower specific gravity than the 50% ($p = 0.046$) and 100% ($p = 0.017$) mungbean paste cookies.

Specific gravity tended to increase in all experimental cookies as more mungbean paste was used. This could have been due to the mungbean paste having a higher density than butter, therefore more mungbean paste used in the recipe resulted in a heavier cookie.

Width

LSD pairwise comparisons indicated that, for specific width, the control cookies were significantly wider ($p \leq 0.05$) than the 100% ($p = 0.009$) mungbean paste cookies.

LSD pairwise comparisons among experimental cookies indicated that width was significantly different ($p \leq 0.05$) in several of the experimental cookies: the 25% mungbean paste cookie was significantly wider than the 75% ($p = 0.041$) and 100% ($p = 0.015$) mungbean paste cookies; the 100% mungbean paste cookie was significantly less wide than the 50% ($p = 0.023$) mungbean paste cookie.

Cookie width decreased as more mungbean paste was added to the recipe. The results were the same when the width ratio was adjusted to constant atmospheric pressure.

The reason for decreased cookie width is not solely because the mungbean paste has a higher percentage of water than butter. Miller et al. (1997) found that increasing the formula water caused the spread rate to increase but shortened the set time. As a result, final cookie diameter was essentially unchanged. The factor affecting cookie width could have also been gluten development.

One hypothesis for reduced cookie width was proposed by Hosensy et al. (1986). They believe cookies in their study exhibited a phase change in the gluten component when the cookie reached a certain temperature called the glass transition temperature. At this temperature, the cookie dough expanded and formed a continuous protein matrix. The continuous protein matrix produced an increase in viscosity which reduced the flow of the cookie dough and caused a reduction in the cookie width and spread.

Miller and Hoseney (1997) found that sugar-snap cookie dough viscosity appeared to control cookie spread rate and, thus affected final cookie diameter. Dough viscosity may be tested by lubricated uniaxial compression. Lubricated uniaxial compression measures the differences in the viscosity of cookie doughs and is useful for predicting the cookie baking quality.

The width of the cookie also has to do with the starch content of the cookie and its moisture binding capacity. This concept will be explained further under the spread factor heading. The results were the same when the width ratio was adjusted to constant atmospheric pressure according to Method 10-50D of the Approved Methods of the American Association of Cereal Chemists (AACC, 1995).

<u>Thickness</u>

When mungbean paste was incorporated into the peanut butter cookie recipe the thickness (as-is) increased. LSD pairwise comparisons indicated that the control cookie was significantly thinner ($p \leq 0.05$) than the 25% ($p = 0.021$), 50% ($p = 0.007$), 75% ($p = 0.004$), and 100% ($p = 0.002$) mungbean paste cookies.

Comparisons among experimental cookies indicated that thickness was significantly different ($p \leq 0.05$) between some of the experimental cookies: the 25% mungbean paste cookie was significantly thinner than the 50% ($p = 0.044$), 75% ($p = 0.032$), and 100% ($p = 0.007$) mungbean paste cookies; the 100% mungbean paste cookie was significantly thicker than the 50% ($p = 0.014$) and 75% ($p = 0.000$) mungbean paste cookies.

The cookies containing mungbean paste were thicker because mungbean paste has a high percentage of water. A high percentage of water results in a more cake-like cookie. Often baked cookies are tender-crisp because little or no starch gelatinization occurs, and the sugar and fat interfere with gluten development. When a formula contains a higher proportion of water, the product is softer and more cakelike. The mungbean paste had a higher percentage of water than the butter that it was replacing. A higher percentage of water results in a flour that is more hydrated. When flour is hydrated, the proteins in flour unfold. This was observed by Bernardin and Kasarda (1973). The flour hydration and protein unfolding lead to a stretched conformation of the dough which is further developed by mixing the dough. In bread doughs the flour proteins become more hydrated than in cookie doughs. This is because bread dough has a higher level of water (35% water on dough weight basis) than the average cookie dough (15% water on dough weight basis) (Kulp, 1994).

The higher the level of hydration of flour proteins, the more likely gluten development will occur. Gluten development is the result of hydration of proteins and the interaction of protein components to form an optimal structure (Kulp, 1994). High water content is a possible explanation for why higher percentages of mungbean paste may have resulted in increased gluten development.

Width/Thickness Ratios

Cookie spread is an important characteristic and is reported as the width/thickness ratio (W/T). Spread ratios may be measured as indicators of cookie dough quality (Penfield and Campbell, 1990). According to Method 10-50D of the AACC (1995), the width/thickness ratio (W/T ratio) is calculated as width divided by thickness.

LSD comparisons indicated that, for width/thickness ratio the control cookies were significantly higher ($p \leq 0.05$) than the 25% ($p = 0.034$), 50% ($p = 0.011$), 75% ($p = 0.006$), and 100% ($p = 0.002$) mungbean paste cookies.

Comparisons among experimental cookies indicated that width/thickness ratio was significantly different ($p \leq 0.05$) when the experimental cookies were compared with each other. The 25% mungbean paste cookies had a significantly higher width/thickness ratio than the 75% ($p = 0.029$) and 100% ($p = 0.008$) mungbean paste cookies. The 100% mungbean paste cookie had a significantly lower width/thickness ratio than the 50% ($p = 0.016$), and 75% ($p = 0.002$) mungbean paste cookies.

The adjusted width/thickness ratio decreased as the level of butter decreased and the amount of moisture increased. Similar results were noted when shortening levels were reduced in cookies. However, other researchers found that fats have a limited effect on cookie spread in general. Sugar and flour tend to have greater influence on spread than fat (Lorenz, 1994). Cookie spread is positively related to the amount of the sugar that dissolves in water in the cookie system (Yamazaki and Lord, 1978).

The amount of shortening influences cookie spread, but in a way that is related to the sugar content of the dough. Detailed studies, using sugar cookies, lead to the following generalizations. When sugar is used at 50% of the flour weight, increasing shortening from 35 to 55% (on a flour weight basis) increases spread about 25%. When sugar is used at 90% of the flour weight, increasing shortening from 35 to 55% decreases the spread (Stauffer, 1998).

Other formula variations, such as the addition of whole egg, change the amount of influence of shortening on spread. The different types of fat used also influence the spread. Each situation is different, and the best way to evaluate the effect of fat level on spread is by experimentation (Stauffer, 1998).

Spread Factor

The spread factor is the adjusted width/thickness ratio multiplied by 10. As expected, the significance and differences in spread factor were the same as the significance and differences in the width/thickness ratio.

The cookie spread decreased as mungbean paste increased. The control cookies had the greatest spread. Abboud et al. (1985) reported that cookie spread was not affected by an increase in shortening from 30 to 35%. This was only a 5% increase in shortening whereas in the mungbean paste cookie study, butter was reduced by 25%. At each 25% reduction in butter a decrease in cookie spread was noted.

Possibly what was happening to cause this spread could be explained by Doescher et al (1987). According to Doescher, in the oven the dough becomes softer as the shortening melts. Additional sugar dissolves, further contributing to fluidity and, therefore, to cookie spread. Carbon dioxide from the chemical leavener diffuses into the gas cell nuclei formed during mixing. With continued heating, steam also forms and contributes to dough expansion, though in most cookies its contribution is small compared with that of carbon dioxide from the leavening agent. The flour proteins, which are discontinuous in the dough, expand and form a continuous structure; the horizontal spreading stops when the viscosity becomes too great to permit flow.

Armbrister and Setser (1994) gathered objective data on low-fat chocolate chip cookies made with protein-based, lipid-based, and carbohydrate-based fat replacers. At the fat replacement levels of 50 and 75% (shortening weight basis), the control cookies had significantly ($p \leq 0.05$) less surface cracking, fewer surface protrusions, and more uniform but larger cells. The control chocolate chip cookies required more force for compression than any of the cookies made with fat replacers with the exception of cookies made with microparticulated protein.

Low-fat shortbread cookies were prepared using carbohydrate-based fat substitutes and emulsifiers in a study by Sanchez et al. (1995). The principal effects of fat substitutes on shortbread cookie attributes were higher moisture content, greater toughness, and lower specific volume. Addition of fat replacers had minimal effect on cookie height and width. Cookie height (in cm) increased with each level of fat replacement. The width (in cm) decreased with each level of fat replacement. This was similar to the results of the mungbean peanut butter cookies studied in this project.

Swanson and Munsayac (1999) studied the acceptability of fruit purees in peanut butter, oatmeal, and chocolate chip reduced-fat cookies. All three types of control cookies had a greater spread than the cookies made with applesauce or prune paste. This indicated restricted dough flow during baking. Regardless of fat replacer selected, reduced-fat cookies typically exhibit less cookie spread than their traditional full-fat counterparts (Swanson, 1998; Armbrister and Setser, 1994; Sanchez et al., 1995).

Lehmann et al. (1994) cited some possible reasons for decreased cookie spread: flour with a high protein content, flour with a high quality protein, chlorinated flour, use of plasticized shortening, large particle size sugar, high fat – low ratio sugar ratio, use of multistage mixing (creaming method), low percentage of moisture added to formula, high initial oven heat during baking, and/or high amount of water absorbing ingredients (e.g., gums, pregelatinized starch, fiber). In the study of mungbean paste peanut butter cookies the most probable reason for decreased spread was a high amount of water absorbing ingredients. Mungbean paste contains a wide array of ingredients that could have been moisture absorbers. One of these ingredients is fiber.

Vratania and Zabik (1978) found that spread showed the highest simple correlation with fiber components. Fiber does not have a Recommended Daily Allowance (RDA). Since it has an important relationship with health, fiber has a Daily Reference Value (DRV) instead. The DRV for fiber is 25 grams (Whitney and Rolfes, 1993).

Though mungbean cotyledon is not high in fiber, it contains more fiber than butter. Butter has no fiber. (See Table 6). The amount of fiber in mungbean varies from source to source depending on if the seed coat was included in the calculation. According to ESHA Research (1993) mungbean contains 7.6 grams of fiber per 100 grams of beans. Adsule et al. (1986) reported that mungbean is comprised of 4% fiber when the seed coat is included, however the cotyledon contains only 0.5% fiber. This small amount of fiber could be enough to make a slight difference in the water absorbing abilities of the cookie doughs compared in this study.

In addition to fiber, the possible impact of bean on decreased cookie spread must be noted. Dreher and Patek (1984) used roasted whole navy bean flour and high-protein bean flour for supplementation to shortbread cookies. The bean-supplemented cookies had lower spread and breaking strength than the control cookies. Rankin (1998) used cannellini bean puree in cookies as a fat replacer, but did not report on the cookie spread.

Sensory Evaluation Data

Analysis of Sensory Data

A panel of 9 members tested five sensory attributes with three replicates over four days during June 1999. There were no significant differences between days for any of the sensory attributes. The panelists based their ratings on a constant value of each attribute of the control cookie that was set during sensory training.

Each day panelists were furnished with a control cookie in addition to the four experimental cookies. The score sheet contained the reference ratings of the control cookie for each sensory attribute during each sensory session so that the panelist could rate all experimental cookies against the control.

Sensory data were analyzed with SPSS (SPSS Institute, Inc., 1997). The sensory data were analyzed by a one-sample t-test and Repeated Measures General Linear Model (GLM) with LSD pairwise comparisons. The one sample t-test was used to compare experimental cookies with the control cookies. The LSD pairwise comparison was used to compare the sensory data on each experimental cookie with all other experimental cookies' data.

