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The purposes of this study were to determine the acceptability and weight loss of ground beef prepared with amounts of soy protein products added according to manufacturers' instructions.

Broiled meat patties were subjectively evaluated by a ten member taste panel consisting of students, staff and faculty of the University of North Carolina at Greensboro. Meat patties were shaped from ground beef, ground beef with soy protein added by the manufacturer (IPD@), ground beef mixed with PlusMeat@, and ground beef mixed with Soyburger@. Each meat patty was weighed before and after broiling.

Acceptability tests were conducted on five replications for all four meat patties. The data were analyzed by one-way and two way analyses of variance. The mean, range, and median were computed on the percentage weight loss of each product for the five sessions.

Results of the one-way analysis indicated that there were highly significant differences ($p \leq 0.01$) in the acceptability of ground beef products prepared with amounts of soy protein product added according to manufacturers' instructions; ground beef was the most acceptable, and ground beef with Soyburger@ was the least acceptable. This was evident in all five testing sessions. Some of the panel members commented that flavor was the most important factor in determining acceptability. Results of the two-way analyses indicated that session did not affect the ratings of the panel members. Although no statistical tests were conducted on weight loss, the descriptive data showed that weight loss of ground beef was greater than weight loss of the ground beef with Soyburger@.

The results obtained from this study led to the following conclusions:

1. Ground beef patties were judged most acceptable by the panel members.

2. Ground beef patties with soy protein added to increase the weight by forty-four percent, PlusMeat@, were ranked second in acceptability by the panel members.

3. Ground beef patties with soy protein added to increase the weight by one hundred percent, Soyburger@, were ranked least acceptable by the panel members.

4. Session did not affect the ratings of the panel members, in that similar results were received for each session.

5. Ground beef patties prepared with Soyburger@ had the lowest weight loss of the four products tested.

6. Patties of ground beef and of IPD@ had the highest weight loss of the four products tested.

NON-COMMERCIAL USE OF SOY PROTEIN PRODUCTS AS EXTENDERS FOR GROUND BEEF

by

Margot Lucile Dale

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Approved by

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APPROVAL PAGE

This thesis has been approved by the following committee of the Faculty of the Graduate School at the University of North Carolina at Greensboro.

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CHAPTER I

STATEMENT OF THE PROBLEM

The consumer of food products in the United States today is faced with hundreds of new products every year, some of which are soy protein products. Market research indicated that the consumers of the 1970's show a great interest in the new -- new products as well as new ways of doing things. Also apparent is a willingness to try new food products (9). Schaal (45) reported that with so many new products, there is a need for reliable, efficient, and representative sampling of consumer opinion. Although this observation was made in 1952, the wide variety of new products available make it equally applicable to today's market.

Rapid changes in lifestyles of the 1970's have caused changes in the needs of consumers. These changes in lifestyle include more women working outside the home, less time spent in home food preparation, and more people eating away from home (9). In 1972 there were over 200 million consumers in America with diverse needs and wants (8). Bates (9) listed some of these needs and wants: the desire for time-saving and convenient food products, the need for less costly food, and the need for supplementing or often replacing accustomed kinds of food, chiefly high protein nourishment. Baker (8) added that consumers want foods that suit their own taste and that give good value for their money. Complicating these trends is the immense growth in world population and the dwindling supply of traditional animal sources of protein as well as other foods (9).

The needs and desires of consumers have made the use of textured vegetable protein more likely. Factors affecting the acceptance of textured vegetable protein include the demand for higher levels of protein content in food, the need for convenience foods, the budget squeeze, and the use of textured vegetable protein in institutions (9). Since soybeans have a protein content of approximately forty percent, have almost all of the essential amino acids present, and are low in cost, they are one of the most common sources of textured vegetable protein (48).

Scott and Aldrich (47) reported that in 1970 most consumers in the United States were not worried about the supply of protein since meat and eggs were plentiful. That was probably a major reason why soybeans had not been used more widely as human food in the United States. However, the meat shortage in 1973 made the public more concerned about the protein supply. Soy protein products and soy-hamburger blends were then made available to more consumers (2). However, as meat became more available and prices stabilized, use of soy protein products by homemakers decreased. Sales of soy-hamburger blends were predicted to continue to rise if ground beef prices continue to increase. The demand for soy-beef blends depends mainly on price of beef because consumers tend to buy more soy containing products when the price of beef is high (32).