Hardness

Sensory panelists rated the control cookie significantly ($p \leq 0.05$) harder than the cookies made with mungbean paste. The control was significantly harder ($p \leq 0.05$) than the 25% ($p = 0.018$), 50% ($p = 0.001$), 75% ($p = 0.010$), and 100% ($p = 0.000$) mungbean paste cookies (Table 8).

Table 8. Hardness of mungbean paste cookies and the control.

	Control	25% Mungbean Paste	50% Mungbean Paste	75% Mungbean Paste	100% Mungbean Paste
Mean	6.5	5.86[a] $\pm$ 0.28	5.55[a] $\pm$ 0.32	5.71[a] $\pm$ 0.36	5.02[a] $\pm$ 0.42

[a] Means are significantly different at $p < 0.05$ from the control.

LSD pairwise comparisons between experimental indicated that hardness was not significantly different ($p \leq 0.05$) between the experimental cookies.

Fracturability

The control cookie was not significantly different ($p \leq 0.05$) in fracturability from the cookies made with mungbean paste (Table 9).

Table 9. Fracturability of mungbean paste cookies and the control.					
	Control	**25% Mungbean Paste**	**50% Mungbean Paste**	**75% Mungbean Paste**	**100% Mungbean Paste**
Mean	4.5	4.36 ± 0.22	4.19 ± 0.16	4.11 ± 0.20	4.22 ± 0.24

Peanut flavor

Sensory panelists reported that the control cookie was significantly different ($p \leq 0.05$) in peanut flavor from the cookies made with mungbean paste. The control was significantly more peanutty ($p \leq 0.05$) than the 25% ($p = 0.032$), 50% ($p = 0.001$), 75% ($p = 0.000$), and 100% ($p = 0.000$) mungbean paste cookies (Table 10). This is interesting since the control cookie contained the same amount of peanut butter as the experimental cookies.

Table 10. Peanut flavor of mungbean paste cookies and the control.					
	Control	**25% Mungbean Paste**	**50% Mungbean Paste**	**75% Mungbean Paste**	**100% Mungbean Paste**
Mean	6.0	$5.26^{a} \pm 0.36$	$4.58^{b} \pm 0.44$	$4.09^{b} \pm 0.60$	$4.03^{b} \pm 0.56$

[a] Means with superscripts are significantly different at p< 0.05 from the control. Means not sharing a common superscript letter are significantly different than each other.

LSD pairwise comparisons among experimental cookies indicated that peanut flavor was significantly different ($p \leq 0.05$) among some of the cookies: the 25% mungbean paste cookie was significantly different in peanut flavor than the 50% ($p = 0.048$), 75% ($p = 0.022$), and 100% ($p = 0.007$) mungbean paste cookies. The 25% mungbean cookie had a significantly higher peanut flavor than the other mungbean cookies. Perhaps mungbean paste interfered with the amount of peanut flavor that panelists perceived.

Butter flavor

The control cookie was significantly different ($p \leq 0.05$) in butter flavor than two of the cookies made with mungbean paste. The control was significantly less buttery ($p \leq 0.05$) than the 25% ($p = 0.001$) and 50% ($p = 0.022$) mungbean paste cookies according to panelists (Table 11). Surprisingly, all experimental cookies were ranked higher in butter flavor than the control cookie.

Table 11. Butter flavor of mungbean paste cookies and the control.

	Control	**25% Mungbean Paste**	**50% Mungbean Paste**	**75% Mungbean Paste**	**100% Mungbean Paste**
Mean	2.0	$3.24^{ab} \pm 0.41$	$2.96^{a} \pm 0.61$	2.57 ± 0.48	$2.5^{b} \pm 0.46$

[a] Means are significantly different at $p < 0.05$ from the control.

[b] Cookie with 25% mungbean paste is significantly different ($p < 0.05$) from 100% mungbean paste cookie using LSD comparison.

LSD pairwise comparisons among experimental cookies indicated that butter flavor was significantly different ($p \leq 0.05$) between some of the cookies: the 100% mungbean paste cookie was significantly lower in butter flavor than the 25% ($p = 0.025$) mungbean paste cookie.

The findings of this study showed that sensory panelists perceived butter flavor in all experimental cookies. Drewnowski et al. (1998) showed that reducing the fat or butter content of six popular cookie recipes affected overall product quality less than did a comparable reduction in sugar content.

Different flavor

The control peanut butter cookie was significantly lower ($p \leq 0.05$) in different flavor than all of the cookies made with mungbean paste. The control was significantly lower ($p \leq 0.05$) for different flavor than the 25% ($p = 0.000$), 50% ($p = 0.000$), 75% ($p = 0.000$), and 100% ($p = 0.000$) mungbean paste cookies (Table 12).

Table 12. Different flavor of mungbean paste cookies and the control.

	Control	25% Mungbean Paste	50% Mungbean Paste	75% Mungbean Paste	100% Mungbean Paste
Mean	0.0	$2.23^a \pm 0.70$	$2.02^a \pm 0.70$	$2.48^a \pm 0.65$	$2.24^a \pm 0.68$

[a] Means are significantly different at $p < 0.05$ from the control.

LSD pairwise comparisons among experimental cookies indicated that different flavor was not significantly different ($p \leq 0.05$) between any of the mungbean paste cookies. When more mungbean paste was incorporated in the cookie recipe a stronger different flavor was not detected.

Consumer Testing Data

Two separate consumer tests were conducted. In the first test, 79 consumers tested the control peanut butter cookie against the 25% mungbean paste peanut butter cookie. This was not a forced choice test. Consumers could rank each cookie from 1 to 6 on a scale of dislike-like (See Fig. 3). A paired t-test showed that the responses for the two cookies were not significantly different ($p = 0.484$). Both cookies were rated between like and like very much on the score sheet (Table 13).

Table 13. Consumer liking of the control peanut butter cookie and 25% mungbean paste peanut butter cookie. (N = 73)

Cookie	Mean[1]	Standard Deviation
25% Mungbean paste	4.7	0.99
Control	4.8	0.99

[1] Rating on a scale from 1= dislike extremely to 6 = like extremely.

In the second test, 108 consumers tested the control peanut butter cookie against the 50% mungbean paste peanut butter cookie. A paired t-test on the data showed that the responses for the two cookies were significantly different ($p \leq 0.000$). On the scale of like-dislike both cookies were liked, but the control was liked more (Table 14). A mean above 4.0 indicates that consumers liked the cookie.

These findings were consistent with the findings of Drewnowski et al. (1998). Drewnowski et al. found that reducing fat content by 25% had no impact on overall product acceptability, which declined only when fat was reduced by 50%. Reducing fat content by 25% or even 50% had little impact on the liking for flavor. Drewnowski et al. concluded that as long as the sweetness of cookies is maintained, consumers will tolerate some deviation from the standard recipe in both texture and flavor.

Table 14. Consumer liking of the control peanut butter cookie and 50% mungbean paste peanut butter cookie. (N = 108)

Cookie	Mean	Standard Deviation
50% Mungbean paste	4.3[a]	0.97
Control	4.8	0.85

[a] Means are significantly different at $p < 0.05$

Nutrition Label

Nutrition labels were developed for this project using Food Processor ESHA Genesis Nutrition Analysis Software Version 7.21 (1998). Labels were made for the control peanut butter cookie and four levels of mungbean replacement (Fig. 4). The emulsifier was added to the label of all cookies containing mungbean paste. The labels show a 17% reduction in calories when 100% mungbean paste is used in place of butter. The control is 50% higher in total fat than the 100% mungbean cookie, 36% higher in total fat than the 75% mungbean cookie, 29% higher in total fat than the 50% mungbean cookie, and 14% higher in total fat than the 25% mungbean cookie. Since the cookies still contain peanut butter, the fat content cannot be completely eliminated.

Labeling laws have been set forth by the FDA (Whitney and Rolfes, 1993). According to these laws, the only cookie that could be labeled "light" is the 100% mungbean paste cookie because it has 50% less fat than the control cookie. The 75% and 100% mungbean paste cookies could be labeled "low in saturated fat" because they meet the criteria as having 1 gram or less of saturated fat per serving. The 50%, 75%, and 100% mungbean paste cookies could be labeled as having "less saturated fat" because they contain 25% or less saturated fat than the control cookie. The words "less fat" could appear on the packaging of the 50%, 75%, and 100% mungbean paste cookies because they meet the criteria as having 25% or less fat than the control cookie. The 25% mungbean paste cookie does not meet the criteria for any of these label claims.

Saturated fat is most dramatically affected by the total fat reduction. The control cookie is 80% higher in saturated fat than the 100% mungbean cookie, 60% higher in saturated fat than the 75% mungbean cookie, 40% higher in saturated fat than the 50% mungbean cookie, and 20% higher in saturated fat than the 25% mungbean cookie.

The control peanut butter cookie is 35% higher in monounsaturated fat than the 100% mungbean paste cookie, 27% higher in monounsaturated fat than the 75%

mungbean paste cookie, 18% higher in monounsaturated fat than the 50% mungbean paste cookie, and 9% higher in monounsaturated fat than the 25% mungbean paste cookie.

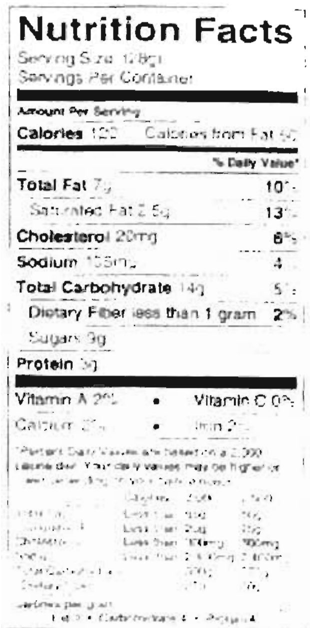
Minerals

Sodium was reduced 50% when 100% mungbean paste was used in place of butter. See Appendix G for complete information on the mineral content of cookies used in this study.

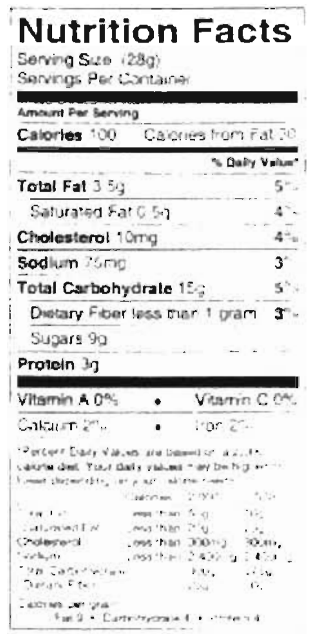
Vitamins

Mungbean paste didn't change values for Vitamins A and C. Folate is increased in cookies containing mungbean paste. When 100% mungbean paste is used in place of butter the folate content is increased by 27%. See Appendix H for complete nutrition information on vitamin content of all cookies used in this study.

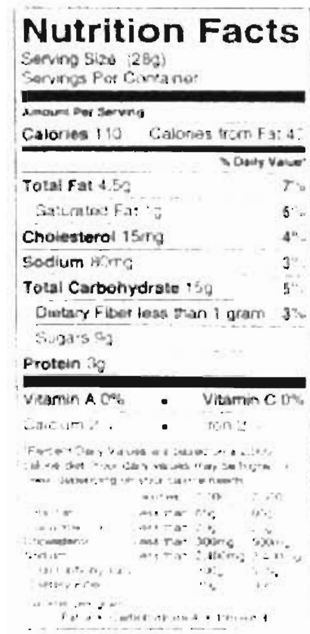
Control



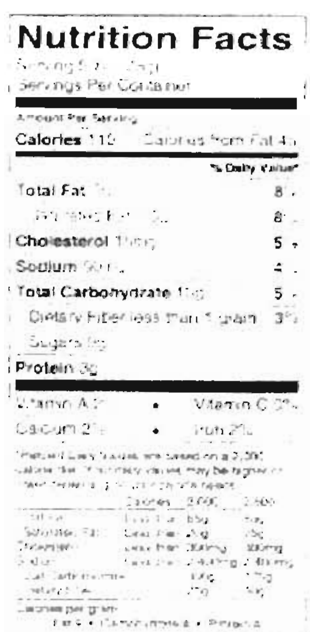
100% Mungbean paste



75% Mungbean paste



50% Mungbean paste



25% Mungbean paste

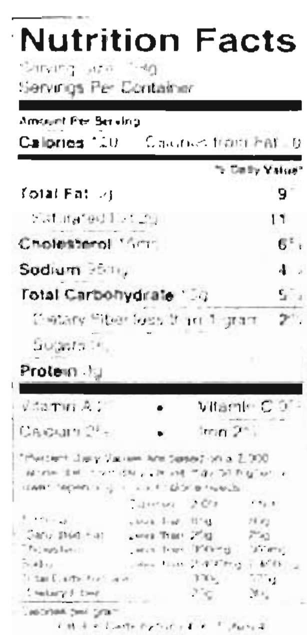


Fig. 4. Nutrition labels for the control peanut butter cookie and experimental cookies containing varying amounts of mungbean paste.

CHAPTER V

SUMMARY, CONCLUSION AND HYPOTHESIS TESTING

The replacement of mungbean paste (MB Paste) for butter in peanut butter cookies yielded cookies that were not significantly different in acceptability at the 25% MB Paste replacement level. Although the 50% MB Paste cookies were significantly different from the control cookie in acceptability, they were still ranked on the hedonic scale as a product that consumer panelists liked.

The 25% MB Paste cookie had 14% less total fat then the control, and the 50% MB Paste cookie had 29% less total fat than the control.

Saturated fat was reduced by 20% in the 25% MB Paste cookie, and 40% in the 50% MB Paste cookie. Monounsaturated fat was reduced by 9% in the 25% MB Paste cookie, and 18% in the 50% MB Paste cookie.

MB Paste cookies had a higher specific gravity than the control. This means that the batters which contained mungbean paste were more dense and had less air incorporated into the batter than the control. The weight of each batch of dough did not differ significantly from the control. The width of the baked cookies decreased and the thickness of the cookies increased as higher levels of mungbean paste were added. The spread factor and width/thickness ratio decreased with increasing levels of mungbean paste. Weight of cookies after baking varied. The control recipe consistently produced the lightest weight cookies (in grams). This can possibly be attributed to a lower density dough and success of the butter at entrapping air into the cookies.

Sensory scores for the texture attribute hardness of the four levels of MB Paste substitution were not significantly different from each other.

Hardness of the control cookie was rated significantly different from all MB Paste cookies. According to panelists, the cookies containing MB Paste were softer than the control. None of the cookies varied significantly in their level of fracturability.

The MB Paste cookies did not rate significantly different from each other in peanut flavor. However, the control rated significantly higher in peanut flavor than all cookies containing MB Paste.

All MB Paste cookies were scored more buttery by semi-trained sensory panelists than the control cookie which contained 100% of the fat as butter. The 25% and 50% MB Paste cookies were rated significantly higher in butter flavor than the control.

Semi-trained sensory panelists scored all MB Paste cookies significantly higher in different flavor than the control. The experimental cookies were not scored significantly different from each other for this flavor attribute, therefore increasing the level of MB Paste did not cause an increase in the perceived different flavor.

Mungbean Paste cookies did not differ significantly in hardness, fracturability, or different flavor. However, in peanut flavor the 25% MB Paste cookie was rated significantly more peanutty than the 50%, 75%, and 100% MB Paste cookies. All cookies containing MB Paste rated higher in butter flavor than the control, though the 25% MB Paste cookie rated significantly higher in butter flavor than the 100% MB Paste cookie.

The results of this study indicate that mungbean paste can be substituted for butter in USDA peanut butter cookies at the level of 25% without significant differences in acceptability from the full fat USDA peanut butter cookie, and mungbean paste substitution at the 50% level produces a cookie that consumers like.

Hypothesis testing

H_1: 1. There were significant differences in sensory attributes of hardness, peanut flavor, butter flavor, and different flavor, between the control cookie and the 50% mungbean paste cookie.

2. There were significant differences in objective tests of adjusted thickness, adjusted width/thickness ratio, average scoop weight, specific gravity, spread factor, thickness (as-is), width/thickness ratio, and weight after baking between the control cookie and the 50% mungbean paste cookie.

Therefore we reject the hypothesis H_1 that there would be no significant differences in the sensory attributes and objective tests between the control cookie and the 50% mungbean paste cookie.

H_2: 1. There were significant differences in sensory attributes of peanut flavor and butter flavor among all mungbean paste cookies.

2. There were significant differences in objective tests of adjusted thickness, adjusted width, adjusted width/thickness ratio, average scoop weight, specific gravity, spread factor, thickness (as-is), width (as-is), width/thickness ratio, and weight after baking among all mungbean paste cookies.

Therefore we reject the hypothesis H_2 that there would be no significant differences in the sensory attributes and objective tests among mungbean paste cookies.

H_3: 1. There were no significant differences in overall consumer acceptability of the control cookie and the 25% mungbean paste cookie.

We accept hypothesis H_3.

H_4: 1. There were significant differences in overall consumer acceptability of the control cookie and the 50% mungbean paste cookie.

Therefore we reject hypothesis H_4 that there would be no significant differences in overall consumer acceptability between the control cookie and the 50% mungbean paste cookie.

CHAPTER VI

SUGGESTIONS FOR FUTURE STUDY

This study showed that mungbean paste substituted for butter can produce a cookie with a more buttery taste than the peanut butter control cookies. Sensory analysis has shown that it is difficult to differentiate between the levels of mungbean paste that a cookie contains. Consumer acceptance testing showed that the 25% mungbean paste cookie was as acceptable as the control, and that the 50% mungbean paste cookie was liked. The following contains suggestions for future study:

The review of literature indicated that a reduction in total fat in cookies is possible when a legume is substituted for butter. Since consumers found the 25% mungbean cookie as acceptable as the control cookie and liked the 50% mungbean cookie, it would be interesting to conduct further studies to determine the optimum level of mungbean replacement for butter between the levels of 25% and 50%. This would be important in determining the maximum amount of total fat and saturated fat that could be reduced and still provide a product with overall acceptability equal to that of the control cookie.

A test of specific gravity should be conducted on mungbean paste, butter, and peanut butter in order to determine what type of a density difference is being dealt with when one product is substituted for another.

Research needs to be conducted to develop an acceptable reduced fat peanut butter cookie mix using mungbean paste as a fat replacer.

Sensory and consumer evaluations were conducted on freshly baked cookies. Research needs to be conducted on the storage and shelf life of mungbean paste cookies.

A highly trained sensory panel could perform a descriptive analysis on the storage qualities of mungbean cookies.

Different levels or combinations of emulsifiers should be tested to determine if one is better than the other. This study was not designed to identify a single critical point.

Since this study was a pilot test with large-scale production in school foodservice facilities as the goal, it would be important to do the same testing in quantity cookie batches to see if cooking characteristics are the same. This type of study should utilize a convection oven rather than a conventional oven so that large batches of cookies could be prepared at the same time. This would help ensure baking time and temperature consistency.

Mungbean paste is very versatile. It would be beneficial to try to reduce the fat content of peanut butter cookies by substituting mungbean paste in place of peanut butter and butter in different amounts. This would allow total fat to be reduced below the level that was possible in this study.

Around the world this legume is highly consumed, but in the United States mungbean is not in high demand as a human food source. Mungbean paste made from non-sprouting mungbeans could be substituted in many recipes in order to develop new food uses that suit the tastes of American consumers and to create a market for this underutilized Oklahoma legume crop.

REFERENCES

Abboud, A.M., Rubenthaler, G.L., and Hoseney, R.C. 1985. Effect of fat and sugar in sugar-snap cookies and evaluation of tests to measure cookie flour quality. Cereal Chem. 62: 124-129.

ACSH. 1995. Facts about fats: Health effects of dietary fats and oils. Am. Council on Science and Health, New York.

Adsule, R.N., Kadam, S.S., and Salunkhe, D.K. 1986. Chemistry and technology of green gram (*Vigna radiata* [L.] Wilczek). Crit. Rev. Food Sci. Nutr. 25(1): 73-105.

AACC. 1995. *Approved Methods of the American Association of Cereal Chemists*, 9th ed. Method 10-50D. American Association of Cereal Chemists Inc., St. Paul, Minnesota.

Araullo, E.V. 1974. Processing and utilization of cowpea, chickpea, pigeonpea, and mungbean. Proceedings of Interdisciplinary Symposium, The Interaction of Agriculture with Food Science, Singapore, February.

Armbrister, W.L. and Setser, C.S. 1994. Sensory and physical properties of chocolate chip cookies made with vegetable shortening or fat replacers at 50 and 75% levels. Cereal Chem. 71(4): 344-351.

ASTM. 1986. Manual on Consumer Sensory Evaluation. E.E. Shaefer (Ed.), p.1-52. American Society for Testing and Materials, Philadelphia.

Bernardin, J.E. and Kasarda, D.D. 1973. Hydrated protein fibrils from wheat endosperm. Cereal Chem. 50: 529-536.

Cady, N.D., Carter, A.E., Kayne, B.E., Zabik, M.E., and Uebersay, M.A. 1987. Navy bean flour substitution in a master mix used for muffins and cookies. Cereal Chem. 64: 193-195.

Carlin, G. T. 1944. A microscopic study of the behavior of fats in cake batters. Cereal Chem. 21: 189-199.

CFR. 1995. *Child nutrition programs: school meal initiatives for healthy children*; final rule, 60 Federal Register 31188 (codified at 7 CFR 210,220).

Chainuvati, C., Potan, N., and Worasan, T. 1988. Mungbean and blackgram production and development in Thailand. Mungbean: Proceedings of the Second International Symposium. Asian Vegetable Research and Development Center, Shanhua, Taiwan.

Chandrasekhar, U. and Jayalakshmi, K. 1978. Evaluation of protein quality of sprouted, roasted and autoclaved legumes on albino rats. Indian J. Nutr. Diet. 15: 414-419.

Charlton, O. and Sawyer-Morse, M.K. 1996. Effect of fat replacement of sensory attributes of chocolate chip cookies. J. Am. Diet Assoc. 96(12): 1288-1290.

Chavan, J.K. and Kadam, S.S. 1993. Nutritional enrichment of bakery products by supplementation with nonwheat flours. Crit. Rev. Food Sci. Nutr. 33(3): 189-226.

Cupka, T.B. and Edwards, L.H. 1988. Production and breeding of mungbean in the U.S.A. Mungbean: Proceedings of the Second International Symposium. Asian Vegetable Research and Development Center, Shanhua, Taiwan.

Devadas, R.P., Leela, R., and Chandrasekaran K.N. 1964. Effect of cooking on the digestibility and nutritive value of the proteins of black gram (*Phaseolus mungo*) and green gram (*Phaseolus radiatus*). J. Nutr. Dietet. 1: 84-86.

DHHS. 1994. Daily dietary fat and total food-energy intakes-Third national health and nutrition examination survey, phase 1, 1988-91. MMWR, 43, 117-124.