The major problem in supplementing the food supply is that of pleasing the taste of the consumer (47). Technology is helping to solve the problems of public acceptability of products containing substances not generally recognized as human foods, or that do not have the

flavor of human foods (12). Some ways in which this is being done are by structuring soybeans in a variety of ways and by varying the form, i.e. isolates, concentrates, flours, or textured products (24, 47).

When textured soy protein products available to the consumer are added to ground beef in the correct proportion, they retain a meat-like texture after cooking (55). Many soy protein products are available to consumers; however, manufacturers' instructions for mixing ground beef and soy protein are not consistent in terms of amounts of soy protein to be added. It would be advantageous to the consumer to know which method of incorporating soy protein into ground beef results in the most acceptable products. Determination of acceptability of ground beef prepared with different soy protein products seemed particularly appropriate.

The objectives of this study were to:

1. compare acceptability of ground beef prepared with amounts of soy protein products, added according to manufacturer's instructions.

2. compare weight loss of ground beef prepared with amounts of soy protein products added according to manufacturer's instructions.

The following operational definitions were utilized in this study:

Acceptability. Degree of satisfaction related to appearance, flavor, moisture, and texture. For this study, degree of acceptability is indicated by a score on each of the four acceptability factors and the overall score (17).

Acceptability factor. Characteristic of food to be evaluated, such as texture (17).

Ground beef. The product labeled "hamburger" or "ground beef" at the grocery store. It contains the skeletal tissue from beef with no more than thirty percent fat (60).

Textured vegetable protein. Products in which the basic protein materials are modified by heat and moisture or by spinning into fibers to give them specific texture (40).

Soy protein product. A highly concentrated vegetable protein food derived from soybeans. It can be textured, powdered or granular.

Patty. Meat or meat and soy protein product formed in a uniform shape and size.

PlusMeat@. A textured soy protein product distributed by J. H. Filbert, Inc., Baltimore, Maryland.

Soyburger@. A textured soy protein product distributed by Earth Household, Hutchinson, Kansas.

IPD@. A blend of ground beef and hydrated textured soy protein distributed by Iowa Beef Processors, Dakota City, Nebraska.

CHAPTER II

REVIEW OF LITERATURE

Introduction

Soybeans have become an integral part of the economy of the United States. First grown in the Orient, they were not seriously considered a commercial crop in the United States until the early 1900's. Originally used a source of oil and animal feed, soybeans are now a part of the diet of many Americans. Due to advanced technology, many products can now be derived from soybeans.

History

Soybeans, a native product of China, are one of the oldest crops grown by man (15). The earliest writings on soybeans are credited to Emperor Shennung who is said to have ruled China in 2838 B.C. (47, 49). Soybeans were and still are a major component of the diet of the people of the Far East (55). Foods made from soybeans include milk, sauce, sprouts, curd, and roasted nuts (52, 54).

There are many varieties of soybeans and hundreds of types of strains. However, two general types, according to use, are commercial field type and edible vegetable type. They are practically identical in nutritive value (15). Soybeans were not seriously considered a commercial crop in the United States until about 1911-1918, and then they were used primarily for hay and silage for animal feeds and for fertilizer. Production changed and the growing of vines was gradually replaced by growing seeds. After World War I, the soybean was

recognized as a source of oil and was raised for this purpose (49). By the 1960's soybeans were grown primarily as a protein source with oil an important by-product (50, 54).

Nutritional Value

Soybeans are unique among plants since the protein value is among the highest of all proteins of plant origin (3). The soybean has probably the most nearly balanced amino acid composition of the vegetable proteins available in quantity in the world (59). They contain forty to forty-three percent protein, twenty percent edible oil, many vitamins and minerals, especially calcium, phosphorus, and iron, some carbohydrates, fiber and other minor constituents (23, 51, 54, 59). They are a good source of all the essential amino acids except methionine and have a high lysine content. This content makes soy protein a useful complement to cereal proteins deficient in lysine (23, 58, 63).

Koury and Hodges (33) conducted a study in which they fed isolated soy protein foods, processed to resemble protein foods, to a group of twelve hospital patients and to twenty-six students and their wives for four weeks. Clinical and laboratory determinations confirmed that all subjects remained in good health. The conclusion was drawn that soy protein, as the major source of protein in human diets, was nutritional and acceptable.