Diwan, M.A., Sastri, P.N., and Rao, B.Y. 1982. Use of green gram (Phaseolus mungo Roxb) flours in biscuits, Ind. Food Process., 36: 71.

Doescher, L.C.. Hoseney, R.C., and Milliken, G.A. 1987. A mechanism for cookie dough setting. Cereal Chem. 64: 158-163.

Drewnowski, A. 1987. Fats and food texture: sensory and hedonic evaluations. In *Food Texture*, H.R. Moskowitz (Ed.), p. 251-272. Marcel Dekker, New York.

Drewnowski, A. 1995. Intense sweetners and the control of appetite. Nutrition Reviews 53: 1-7.

Dreher, M.L. and Patek, J.W. 1984. Effects of supplementation of short bread cookies with roasted whole navy bean flour and high protein flour. J. Food Sci. 49(1): 922-924.

Drewnowski, A., Nordensten, K., and Dwyer, J. 1998. Replacing sugar and fat in cookies: impact on product quality and preference. Food Quality and Preference 9(1-2): 13-20.

Engell, D., Bordi, P., Borja, M., Lambert, C., and Rolls, B. 1998. Effects of information about fat content on food preferences in pre-adolescent children. Appetite 30: 269-282.

Epstein, M. 1994. *Serving Up Success: Schools Making Nutrition a Priority.* Public Voice for Food and Health Policy, Washington, D.C.

ESHA Research. 1993. Table of Food Composition. Appendix H in *Understanding Nutrition*, E. N. Whitney and S. R. Rolfes, 6th ed., p. H1-H99. West Publishing Company, Minnesota.

Fleming, S.E. 1981. A study of relationship between flatus potential and carbohydrate distribution in legume seeds. J. Food Sci. 46: 794-798.

Food Processor ESHA Genesis Nutrition Analysis Software. 1998. Version 7.21.

Freeland-Graves, J.H. and Peckham, G.C. 1987a. Cakes, cookies, and mixes. Ch. 24 in *Foundations of Food Preparation,* 5th ed. p. 308-329. Macmillan Publishing Co., Englewood Cliffs, New Jersey.

Freeland-Graves, J.H. and Peckham, G.C. 1987b. Lipids. Ch. 5 in *Foundations of Food Preparation,* 5th ed. p. 43-54. Macmillan Publishing Co., Englewood Cliffs, New Jersey.

Giese, J. 1996. Fats, Oils, and Fat Replacers. Food Technol. 4: 78-83.

Gupta, V.P. and Kapoor, A.C. 1980. Chemical evaluation of protein quality of various grain legumes. Indian J. Agr. Sci. 50: 393-398.

Guthrie, H.A. 1983. *Introductory Nutrition.* C.V. Mosby Co., St. Louis, Missouri.

Handlemen, A. R., Conn, J. F., and Lyons J. W. 1961. Bubble mechanics in thick foams and their effects on cake quality. Cereal Chem. 38: 294-305.

Haytowitz, D.B. and Matthews, R.H. 1986. *Composition of Foods: Legumes and Legume Products.* The United States Department of Agriculture, Agriculture Handbook No. 8-16.

Herbst, S.T. 1995. *The New Food Lover's Companion: Comprehensive Definitions of Over 4000 Food, Wine, and Culinary Terms,* 2nd ed. Barron's Educational Series Inc., Hauppauge, New York.

Hess, J.L. 1994. The United States cookie industry. Ch. 1 in *Cookie Chemistry and Technology*, K. Kulp (Ed.), p. 1-19. The American Institute of Baking, Kansas.

Hoseney, R.C., Zeleznak, K., and Lai, C.S. 1986. Wheat gluten: glassy polymer. Cereal Chem. 63: 285-286.

Hutchinson, P.E., Baiocchi, F., and Del Vecchio, A.J. 1977. Effect of emulsifiers on the texture of cookies. J. Food Sci. 42(2): 399-401.

IFT Sensory Evaluation Division. 1981. Sensory evaluation guide for testing food and beverage products. Food Technol. 35(11): 50-59.

IFT. 1964. Sensory testing guide for panel evaluation of foods and beverages. Food Technol. 18: 1135-1141.

IFT. 1975. Minutes of sensory evaluation div. business meeting at 35th Ann. Mtg., Inst. of Food Technologists, Chicago, IL, June 10.

Jyothi, E. and Reddy, P.R. 1981. The effect of germination and cooking on in vitro digestibility of starch in some legumes. Nutr. Rep. Int. 23(5): 799-804.

King, B.M., Arents, P., and Moreau, N. 1995. Cost/efficiency evaluation of descriptive analysis panels. Part 1. Panel size. Food Quality and Preference. 6: 245.

Kissell, L.T. and Yamazaki, W.T. 1975. Protein enrichment of cookie flours with wheat gluten and soy flour derivatives. Cereal Chem. 52: 638-649.

Kulp, K. 1994. Functionality of Ingredients in Cookie Systems. Ch. 10 in *Cookie Chemistry and Technology*, K. Kulp (Ed.), p. 210-279. The American Institute of Baking, Kansas.

Latta, S. 1990. Dietary fats: New directions in research. Inform 1(4): 238-258.

Lawless, H.T. 1994. Getting results you can trust from sensory evaluation. Cereal Foods World. 39(11): 809-814.

Lawless, H.T. and Claassen, M.R. 1993. Application of the central dogma in sensory evaluation. Food Technol. 47(6): 139-146.

Lee, C. C., Hoseney, R. C., and Varriano-Marston, E. 1982. Development of a laboratory-scale single-stage cake mix. Cereal Chem. 59: 389-392.

Lehmann, T.A., Zeak, J.A., and Strouts, B.L. 1994. Technological processes and problems in cookie production. Ch. 11 in *Cookie Chemistry and Technology*, K. Kulp (Ed.), p. 280-306. The American Institute of Baking, Kansas.

Ling, Y., Gu, H., Liu, C., and Sun., L. 1988. Mungbean production in China and AVRDC's variety performance in Jiangsu Province. Mungbean: Proceedings of the Second International Symposium. Asian Vegetable Research and Development Center, Shanhua, Taiwan.

Lorenz, K.J. 1994. Fats and Oils in Cookies. Ch. 6 in *Cookie Chemistry and Technology*, K. Kulp (Ed.), p. 120-148. The American Institute of Baking, Kansas.

Lyle, B.J., McMahon, K.E., and Kreutler, P.A. 1992. Assessing the potential dietary impact of replacing dietary fat with other macronutrients. J. Nutr. 122: 211-216.

Mabesa, L.B., Atutubo, E.O., and Daquil, M.M. 1983. Nutritional quality of products prepared from germinated legumes. Philippine J. Nutr. 36: 182.

Mabesa, L.B. 1983. Water absorption, water adsorption, and gelation characteristics of flours from germinated legumes. Philipp. Agric. 66: 136-143.

Mancini, L. 1992. Taste trials: making sensory panels work. Food Eng. 64(9): 121-126.

Mattes, R. 1993. Fat preference and adherence to a reduced-fat diet. Am. J. Clin. Nutr. 57: 373-381.

Meilgaard, M., Civille, G.V., and Carr, B.T. 1987. *Sensory Evaluation Techniques*, Volume II. CRC Press, Boca Raton, Florida.

Mela, D.J. 1992. Nutritional implications of fat substitutes. J. Am. Diet. Assoc. 92: 472-476.

Miller, R.A. and Hoseney, R.C. 1997. Use of elongational viscosity to estimate cookie diameter. Cereal Chem. 74(5): 614-616.

Miller, R.A., Hoseney, R.C., and Morris, C.F. 1997. Effect of formula water content on the spread of sugar-snap cookies. Cereal Chem. 74(5): 669-671.

Morton, F., Smith, R.E., and Poehlman, J.M. 1982. *The Mungbean.* Special Publication of the College of Agricultural Sciences. Department of Agronomy and Soils, Mayaguez, Puerto Rico.

Murphy, E.L. 1975. The possible elimination of legume flatulence by genetic selection. In *Nutritional Improvement of Food Legumes by Breeding*, M. Milner (Ed.), p.273. John Wiley & Sons, New York.

Naikare, S.M., Chavan, J.K., and Kadam, S.S. 1986. Studies on protein enrichment of cookies and biscuits prepared from wheat: pearl millet blends with green gram. J. Maharashtra Agric. Univ. 11(2): 257-258.

O'Mahony, M. 1995. Sensory measurement in food science: fitting methods to goals. Food Technol. 49(4): 72-82.

Oplinger, E.S., Hardman, L.L., Kaminski, A.R., Combs, S.M., and Doll, J.D. 1990. Mungbean. Rept. Alternative Field Crops Manual/Minnesota Extension Service/ University of Wisconsin-Extension/University of Minnesota/Center for Alternative Plant and Animal Products. May, p.1-4.

Payumo, E.M. 1978. The potentials of mungbean as a protein supplement for child feeding. Proceedings 1st International Mungbean Symposium. Asian Vegetable Research and Development Center, Shanhua, Taiwan, 49-53.

Payumo, E.M. and Castillo, E.S. 1979. Preparation and storage qualities of instant mungbean soup. Phil. J. Nutr. 32: 87-91.

Payumo, E.M., Briones, P.R., Banzon, E.A., and Torres, M.L. 1969. The preparation of coco noodle. Phil. J. Nutr. 22: 216-224.

PCARR. 1977. *The Philippines Recommends for Mungo 1977.* Philippine Council of Agriculture and Resources Research, Los Baños.

Penfield, M.P. and Campbell, A.M. 1990. *Experimental Food Science.* 3rd ed. Academic Press, Inc., San Diego, California.

Poehlman, J.M. 1991. *The Mungbean.* Westview Press, Boulder, Colorado.

Pyler, E.J. 1988. *Baking Science and Technology Vol II*, 3rd ed. Sosland Publishing, Merriam, Kansas.

Rachie, K.O. and Roberts, L.M. 1974. Grain legumes in lowland tropics. Adv. Agron. 26: 62-77.

Rankin, L.L. 1998. Acceptability of chocolate chip cookies prepared using pureed white beans as a fat replacement. J. Am. Diet. Assoc. 98(9): A-101.

Rolls, B.J. 1994. Modification of foods to achieve dietary recommendations. Mini-Symposium, Experimental Biology '94 Annual Meeting, Anaheim, California, April 25.

Rolls, B.J. and Hammer. V.A. 1995. Fat, carbohydrate, and the regulation of energy intake. Am J Clin Nutr 62(Suppl.): 1086S-1095S.

Rusch, D.T. 1981. Emulsifiers: Uses in cereal and bakery foods. Cereal Foods World. 26: 111-115.

Rutledge, K.P. and Hudson, J.M. 1990. Sensory evaluation: method for establishing and training a descriptive flavor analysis panel. Food Technol. 44(12): 78-84.

Salunkhe, D.K., Sathe, S.K., and Reddy, N.R. 1982. Legume lipids. In *Chemistry and Biochemistry of Legumes,* S.K. Arora (Ed.), p. 51-109. Oxford and IBH Publishing, New Delhi, India.

Sanchez, C., Klopfenstein, C.F., and Walker, C.E. 1995. Use of carbohydrate-based fat substitutes and emulsifying agents in reduced-fat shortbread cookies. Cereal Chem. 72(1): 25-29.

Sandu, T.S., Singh, K., and Singh, B. 1988. Mungbean germplasm resources: evaluation and utilization. Mungbean: Proceedings of the Second International Symposium. Asian Vegetable Research and Development Center, Shanhua, Taiwan.

Sigman-Grant, M. 1997. Can you have your low-fat cake and eat it too? The role of fat-modified products. J. Am. Diet. Assoc. 97(suppl): S76-S81.

Sigman-Grant, M.J., Kris-Etherton, P.M., and Zimmerman, S. 1993. Dietary approaches for reducing fat intake for pre-school-aged children. Pedia. 91: 955-960.

Sneed, J. 1992. Continuing education needs of school food service supervisors. Sch. Food Serv. Res. Rev. 16(1): 23-28.

Souci, S.W., Pachmann, W., and Kraut, H. 1986. Food Composition and Nutrition Tables. Wissenschaftliche Verlagsgesellschaft Mbh, Stuttgart.

SPSS Institute, Inc. 1997. SPSS User's Guide, SPSS for Windows Release 8.0, Chicago, Illinois.

Stauffer, CE. 1998. Fats and Oils in Bakery Products. Cereal Foods World. 43(3): 120-126.

Stockwell, A.C. 1995. The quest for low fat. Baking & Snack. 17(4): 32-42.

Stone, H., McDermott, B.J., and Sidel, J.L. 1991. The importance of sensory analysis for the evaluation of quality. Food Technol. 45(6): 88-95.

Swanson, R.B. 1998. Acceptability of reduced-fat peanut butter cookies by school nutrition managers. J. Am. Diet. Assoc. 98(8): 910-912.

Swanson, R.B. and Munsayac, L.J. 1999. Acceptability of fruit purees in peanut butter, oatmeal, and chocolate chip reduced-fat cookies. J. Am. Diet. Assoc. 99(3): 343-345.

Tuorila, H., Cardello, A.V., and Lesher, L.L. 1994a. Antecedents and consequences of expectations related to fat-free and regular-fat foods. Appetite 23(3): 247-263.

Tuorila, H., Meiselman, H.L., Bell, R., Cardello, A.V., and Johnson, W. 1994b. Role of sensory and cognitive information in the enhancement of certainty and liking for novel and familiar foods. Appetite 23: 231-246.

USDA. 1988. World Grain Situation and Outlook. U.S. Pulse Reference Tables and Graphs. Foreign Agricultural Service, Circular Series, Supplement 13-88. p. 94.

USDA: *Quantity Recipes for School Food Service*. 1988. USDA Food and Nutrition Service Program Aid Rept. 1371., Washington, D.C.

USDA and DHHS. 1995. *Nutrition and your Health: Dietary Guidelines for Americans*, 4th ed. Home and Garden Bulletin No. 232, Washington, D.C.

Vijayaraghavan, P.K. and Srinivasan, P.R. 1953. Essential amino acid composition of some common Indian pulses. J. Nutr. 51: 261-271.

Vratanina, D.L. and Zabik, M.E. 1978. Dietary fiber sources for baked products: bran in sugar-snap cookies. J. Food Science 43(5): 1590-1593.

Vratanina, D.L. and Zabik, M.E. 1980. Bran as a source of dietary fiber in oatmeal cookies. J. Am. Diet. Assoc. 77: 26-30.

Whitney, E.N. and Rolfes S.R. 1993. Food Labels. Highlight 2 in *Understanding Nutrition*, 6th ed., p. 58-65. West Publishing Company, Minnesota.

Williams, C. 1992. Consumer considerations in reduced fat foods. In *Dietary Fats: Determinants of Preference, Selection and Consumption*, D.J. Mela (Ed.), p. 179-192. Elsevier Science, London.

Yamazaki, W.T. 1955. The concentration of a factor in soft wheat flours affecting cookie quality. Cereal Chem. 32: 26-37.

Yamazaki, W.T. and Lord, D.D. 1978. Soft wheat products. In: *Wheat Chemistry and Technology*, 2nd ed., Y. Pomeranz (Ed.) p. 743-776. St. Paul, Minnesota: AACC.

APPENDIX A

Fatty acid comparison of butter and mungbean paste

Mungbean[a] Saturated Fat 27.7% Unsaturated Fat 72.8%

Percentage	Fatty Acid	C Atoms	Double Bonds	Melting Point
14.1%	Palmitic	16	0	145.4 °F
4.3%	Stearic	18	0	161.2
9.3%	Behenic	NA[b]	NA[b]	NA[b]
20.8%	Oleic	18	1	61.3
16.3%	Linoleic	18	2	41.0
35.7%	Linolenic	18	3	11.7

Butter[c]

Percentage	Fatty Acid	C Atoms	Double Bonds	Melting Point
4%	Butyric	4	0	24.3
2%	Caproic	6	0	29.3
1%	Caprylic	8	0	61.7
3%	Capric	10	0	88.7
3%	Lauric	12	0	111.2
11%	Myristic	14	0	136.4
27%	Palmitic	16	0	145.4
12%	Stearic	18	0	161.2
2%	Palmitoleic	16	1	32.0
29%	Oleic	18	1	61.3
2%	Linoleic	18	2	41.0
1%	Linolenic	18	3	11.7

[a] Salunkhe et al., 1982
[b] Data not available
[c] Lorenz, 1994

APPENDIX B

Vitamin and mineral comparison of butter[a] and mungbean paste[a]

Vitamins	Mungbean (100g)	Butter (100g)
Thiamin	0.12 - 0.68 mg	0.02 mg
Riboflavin	0.24 - 0.50 mg	0.08 mg
Niacin	1.1 - 2.5 mg	0.1 mg
Pantothenic acid	1.91 mg	0
Folacin	624.9 mcg	6 IU
Vitamin A	114 IU	1704 RE

Minerals	Mungbean (100g)	Butter (100g)
Calcium	132 mg	54 mg
Phosphorus	367 mg	52 mg
Iron	6.74 mg	0.36 mg
Sodium	15 mg	1866 mg
Potassium	1246 mg	58 mg
Zinc	2.68 mg	0.12 mg
Copper	0.941 mg	NA[b]
Manganese	1.035 mg	NA[b]

[a] ESHA Research, 1993.
[b] Data not available

APPENDIX C

Amino acid composition of seeds of mungbean, wheat, rice, soybean, and egg protein. Values expressed as milligrams per gram of nitrigen, edible portion [a,b,c]

	Mungbean	Wheat (Whole grain)	Rice (unpolished)	Soybean	Egg Protein
Lysine	436	201	262	416	450
Methionine	75	120	144	84	213
Cystine	55	152	84	101	150[d]
Tryptophan	68	82	76	91	94
Threonine	205	228	287	272	325

[a] Mungbean and soybean data adapted from Haytowitz and Matthews (1986). The number of samples analyzed ranged from 23 for tyrosine to 383 for lysine.
[b] Cereal data adapted from Souci et al. (1986)
[c] Except for cystine, egg protein data adapted from Gupta (1983).
[d] Gupta and Kapoor (1980).

APPENDIX D

Recipe for varying percentages of fat replacement

Control (100% butter)

Ingredients	Bakers' Percent
AP Flour	100.0 g
Baking Soda	1.1
Salt	0.7
Dry Milk	16.8
Sugar	99.2
Brown Sugar	28.0
Vanilla	3.3
Butter	
full fat	59.9
Egg	39.3
Peanut Butter	99.2

25% Mungbean

Ingredients	Bakers' Percent
AP Flour	100.0 g
Baking Soda	1.1
Salt	0.7
Dry Milk	16.8
Sugar	99.2
Brown Sugar	28.0
Vanilla	3.3
Butter	
75% fat	44.9
Egg	39.3
Peanut Butter	99.2
Mungbean	
25% mung	15.0

50% Mungbean

Ingredients	Bakers' Percent
AP Flour	100.0 g
Baking Soda	1.1
Salt	0.7
Dry Milk	16.8
Sugar	99.2
Brown Sugar	28.0
Vanilla	3.3
Butter	
50% fat	30.0
Egg	39.3
Peanut Butter	99.2
Mungbean	
50% mung	30.0

75% Mungbean

Ingredients	Bakers' Percent
AP Flour	100.0 g
Baking Soda	1.1
Salt	0.7
Dry Milk	16.8
Sugar	99.2
Brown Sugar	28.0
Vanilla	3.3
Butter	
25% fat	15.0
Egg	39.3
Peanut Butter	99.2
Mungbean	
75% mung	44.9

100% Mungbean (no butter)

Ingredients	Bakers' Percent
AP Flour	100.0 g
Baking Soda	1.1
Salt	0.7
Dry Milk	16.8
Sugar	99.2
Brown Sugar	28.0
Vanilla	3.3
Egg	39.3
Peanut Butter	99.2
Mungbean	
100% mung	59.9

APPENDIX E

Ingredients listed as bakers' percent and true percent

Ingredients	True Percent	Bakers' Percent
AP Flour	22.3%	100.0 g
Baking Soda	0.2%	1.1
Salt	0.17%	0.7
Dry Milk	3.8%	16.8
Sugar	22.2%	99.2
Brown Sugar	6.2%	28.0
Vanilla	0.7%	3.3
Butter		
full fat	13.4%	59.9
25% fat	3.3%	15.0
50% fat	6.7%	30.0
75% fat	10.0%	44.9
Egg	8.8%	39.3
Peanut Butter	22.2%	99.2
Mungbean		
full mung	13.4%	59.9
25% mung	3.3%	15.0
50% mung	6.7%	30.0
75% mung	10.0%	44.9

APPENDIX F

Preliminary score sheet

Mungbean peanut butter cookie premliminary score sheet.
Circle the number that most closely matches your sample. You may write in a decimal point if you wish.

Sample from Batch #_________

Peanut Flavor	0__1__2__3__4__5__6__7__8__9__10 little	 much
Bean Flavor	0__1__2__3__4__5__6__7__8__9__10 little	 much
Texture	0__1__2__3__4__5__6__7__8__9__10 chewy	 hard
Acceptability	0__1__2__3__4__5__6__7__8__9__10 not acceptable	 very acceptable

Comments

APPENDIX G

Nutritional composition of Surfax™ (7001) per 100 grams

Calories	322.4 Calories
Calories from fat	264.5 Calories
Moisture	55.9 g
Protein	0 g
Total carbohydrate	14.5 g
Sugars	0 g
Dietary fiber	0 g
Total fat	29.4 g
Saturated fat	29.4 g
Sodium	5.1 mg
Potassium	0 mg
Ash	0.2 g
Cholesterol	0 mg
Vitamin A	Negligible
Vitamin C	Negligible
Thiamin	0 mg
Folate	0 mg
Riboflavin	0 mg
Niacin	0 mg
Calcium	0 mg
Iron	0.001 mg

The information above has been complied from publications of the USDA and from data provided by Caravan's suppliers.

APPENDIX H

Consent to Participate in Sensory Evaluation of Peanut Butter Cookies with Mungbean as a Fat Replacer

I, ________________________________, voluntarily agree to participate in the above titled research that is sponsored by the College of Human Environmental Sciences at Oklahoma State University.

I understand that:

1. I will be participating in research to test the sensory qualities of peanut butter cookies with mungbean as a fat replacer.

2. The sensory panel will be drawn from faculty, staff, parents and students of Oklahoma State University and/or Langston University.

3. This study will take place during the 1999 school year.

4. Participation or non-participation in this study will in no way affect my grade or performance rating; but by participating in this research I will see how sensory evaluation can contribute to scientific research designed to encourage economic development in Oklahoma.

5. I will be informed of all foods and ingredients that I will be asked to evaluate. If I know or suspect that I am allergic to any of them, I will withdraw myself from testing this product.