Turk, et al. (58) undertook to test the efficiency of a commercially available soy spun-fiber product in maintaining nitrogen balance at varied levels of intake in eight healthy teen-agers and young adults. Egg albumin was included in the mixture of soy to make the spinning of the soy product into a fiber possible. The amount of egg protein

consumed was not adequate by itself to establish nitrogen equilibrium, but a mixture of spun-soy protein and egg white in ratio of two to one resulted in nitrogen balance in the subjects at intakes as low as 0.06 grams per kilogram of body weight per day. The researchers concluded that spun fiber soy foods such as those used in the study represented a high quality of protein for teen-agers and adults.

Protein Supply

As much as half of the world is suffering from malnutrition, and protein deficiency is one of the most serious aspects. Since the world population is increasing rapidly, enough food is a serious problem; however, trying to meet growing food problems with animal protein is not logical. Animal products are more expensive than vegetable protein, even though many consumers prefer to eat animal products (12, 21). Smith (49) reported that world surveys of population and health indicate that for years to come the world supply of food will be deficient in protein. These shortages in the world supply of protein foods have been a major reason that nonconventional sources of protein for human consumption have been sought after by food technologists (34). Plant proteins are needed to alleviate the world protein shortage problem (23).

Many view the use of soybean products for human consumption as a nonconventional source to help solve the problems. Soybean technology can be a leading contributor in using every available source of protein to feed the population of the United States as well as other nations (9). The essential problem of protein supply is the fact that there are great differences in the consumption of proteins between countries, between socio-economic groups, within a country, and between family

members in the home. Sterner (53) noted that scientists need to devise quality protein foods that are low cost, convenient to use, and that will fit into regional food preference patterns. He suggested the need for protein foods that will be appealing to all socio-economic levels. Soybean by-products can be processed to provide an excellent source of protein to meet the needs of a variety of people (12).

Soybean technology offers several ways to increase the supply of food protein (16). Developments such as meat analogs, textured vegetable proteins, soybean flours and grits, and soy protein concentrates are important steps toward the successful use of soybeans for human consumption (10, 12). Soybeans are of special importance because they are acceptable to many people in the world as a food item, can be cheaply produced, can be adapted to a wide range of soil and climatic conditions, can be made into a great variety of acceptable dishes, and have protein of good quality (3, 16).

Although there is no serious total protein shortage in the United States, the diets of some individuals within certain groups are deficient in dietary protein. The problem is probably due to unequal distribution (11, 53). There is the possibility, however, that the United States population may be faced with possible shortages in the future. The problem will become worse as the United States population increases, as the demand for animal protein abroad increases, and as animal protein supplies decrease. Thus, Americans will be forced to make the transition from a primarily animal protein food economy to one in which plant proteins have a larger role. In the United States in 1974 about two-thirds of the food grade proteins came from animal

foods. Bird (11) predicts that in a few decades, the United States will be obtaining one-half to one-third of food grade protein from plant sources. He states, "If the change is gradual, and if we have good quality plant proteins, this transition may not be at all burdensome." (p. 36).

Currently in the United States, economic conditions seem to be altering the family menu in terms of content and quantity, and meat is one of the major mealtime cutbacks. Many of the changes in eating patterns reflect efforts to keep down food costs, and a major strategy to deal with inflation is to change buying patterns (7). One of these changes has been an increased purchase of soy protein products by consumers (2). In 1973 the use of soy protein in foods had increased at the rate of five to seven percent. Adolphson and Horan (2) predict an increase in the use of soy protein products, particularly textured soy protein for use with ground beef, because it has already been established that most people like to eat meat if they can afford it. As levels of income increase, there is also an increase in the consumption of meat products. So any program that will allow more people to have more meat products in their diet without an increase in the percentage spent out of their take-home pay has to be a sound one.

Others have predicted that soy proteins will have a 110 million dollar market by 1980 as compared to a thirty-six million dollar market in 1970 (56). It is anticipated that food and selected food use of soy protein products will account for 2.5 percent of world production by 1985 in contrast to about one percent in 1974 (18). Also the use of textured soy protein is expected to replace ten to twenty percent of the total beef market by 1980 (62).