6. A code number will record all results obtained from my participation in this research. My identity will be kept confidential, and I will not be identified as an individual or by response in any presentation of the results.

7. My participation is voluntary, and I have the right to withdraw from this study at any time with no penalty by contacting the principal investigators.

8. I have not waived any of my legal rights or released this institution from liability or negligence.

I may contact Dr. Sue Knight at (405)744-5043, Dr. Barbara Stoecker (405)744-5040, or Melissa Adair (405)747-0068 should I need further information. I may contact the office of University Research Services, 305 Whitehurst, Oklahoma State University, Stillwater, OK 74078 at (405)744-5700.

I have read and fully understand this consent form. I sign it voluntarily. A copy has been given to me.

Date______________________ Time ______________(am/pm)

Signed____

I certify that I have personally explained all elements of this form to the subject before requesting the subject to sign it.

Signed____
(project director of authorized representative)
Printed Name_______________________________________
(project director or authorized representative)

APPENDIX I

Sensory Panelist Packet

Evaluation of USDA Peanut Butter Cookies

Summer 1999

Panelist Name________________

Sensory Panel Training Session Outline

1. Taste Acuity Exercise (Exercise - 1)
You have 5 samples in front of you. Beginning with the sample at your left, take a sip and identify the sample as one of the following: sweet, sour, salty, or bitter. Write the number that is on the side of the cup that you sampled next to the word which best describes it. Continue this activity until you have sampled all 5 cups in front of you. One of the samples is used twice. Can you identify which one it is?

2. Introduction to Scaling (Exercise - 2)
This scaling exercise shows us how to use a scale and how we perceive things differently. If you look at how the person next to you marked their scaling sheet you will see that differences exist between your sheet and theirs. Neither one of you is necessarily right or wrong. You both perceive things differently. The scale used in this exercise was developed by Meilgaard et al. (1987).

3. Scaling Practice Using New Terminology (Exercise -3)
We will work with the following descriptors hardness, fracturability, peanut flavor, butter flavor, and different flavor. We will review the definition for each flavor and discuss the technique for determining that characteristic. We will view the scale for that characteristic and taste samples that have been determined by a trained panel to be at different locations on that scale.

4. Scaling of the control peanut butter cookie.
Using the terminology we have learned and the reference points which were established in step 3, we will determine where the control cookie falls on the scale. We must determine where the control cookie falls on the following scales: hardness, fracturability, peanut flavor, butter flavor, and different flavor.

5. Introduction to evaluation form
Review the evaluation form and explain how to fill it out according to what we have learned in previous sessions. The control cookie and several other values will be on the scale to help serve as a reference point.

6. Explain procedure for next three sessions
Find a cubicle that is available and have a seat. A panel instructor will bring you an evaluation form, writing utensil, glass of deionized water, spit cup, four cookie samples and a control cookie sample. (The control sample is identical to the one we scaled in class during the last training session. The control should serve as the reference point by which all other cookies will be judged.) You may begin rating the cookies when you have all the items mentioned above. When you have completed your evaluation you are free to leave. The next two sessions will follow this procedure.

Exercise - 1

Taste Acuity Exercise

Instructions. You have 5 samples in front of you. Beginning with the sample at your left, take a sip and identify the sample as one of the either sweet, sour, salty, or bitter. Write the number that is on the side of the cup that you sampled next to the word which best describes it. Continue this activity until you have sampled all 5 cups. One of the samples is used twice. Can you identify which one it is? When everyone has completed this exercise we will discuss the results. While you wait for everyone to finish, you can read over exercise 2.

Flavor	Sample number
Sweet	___________
Sour	___________
Salty	___________
Bitter	___________

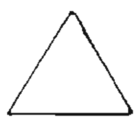
Exercise - 2

Introduction to Scaling

Instructions. Mark on the line at the right to indicate the proportion of the area that is shaded.

NONE ______________________ ALL

NONE ______________________ ALL

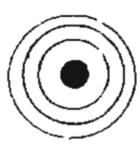


NONE ______________________ ALL

1.

NONE ______________________ ALL

2.



NONE ______________________ ALL

3.

NONE ______________________ ALL

4.

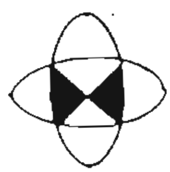
NONE ______________________ ALL

Exercise - 2

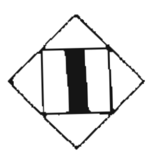
Introduction to Scaling

Instructions. Mark on the line at the right to indicate the proportion of the area that is shaded.

5.  NONE______________________ALL

6.  NONE______________________ALL

7.  NONE______________________ALL

8.  NONE______________________ALL

9.  NONE______________________ALL

10.  NONE______________________ALL

Exercise - 3.1

Scaling Practice Using New Terminology

Instructions. Review the definition for hardness and discuss the technique for measuring hardness. Review the scale that has been determined for hardness and sample items that are on the scale.

Hardness

Definition: The force to attain a given deformation, such as:
- -force to compress between molars
- -force to compress between tongue and palate
- -force to bite through with incisors

Technique: For solids, place food between molars and bite down evenly, evaluating the force required to compress the food.

On sensory evaluation form this will appear as follows:

Hardness |____|____|____|____|____|____|____|____|____|____|
0 (soft) 5 (hard) 10

The standard hardness scale below was obtained from repeated tests at Hill Top Research or developed at Best Foods Division, CPC International, Union, N.J.

Scale value	Reference	Brand	Sample size
1.0	Cream cheese	Philadelphia/Kraft	½" cube
2.5	Egg white	Hard cooked	½" cube
4.5	Cheese	Yellow American pasteurized process/Land O' Lakes	½" cube
6.0	Olives	Goya Foods, giant size, stuffed	1 olive pimento removed
7.0	Frankfurter	Large, cooked 5 min/Hebrew National	½" slice
9.5	Peanuts	Cocktail type in vacuum tin/Planters	1 nut, whole

Our Standard

Scale value	Reference	Brand	Sample size
6.5	Peanut Butter Cookie	Control	½ cookie

Exercise - 3.2

Scaling Practice Using New Terminology

Instructions. Review the definition for fracturability and discuss the technique for measuring fracturability. Review the scale that has been determined for fracturability and sample items that are on the scale.

Fracturability

Definition: The force with which a sample breaks.

Technique: Place food between molars and bite down evenly until the food crumbles, cracks, or shatters.

On sensory evaluation form this will appear as follows:

Fracturability |____|____|____|____|____|____|____|____|____|____|
0 (crumbly) 5 (brittle) 10

The standard hardness scale below was obtained from repeated tests at Hill Top Research or developed at Best Foods Division, CPC International, Union, N.J.

Scale value	Reference	Brand	Sample size
1.0	Corn muffin	Thomases	½" cube
2.5	Egg jumbos	Stella D'Oro	½" cube
4.2	Graham crackers	Nabisco	½" square
6.7	Melba toast	Plain, rectangular/Devonsheer, Melba Co.	½" square
8.0	Ginger snaps	Nabisco	½" square
10.0	Rye wafers	Finn Crisp/Shaffer, Clard & Co	½" square

Our Standard

Scale value	Reference	Brand	Sample size
4.5	Peanut Butter Cookie	Control	½ cookie

Exercise - 3.3

Scaling Practice Using New Terminology

Peanut Flavor

Definition: Flavor = the impression perceived via the chemical senses formed by a product in the mouth. This term relates to specific ingredients which may be added to the product.

Technique:

On sensory evaluation form this will appear as follows:

Peanut Flavor

|____|____|____|____|____|____|____|____|____|____|

0 (none) 5 (strong) 10

No scale has been determined for peanut flavor so we will establish some of our own reference points before we evaluate the control cookie for peanut flavor.

Scale value	Reference	Brand	Sample size
	Peanut	Planters, medium roasted	3 pieces
	PB Jelly Beans	Jelly Belly	3 pieces
	Peanut Butter Cookie	Commercial Mix	½ cookie

Our Standard

Scale value	Reference	Brand	Sample size
6.0	Peanut Butter Cookie	Control	½ cookie

Exercise - 3.3

Scaling Practice Using New Terminology

Butter Flavor

Definition:

Technique:

On sensory evaluation form this will appear as follows:

Butter Flavor

|_____|_____|_____|_____|_____|_____|_____|_____|_____|_____|

0 (none) 5 (strong) 10

No scale has been determined for butter flavor so we will establish some of our own reference points before we evaluate the control cookie for butter flavor.

Scale value	Reference	Brand	Sample size
	Buttered Popcorn Jelly Bean	Jelly Belly	3 pieces
	Butter Rum Jelly Bean	Jelly Belly	3 pieces
	Butter Cookie	Commercial Mix	½ cookie

Our Standard

Scale value	Reference	Brand	Sample size
2.0	Peanut Butter Cookie	Control	½ cookie

Exercise - 3.3

Scaling Practice Using New Terminology

Different Flavor

Definition: Impression perceived via the chemical senses formed by a product that has an uncustomary flavor attribute for that type of food. This does not have to be a bad flavor. You don't have to identify what the different flavor is, but just identify that it is present and to what degree it is present in the product.

Technique:
On sensory evaluation form this will appear as follows:

Different Flavor

|____|____|____|____|____|____|____|____|____|____|
0 (none) 5 (strong) 10

No scale has been determined for different flavor so we will establish some of our own reference points before we evaluate the control cookie for different flavor.

Scale value	Reference	Brand	Sampl e size
	Pecan Oil Cookie	Knight, Company	½ cookie
	Cookie	Commerial Mix + Flavoring	½ cookie

Our Standard

Scale value	Reference	Brand	Sample size
0.0	Peanut Butter Cookie	Control	½ cookie

EVALUATION OF USDA PEANUT BUTTER COOKIES

Instructions. Evaluate the cookie for texture and taste by placing a mark on each line below:

Texture

Hardness

|____|____|____|____|____|____|____|____|____|____|

0 (soft) 5 (hard) 10

Fracturability

|____|____|____|____|____|____|____|____|____|____|

0 (crumbly) 5 (brittle) 10

Taste

Peanut Flavor

|____|____|____|____|____|____|____|____|____|____|

0 (none) 5 (strong) 10

Butter Flavor

|____|____|____|____|____|____|____|____|____|____|

0 (none) 5 (strong) 10

DifferentFlavor

|____|____|____|____|____|____|____|____|____|____|

0 (none) 5 (strong) 10

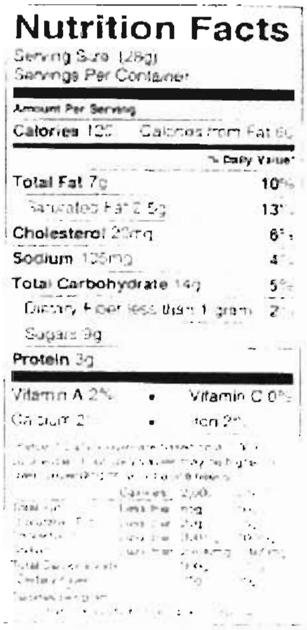
Panelist code number ____________________

Date____________________

APPENDIX J

Nutritional composition of **basic components** of mungbean cookies compared with the control