Soy Protein Products

The use of soy protein products, however, has been slow in gaining momentum. Before textured soy proteins were developed in 1957, the main reason for adding soy products to foods used in the United States was for their functional properties or for health or religious reasons. One of the first breakthroughs came in 1971 when the USDA permitted the use of textured vegetable protein in the national School Lunch Program (56). On March 22, 1971 USDA authorized the use of textured vegetable proteins (TVP), fortified with vitamins and minerals, to meet part of the minimum requirement of two ounces of cooked meat for type A lunch. The ratio of hydrated TVP to uncooked meat, poultry or fish (in combination) could not exceed thirty parts to seventy parts, respectively, on the basis of weight, with the moisture content of the hydrated vegetable protein at sixty to sixty-five percent (34).

Other milestones in the acceptance of soy protein products were the formation of the Food Protein Council in 1971 as well as the marketing of beef patty products of seventy-five percent meat and twenty-five percent textured soy protein to the consumer in March, 1973 (14, 61, 64). Consumer acceptance of the soy-ground beef blend was excellent, but as retail beef sales increased in 1974, sales of blends decreased (56).

The soybean contains numerous biochemical substances which can yield an almost unbelievable number of products for the food industry (25). Soy protein is produced from high quality, sound, clean, dehulled soybeans. The dehulled beans are crushed into flakes and giant solvent extractors then remove the oil, leaving oil-free flakes

which furnish the base material for the major soy products developed for the consumer market (6, 51).

Grits and flours. In 1929 the first edible soy flour and soy grits, obtained from finely or coarsely ground flakes, were commercially produced (47). Grits are coarse while flours will pass through a fine mesh or screen. Oil may be added to the flours or in some instances, dehulled beans are ground for full-fat flour. Grits and flours vary from forty to sixty percent protein and are available in many forms such as defatted, low-fat, and high-fat (6, 36, 47). These soy products may contain more undesirable flavors because sometimes they contain fiber and sugar (47). They are low in cost and improve the flavor and the dough handling properties of baked goods, and improve the consistency and texture of meat products (3, 36, 47).

Concentrates. Soy concentrates, containing approximately seventy percent protein on a dry basis, are produced by removing the soluble carbohydrate and mineral components from fat-free flakes. They can be made into various sizes and given artificial flavor and are used in baked goods and in meat products (3, 6). They are used for their better flavor and higher protein characteristics, as well as for functional reasons such as moisture absorption, juice holding, fat binding properties, and textural properties (1, 36).

Isolates. Isolated soy protein is the major proteinaceous faction prepared from the flakes by removing the majority of the non-protein components. Isolates usually contain more than ninety percent protein and are stable, bland in flavor, light in color and not affected by moist atmosphere (6, 19). They can be stored indefinitely without

perceptable deterioration (19). Isolates are generally used for functional properties in food processing as well as to increase protein content. They improve the appearance of and provide necessary structure to several processed foods (36, 37).

Textured protein. Textured soy products have been developed since soy flour, concentrates and isolates usually have a powdery consistency (6). Textured soy protein (TSP) can be made from soy concentrates or from soy flours (40). Basically the two types of TSP are extruded (or expanded) and spun fiber proteins. The special processing produces bland fifty percent proteins of different sizes and shapes. Textured soy products simulate meat and are widely used as extenders and supplements for meat products (23, 36).

Extruded soy protein is manufactured by cooking a mixture of soy flour and other ingredients such as flavoring and coloring. The mixture is extruded through dies that form the desired shape. The particles can be made to resemble a variety of products from beef granules to nut meats. The food is then dehydrated and sold to use as analogs in place of meat or with fresh meat (31, 35, 37, 44).

Around 1957, Boyer developed the technique of spinning proteins into fibers. A colorless, odorless, tasteless soy protein concentrate powder is turned into a viscous solution and pumped through spinnerettes that spin the liquid into tiny white fibers. These bundles are flavored and colored, then cut and processed to simulate existing products. Soy protein fibers can simulate nearly any biological structure that exists in meat, nut, or vegetable product (29, 31, 35, 44).

According to Register and Sonnenberg (43), consumers are finding special interest in TSP. These products offer great potential and versatility since they can be formulated to any level of protein, fat, or carbohydrate (27, 43). Since TSP can be produced in shelf stable, frozen or refrigerator forms, they are versatile and convenient for transport and storage (9, 44). Textured soy products have gained acceptance as a meat extender and result in extended products which are comparable nutritionally and in texture to the natural meat product (23).