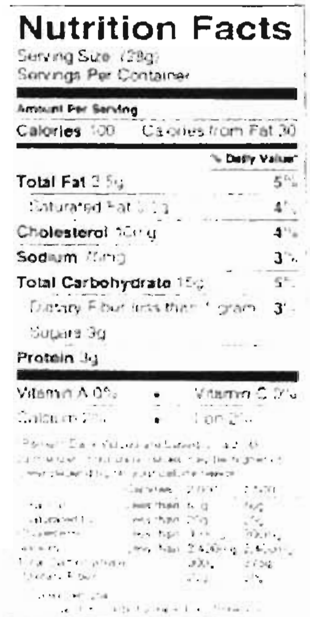
Control


Nutrition Facts
Serving Size (28g)
Servings Per Container
Amount Per Serving
Calories 12[illegible] Calories from Fat [illegible]
% Daily Value*
Total Fat 7g 10%
Saturated Fat 2.5g 13%
Cholesterol [illegible]mg 6%
Sodium [illegible]mg 4%
Total Carbohydrate 14g 5%
Dietary Fiber less than 1 gram 2%
Sugars 9g
Protein 3g
Vitamin A 2% • Vitamin C 0%
Calcium 2[illegible] • Iron 2%

Basic Components

Calories 124.95
Calories from Fat 58.72
Protein 2.93g
Carbohydrates 14.46g
Dietary Fiber 0.54g
Soluble Fiber 0.17 g
Sugar –Total 8.89g
Monosaccharides 0.26 g
Disaccharides 8.46 g
Other Carbs 5.03 g
Fat – Total 6.52 g
Saturated Fat 2.63 g
Mono Fat 2.49 g
Poly Fat 1.03 g
Trans Fatty Acids 0 g
Cholesterol 18.87 g
Water 3.44 g

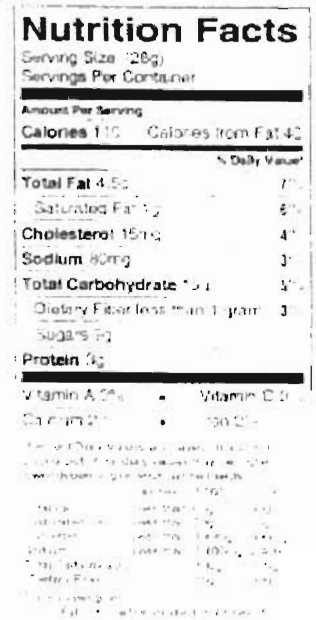
100% Mungbean Paste


Nutrition Facts
Serving Size (28g)
Servings Per Container
Amount Per Serving
Calories 100 Calories from Fat 30
% Daily Value*
Total Fat 3.5g 5%
Saturated Fat [illegible] 4%
Cholesterol [illegible] 4%
Sodium [illegible] 3%
Total Carbohydrate 15g 5%
Dietary Fiber less than 1 gram 3%
Sugars 9g
Protein 3g
Vitamin A 0% • Vitamin C 0%
Calcium 2% • Iron 2%

Basic Components

Calories 101.96
Calories from Fat 31.52
Protein 3.15g
Carbohydrates 15.15 g
Dietary Fiber 0.82 g
Soluble Fiber 0.22 g
Sugar –Total 8.95g
Monosaccharides 0.26 g
Disaccharides 8.45 g
Other Carbs 5.38 g
Fat – Total 3.5 g
Saturated Fat 0.75 g
Mono Fat 1.61 g
Poly Fat 0.92 g
Trans Fatty Acids 0 g
Cholesterol 10.64 g
Water 5.59 g

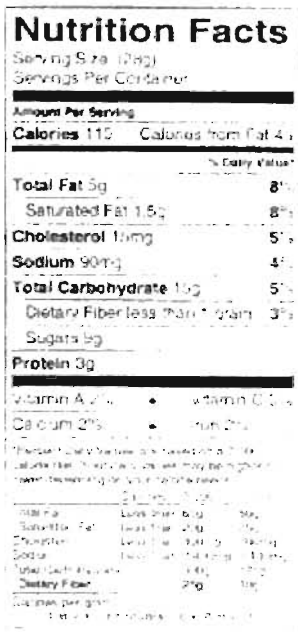
75% Mungbean Paste


Nutrition Facts
Serving Size (28g)
Servings Per Container
Amount Per Serving
Calories 11[illegible] Calories from Fat 4[illegible]
% Daily Value*
Total Fat 4.5g 7%
Saturated Fat [illegible] 6%
Cholesterol 15mg 4%
Sodium 80mg 3%
Total Carbohydrate [illegible] 5%
Dietary Fiber less than 1 gram 3%
Sugars [illegible]
Protein 3g
Vitamin A [illegible] • Vitamin C [illegible]
Calcium 2[illegible] • Iron 2%

Basic Components

Calories 107.69
Calories from Fat 38.33
Protein 3.10g
Carbohydrates 14.98g
Dietary Fiber 0.75g
Soluble Fiber 0.21 g
Sugar –Total 8.93g
Monosaccharides 0.26 g
Disaccharides 8.45 g
Other Carbs 5.29 g
Fat – Total 4.26 g
Saturated Fat 1.22 g
Mono Fat 1.83 g
Poly Fat 0.95 g
Trans Fatty Acids 0 g
Cholesterol 12.69 g
Water 5.06 g

50% Mungbean Paste

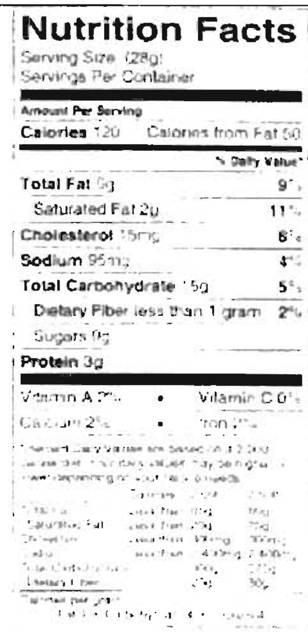


Nutrition Facts
Serving Size (28g)
Servings Per Container
Amount Per Serving
Calories [illegible] Calories from Fat [illegible]
% Daily Value*
Total Fat 5g 8%
Saturated Fat 1.5g 8%
Cholesterol [illegible] 5%
Sodium [illegible] 4%
Total Carbohydrate [illegible] 5%
Dietary Fiber less than 1 gram 3%
Sugars [illegible]
Protein 3g
Vitamin A [illegible] • Vitamin C [illegible]
Calcium 2% • Iron 2%

Basic Components

Calories 113.42
Calories from Fat 45.13
Protein 3.04g
Carbohydrates 14.8g
Dietary Fiber 0.68g
Soluble Fiber 0.19 g
Sugar –Total 8.91g
Monosaccharides 0.26 g
Disaccharides 8.45 g
Other Carbs 5.20 g
Fat – Total 5.01 g
Saturated Fat 1.69 g
Mono Fat 2.05 g
Poly Fat 0.97 g
Trans Fatty Acids 0 g
Cholesterol 14.74 g
Water 4.53 g

25% Mungbean Paste



Nutrition Facts
Serving Size (28g)
Servings Per Container
Amount Per Serving
Calories 120 Calories from Fat 50
% Daily Value*
Total Fat 6g 9%
Saturated Fat 2g 11%
Cholesterol 15mg 6%
Sodium 95mg 4%
Total Carbohydrate 15g 5%
Dietary Fiber less than 1 gram 2%
Sugars 9g
Protein 3g
Vitamin A 2% • Vitamin C 0%
Calcium 2% • Iron 2%

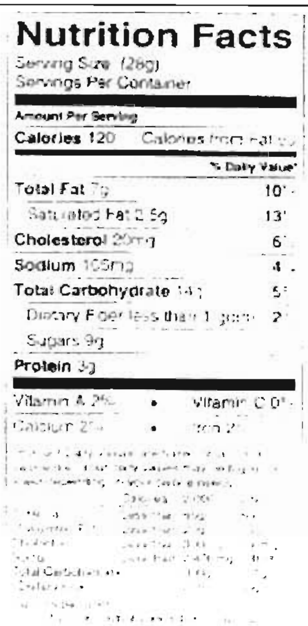
Basic Components

Calories 119.16
Calories from Fat 51.94
Protein 2.98g
Carbohydrates 14.62g
Dietary Fiber 0.61g
Soluble Fiber 0.18 g
Sugar –Total 8.89g
Monosaccharides 0.26 g
Disaccharides 8.45 g
Other Carbs 5.11 g
Fat – Total 5.77g
Saturated Fat 2.16 g
Mono Fat 2.26 g
Poly Fat 1.00 g
Trans Fatty Acids 0 g
Cholesterol 16.79 g
Water 3.99 g

APPENDIX K

Nutritional composition of **vitamins** in mungbean cookies compared with the control

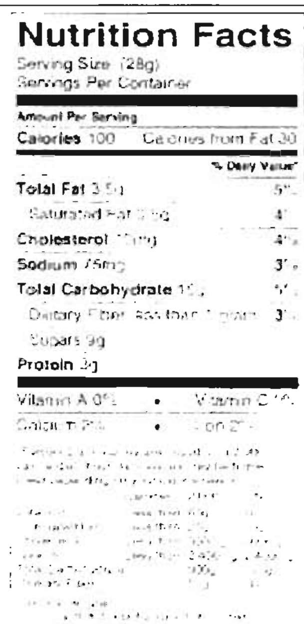
Control



Vitamins

Vitamin A RE 33.08 RE
A – Carotenoid 2.29 RE
A – Retinol 30.71 RE
A – Beta Carotene 0 mcg
Thiamin- B1 0.06 mg
Riboflavin- B2 0.07 mg
Niacin- B3 1.22 mg
Niacin Equiv. 1.75 mg
Vitamin-B6 0.04 mg
Vitamin- B12 0.07 mcg
Vitamin C 0.07 mg
Vitamin D 0.20 mcg
Vit E-Alpha Equiv 0.71 mg
Folate 16.04 mcg
Pantothenic Acid 0.15 mg

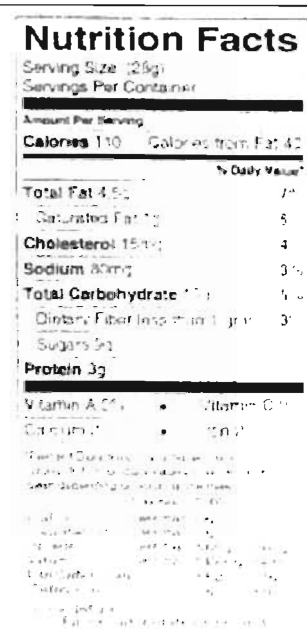
100% Mungbean Paste



Vitamins

Vitamin A RE 4.85 RE
A – Carotenoid 0.07 RE
A – Retinol 4.69 RE
A – Beta Carotene 0.43 mcg
Thiamin- B1 0.07 mg
Riboflavin- B2 0.07 mg
Niacin- B3 1.23 mg
Niacin Equiv. 1.81 mg
Vitamin-B6 0.04 mg
Vitamin- B12 0.07 mcg
Vitamin C 0.11 mg
Vitamin D 0.15 mcg
Vit E-Alpha Equiv 0.67 mg
Folate 21.86 mcg
Pantothenic Acid 0.16 mg

75% Mungbean Paste



Vitamins

Vitamin A RE 11.89 RE
A – Carotenoid 0.63 RE
A – Retinol 11.18 RE
A – Beta Carotene 0.32 mcg
Thiamin- B1 0.06 mg
Riboflavin- B2 0.07 mg
Niacin- B3 1.23 mg
Niacin Equiv. 1.80 mg
Vitamin-B6 0.04 mg
Vitamin- B12 0.07 mcg
Vitamin C 0.10 mg
Vitamin D 0.16 mcg
Vit E-Alpha Equiv 0.68 mg
Folate 20.40 mcg
Pantothenic Acid 0.16 mg