Textured soy proteins have a bland flavor so they easily blend with and absorb the flavor of poultry, fish, pork, beef or lamb, according to the manufacturing process (56). Dehydrated TSP has several advantages because it can be manufactured in a variety of shapes and sizes, is convenient, has a rapid rate of rehydration, is available flavored or unflavored, and is crunchy when dry and chewy when rehydrated. Textured soy products is difficult to identify as vegetable protein and ground meat dishes benefit from adding it because these products absorb meat juices often lost in cooking. Therefore, these ground meat dishes lose less weight, dry out less and shrink less (34, 37). The fat content of combined TSP and meat product is usually less than that of pure meat since there is little fat in the soy protein products (35). Economics is another motivation for using TSP in combination with meat since rehydrated TSP and meat is often fifteen to twenty cents per pound lower in price than ground beef (2).

Research Involving Soy Protein

In the late 1960's and early 1970's a disadvantage of using soy protein products was an apparent beany taste or flavor. Hammond and

Call (26) reported that when soy proteins were used at three percent levels, a beany-bitter taste became noticeable. Honig, et al. (28) noted that flavor limited the use of soy protein products for use in food products. At that time industry indicated that flavor components found in defatted soy flour, protein concentrates and protein isolates reduced consumer acceptance (28). In a series of studies conducted in Japan, it was found that a possible way to prepare soybean protein having a less beany flavor was using a proteolytic enzyme (aspergillopeptidase A) in the processing. Chemical and sensory tests showed that partial digestion of soybean curd and defatted soybean flour by this enzyme removed flavor compounds and related fatty materials. The products of this process had less odor, taste, and color (20, 21, 41). By 1976 technology had solved the problem of undesirable flavors with the production of soy protein products that were flavorless or had a particular flavor (34, 56, 64). In a study conducted in Brussels, Belgium, ten percent soy concentrate was added to frankfurters and ten, fourteen, and sixteen percent concentrates were added to luncheon meat. A taste panel evaluated the products and no flavor or color problems were noted (46).

Judge, et al. (30) reported that the use of soy products as ground beef extenders was widespread but technological information concerning their performance was severely limited. However, reports of several studies that have been conducted on the use of soy protein products with ground beef or ground meat are available and are reported in the following paragraphs.

Nollman and Pratt (42) directed a study in which low levels of TSP, fish protein concentrate, and microcrystalling cellulose were added to meat loaves. Six trained panel members tasted the meat loaves for acceptability using a hedonic scale. The meat loaves prepared with TSP were well accepted for flavor and texture and none of the additives affected the juiciness. The researchers did not expect these results and thought they were due to relatively small amounts of proteins added. Anderson and Lind (5) arrived at different conclusions concerning juiciness. The purpose of their study was to determine whether or not the apparent differences in juiciness in ground beef patties with TSP was due to increased water retention, fat, or both water and fat in the extended patties. Results obtained indicated that regardless of fat and moisture levels of raw patties, patties composed of a mixture of twenty-five percent by weight of hydrated TSP with beef retained a greater percentage of moisture and a decreased percentage of fat in cooking than all-beef patties of comparable fat level.

Other investigations found that adding soy protein products to ground beef resulted in a juicier product. Mustakas, et al. (39) added soy protein to meat loaf and obtained a product that shrank less and retained more juice than meat loaf without soy. Judge, et al. (30) prepared beef patties with twenty and thirty percent fat and high and low levels of soy protein. The diameters of the cooked patties indicated that adding soy substantially reduced shrinkage in both the twenty percent and thirty percent fat samples.

Schweiger (46) reported that coarsely ground meat products containing six and ten percent soy concentrate were rated higher by a taste

panel than ground meat products without soy concentrates. In this study the total fat content decreased from thirty to about twenty-four percent and from twenty-five to about twenty percent as more soy was added. The shrinkage of cooked patties was reduced significantly as the level of concentrate increased.

Wolford (64) has recommended a fresh red beef mixture that includes seventy-five percent beef and twenty-five percent hydrated TVP. Also suggested was that the moisture hydration be restricted to two parts water and one part soy product by weight. The advantages of this mixture were that it maintained the appearance and flavor expected of regular ground beef, it kept the nutritional value about the same as ground beef and it reduced cooking shrinkage.

Bressani, et al. (13) evaluated the protein quality of a ground meat-like soybean protein textured food fed to children and experimental animals, and they concluded that the protein quality of the textured food was high (about eighty percent of the protein quality of milk). They found that it was adequately digestable and was readily acceptable and free of adverse psychological effects.

Not all studies have shown soy protein products to be acceptable by a taste panel. Thomas, et al. (57) found that soy protein added to sausages resulted in a product that was rated low on sensory qualities by a taste panel. Although the first TSP product, frozen "Fri-chik" manufactured by Worthington Foods, appeared to be acceptable to consumers, certain consumer psychological barriers existed which prevented widespread use. When tasted, unidentified samples received very favorable ratings, but ratings of identified samples were much lower (27).

Summary

Soybeans have been grown by man for hundreds of years and used for human as well as for animal consumption. Soybeans are nutritionally valuable because of their high protein content and because they contain all the essential amino acids except for methionine, which is present in limited amounts.

Many scientists and food technologists believe that soybeans can be utilized to alleviate a world protein shortage, since soybeans can be processed into products which resemble meat or can be used to extend ground beef and provide more servings. The acceptance of soy protein products by consumers is necessary for the consumption of these products to increase. Economic conditions are a major factor since more soy products are purchased when meat prices increase. Soy protein products are available in the form of grits and flours, concentrates, isolates, and textured protein. Textured soy protein products are more readily accepted by consumers since they have a bland flavor and since they blend easily with and absorb the flavor of poultry, fish, pork, beef or lamb.

Research on soy protein has indicated that soy protein products can be produced that are flavorless or have a particular desired flavor, that adding soy protein products to ground beef can result in a juicier product, and that adding soy protein products to ground beef is not always detectable by a taste panel. However, many consumers do not use TSP products and some of these products do not have a flavor that is accepted by consumers. More research on the acceptability of soy protein products needs to be done so that these products can be improved in order to increase their use by consumers.

CHAPTER III

PROCEDURES

Soy protein products are available to the consumer in forms such as TSP to add to ground meat, meat analogs which can replace meat, and soy grits and flours which can be added to flour products. Textured soy proteins can be of benefit to consumers who combine these products with ground beef to make more servings per pound available. However, the consumer is faced with the problem of knowing which TSP to add to ground beef so that the resultant product will still be consumed without adverse reactions. The purposes of this study were to compare acceptability and weight loss of ground beef prepared with amounts of soy protein products added according to manufacturers' instructions.

Selection of Subjects

The ten members of the taste panel were selected from the University of North Carolina at Greensboro personnel. The taste panel included one male staff person, one female staff person, one female faculty person, two male students, and five female students. The individuals were asked to taste broiled ground beef/soy protein patties and complete score sheets designed to determine acceptability.

Development of Score Sheet and Ranking Sheet

A one-page score sheet was developed for use in evaluation of the patties (Appendix A). A Likert-type rating scale with rankings ranging from "very good" (score = 5) to "very poor" (score = 1) was used to

determine the acceptability of appearance, flavor, texture, moistness, and overall score. A ranking sheet on which subjects were asked to list the most acceptable and least acceptable was developed to obtain a rating of overall acceptance (Appendix B).

Griswold (22) and Amerine, et al. (4) recommend using a five-point rating scale, with appropriate adjectives, for the sensory evaluation of food. A professor and graduate student, both knowledgeable in evaluating food by sensory methods, examined the score sheet and ranking sheet in relation to validity and useability. To further determine the clarity of the instruments, a member of the target population sampled four broiled patties and evaluated them on the score sheet and ranking sheet. Suggested changes were made in the instruments.

Taste Testing Procedures

Ground beef containing approximately fifteen percent fat was purchased from a local chain grocery store. Ground beef with TVP added commercially (IPD@) was purchased from another local chain grocery store (Appendix C). PlusMeat@ was added according to the manufacturer's instructions to a portion of the pure ground beef (Appendix C). This addition increased the volume by forty-four percent. Soyburger@ was added according to the manufacturers' instructions to another portion of the pure ground beef which increased the volume by fifty percent (Appendix C).

In a trial test using two, three, and four ounce patties, each one-half inch thick, the three ounce patty was the most acceptable size. It did not shrink excessively and was large enough to give an adequate sample for the taste panel member.

All the meat was shaped into three ounce (eighty-eight grams) patties, one-half inch thick and three and one-half inches in diameter. Each patty was placed in a plastic bag and stored in an upright freezer at zero degrees F. The day before being broiled, the needed patties were removed from the freezer, and placed in a refrigerator to thaw.