50% Mungbean Paste

Nutrition Facts

Serving Size (28g)
Servings Per Container

Amount Per Serving	
Calories 110	Calories from Fat 45
	% Daily Value*
Total Fat 5g	8%
Saturated Fat 1.5g	8%
Cholesterol 15mg	5%
Sodium 90mg	4%
Total Carbohydrate 15g	5%
Dietary Fiber less than 1 gram	3%
Sugars 9g	
Protein 3g	

Vitamin A 2% • Vitamin C 0%
Calcium 2% • Iron 2%

Vitamins

Vitamin A RE 18.94 RE
A – Carotenoid 1.18 RE
A – Retinol 17.67 RE
A – Beta Carotene 0.22 mcg
Thiamin- B1 0.06 mg
Riboflavin- B2 0.07 mg
Niacin- B3 1.22 mg
Niacin Equiv. 1.78 mg
Vitamin-B6 0.04 mg
Vitamin- B12 0.07 mcg
Vitamin C 0.09 mg
Vitamin D 0.17 mcg
Vit E-Alpha Equiv 0.69 mg
Folate 18.93 mcg
Pantothenic Acid 0.16 mg

25% Mungbean Paste

Nutrition Facts

Serving Size (28g)
Servings Per Container

Amount Per Serving	
Calories 120	Calories from Fat 50
	% Daily Value*
Total Fat 6g	9%
Saturated Fat 2g	11%
Cholesterol 15mg	6%
Sodium 95mg	4%
Total Carbohydrate 15g	5%
Dietary Fiber less than 1 gram	2%
Sugars 9g	
Protein 3g	

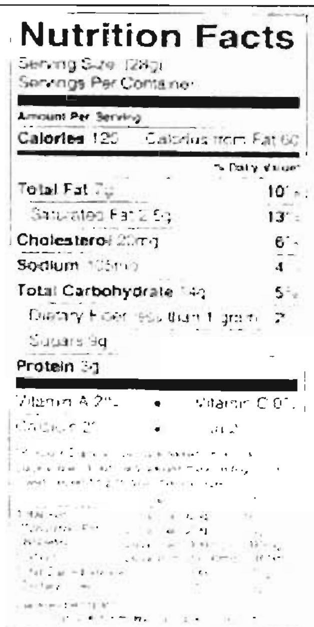
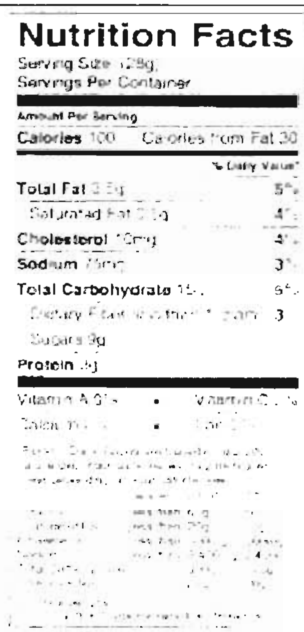
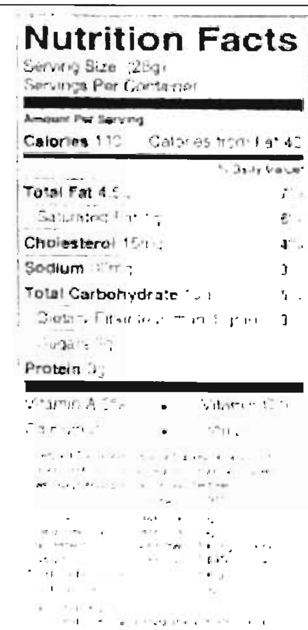
Vitamin A 2% • Vitamin C 0%
Calcium 2% • Iron 2%

Vitamins

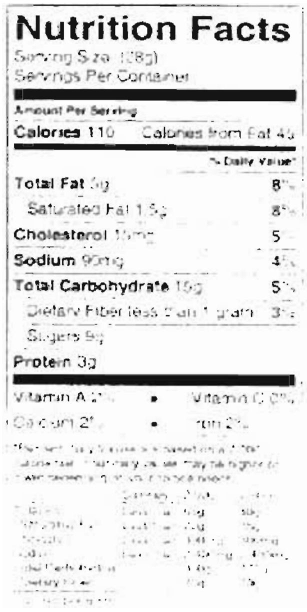
Vitamin A RE 25.98 RE
A – Carotenoid 1.73 RE
A – Retinol 24.16 RE
A – Beta Carotene 0.11 mcg
Thiamin- B1 0.06 mg
Riboflavin- B2 0.07 mg
Niacin- B3 1.22 mg
Niacin Equiv. 1.76 mg
Vitamin-B6 0.04 mg
Vitamin- B12 0.07 mcg
Vitamin C 0.08 mg
Vitamin D 0.19 mcg
Vit E-Alpha Equiv 0.70 mg
Folate 17.47 mcg
Pantothenic Acid 0.15 mg

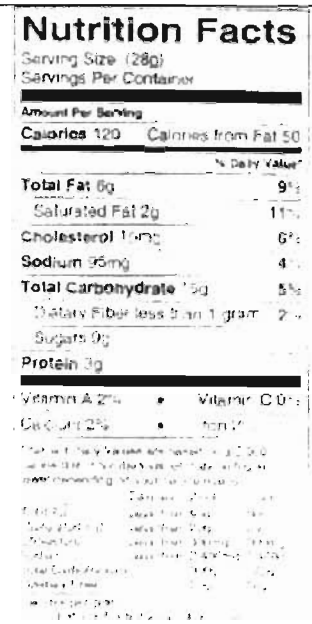
APPENDIX L

Nutritional composition of **minerals** in mungbean cookies compared with the control

Control	**100% Mungbean Paste**	**75% Mungbean Paste**
		
<u>Minerals</u>	**<u>Minerals</u>**	**<u>Minerals</u>**
Calcium 20.17 mg	Calcium 20.24 mg	Calcium 20.22 mg
Copper 0.03 mg	Copper 0.03 mg	Copper 0.03 mg
Iron 0.49 mg	Iron 0.53 mg	Iron 0.52 mg
Magnesium 13.23mg	Magnesium 14.93mg	Magnesium 14.50mg
Manganese 0.08 mg	Manganese 0.09 mg	Manganese 0.09 mg
Phosphorus 45.58 mg	Phosphorus 48.35 mg	Phosphorus 47.64 mg
Potassium 77.20 mg	Potassium 86.06 mg	Potassium 83.82 mg
Selenium 3.73 mcg	Selenium 3.78 mcg	Selenium 3.76 mcg
Sodium 105.37 mg	Sodium 74.32 mg	Sodium 82.04 mg
Zinc 0.30 mg	Zinc 0.33 mg	Zinc 0.32 mg
<u>Other Fats</u>	**<u>Other Fats</u>**	**<u>Other Fats</u>**
Omega 3 Fatty Acids 0.05 g	Omega 3 Fatty Acids 0.01 g	Omega 3 Fatty Acids 0.02 g
Omega 6 Fatty Acids 0.98 g	Omega 6 Fatty Acids 0.91 g	Omega 6 Fatty Acids 0.93 g
<u>Other</u>	**<u>Other</u>**	**<u>Other</u>**
Alcohol 0.06 g	Alcohol 0.06 g	Alcohol 0.06 g
Caffeine 0 mg	Caffeine 0 mg	Caffeine 0 mg

50% Mungbean Paste	25% Mungbean Paste





50% Mungbean Paste

Minerals

Calcium 20.19 mg
Copper 0.03 mg
Iron 0.51 mg
Magnesium 14.07mg
Manganese 0.08 mg
Phosphorus 46.92 mg
Potassium 81.57 mg
Selenium 3.75 mcg
Sodium 89.76 mg
Zinc 0.32 mg

Other Fats

Omega 3 Fatty Acids 0.03 g
Omega 6 Fatty Acids 0.94 g

Other

Alcohol 0.06 g
Caffeine 0 mg

25% Mungbean Paste

Minerals

Calcium 20.16 mg
Copper 0.03 mg
Iron 0.5 mg
Magnesium 13.64mg
Manganese 0.08 mg
Phosphorus 46.21 mg
Potassium 79.32 mg
Selenium 3.73 mcg
Sodium 97.48 mg
Zinc 0.31 mg

Other Fats

Omega 3 Fatty Acids 0.04 g
Omega 6 Fatty Acids 0.96 g

Other

Alcohol 0.06 g
Caffeine 0 mg

APPENDIX M

Amino acid composition of control and mungbean paste cookies[a]

	Ideal Ratio	Control	25% Mungbean Paste	50% Mungbean Paste	75% Mungbean Paste	100% Mungbean Paste
Histidine	19	24.39	24.49	24.59	24.69	24.78
Isoleucine	28	40.06	40.06	40.07	40.07	40.07
Leucine	66	71.65	71.73	71.80	71.86	71.93
Lysine	58	42.01	42.54	43.04	43.53	43.99
Methionine + Cystine	25	32.13	31.87	31.63	31.40	31.17
Phenylalanine + Tyrosine	63	89.66	89.67	89.68	89.69	89.70
Threonine	34	35.20	35.13	35.06	34.99	34.92
Tryptophan	11	11.04	11.03	11.01	11.00	10.99
Valine	35	46.46	46.53	46.60	46.67	46.74

[a] Food Processor ESHA Genesis Nutrition Analysis Software, 1998.

APPENDIX N

Institutional review board human subjects review

OKLAHOMA STATE UNIVERSITY
INSTITUTIONAL REVIEW BOARD

Date	April 28, 1999	IRB #: HE-99-097
Proposal Title	"SENSORY EVALUATION OF COOKIES MADE WITH MUNGBEAN PASTE AS A FAT REPLACER	
Principal Investigator(s)	Barbara Stoecker Melissa Adair	
Reviewed and Processed as	Exempt	

Approval Status Recommended by Reviewer(s): Approved

Signature:

Carol Olson

Carol Olson, Director of University Research Compliance

April 28, 1999
Date

Approvals are valid for one calendar year, after which time a request for continuation must be submitted. Any modification to the research project approved by the IRB must be submitted for approval. Approved projects are subject to monitoring by the IRB. Expedited and exempt projects may be reviewed by the full Institutional Review Board.

VITA

Melissa Adair

Candidate for the Degree of

Master of Science

Thesis: MUNGBEAN PASTE SUBSTITUTION FOR BUTTER IN PEANUT BUTTER COOKIES.

Major Field: Nutritional Sciences

Biographical:

Personal Data: Born in Mooreland, Oklahoma, on January 10, 1975, the only daughter of Dennis and Wanda.

Education: Graduated from Seiling High School, Seiling, Oklahoma in 1993; received Bachelor of Science degree in Nutritional Science from Oklahoma State University, Stillwater, Oklahoma in 1998; received general honors award from Oklahoma State University, Stillwater, Oklahoma in 1998; completed requirements for the Master of Science degree with major in Nutritional Sciences at Oklahoma State University in December, 1999.

Experience: Intern Southern Progress Corporation, Birmingham, Alabama 1997; Intern Dietitian at St. Johns Medical Center, Tulsa, Oklahoma 1998-1999. Nutrition Communications Graduate Assistant, Department of Nutritional Sciences, Oklahoma State University, June 1998 – July 1999. Food and Nutrition Branch of Oklahoma Cooperative Extension Graduate Assistant, Oklahoma State University, May 1999 – December 1999.

Professional Memberships: American Dietetic Association; Oklahoma Dietetic Association; Institute of Food Technologists