Acceptability tests were conducted on five replications of the following patties: one hundred percent ground beef, ground beef with soy protein commercially added (IPD@), ground beef with PlusMeat@, and ground beef with Soyburger@. With one exception, all tasting sessions were held before noon. Ten days were required to complete testing. To avoid monotony, a panel member was not asked to come to a testing session two days in succession. Dates for the testing sessions were worked out at the convenience of the taste panel members, and collection of data was completed during June of 1975.

Before each taste session, one patty of each type was removed from the refrigerator, assigned a random number, weighed, and placed on a broiling pan in a random arrangement. This information was recorded on the Cooking Test Data Sheet (Appendix D). The patties were broiled three and one-fourth inches from the heating element in a preheated electric oven for five minutes on each side. Each patty was again weighed, placed on a five inch white paper plate that had the code number on it. The four plates were randomly placed on a brown plastic serving tray. In order to keep the time lapse between broiling and tasting to a minimum, the cooking of the patties was scheduled to be completed at the time the taste panel member was to arrive. The patties then had to be weighed and presented to the panel member for

tasting. The importance of arriving on time was stressed to the panel member.

Taste testing sessions were conducted in a room separated from the preparation area. Although the room was not specifically designed for taste panel work, judges did work independently and in a serious manner. Often only one member at a time was evaluating the patties. At the first taste session, the score sheets and ranking sheets were explained by the investigator and additional instructions for taste test procedures were read (Appendix E). Questions were answered regarding method of rating, but no product information was provided. At each session a card containing instructions for panel members was presented with the scoring sheets (Appendix F).

Analysis of Data

A two-way analysis of variance was run on the data obtained on the score sheets. Factors (appearance, flavor, texture, moistness, and overall score) and products (ground beef, commercial mixture-IPD@, PlusMeat@ blend, and Soyburger@ blend) were considered the independent variables or main effect with sessions one, two, three, four, and five the dependent variable. Differences were tested at the .01 and .05 levels of significance. One-way analysis of variance was run with the factors as dependent variable and products as independent variable. The mean, range, and median were computed on the percentage weight loss of each product for the five sessions.

CHAPTER IV

RESULTS AND DISCUSSION

One type of soy protein available to the consumer in the United States is a textured soy protein which can be mixed with ground beef. Mixing procedures, however, are not consistent among manufacturers, and consumers are faced with the problem of determining which soy protein product is most acceptable. The purposes of this study were to compare acceptability and weight loss of ground beef prepared with amounts of soy protein products added according to manufacturers' instructions. Results of the study are presented in this chapter in the following order: comparison of product ratings, acceptability of products by factors, acceptability of products by session, weight loss of meat products, most acceptable and least acceptable products, and summary.

Comparison of Product Ratings

Patties of ground beef and ground beef with soy protein were evaluated by a taste panel which rated the patties on appearance, flavor, texture, moistness, and a composite score assessing overall acceptability. The products evaluated were ground beef; IPD@, a commercially prepared mixture; ground beef mixed with PlusMeat@; and ground beef mixed with Soyburger@.

The products varied in the degree of acceptability by the panel members (Table 1). The mean scores for the ground beef patties were the highest and were above 4.0 (4 = good) on all factors. The lowest

mean scores were received by the Soyburger@ patties with a score of 2.04 (2 = poor) for flavor and an overall score of 2.65. The factor means for the IPD@ patties ranged from 3.18 for texture to 3.90 for flavor (3 = fair). The mean scores for PlusMeat@ patties were higher than those for IPD@ and Soyburger@ patties with the exception of flavor; in this instance, the IPD@ score was the highest of the three (3.90). None of the products had a mean score of five or one for any of the factors (5 = very good, 1 = very poor).

Table 1. Mean, Standard Deviation, and F-Value of Product Ratings.

	Factor				
Product	Appearance	Flavor	Texture	Moistness	Overall Score
Ground Beef	4.51	4.22	4.37	4.41	4.31
PlusMeat@	4.27	3.22	3.98	3.86	3.43
IPD@	3.41	3.90	3.18	3.43	3.51
Soyburger@	4.08	2.04	3.37	3.29	2.65
Total Mean	4.08	3.34	3.72	3.75	3.48
Standard Deviation	.76	.87	.83	.82	.85
F-Values	10.39**	13.89**	21.90**	45.24**	87.77**
Degrees of Freedom	1; 192	1; 192	1; 192	1; 192	1;192

Scale: 5 = very good, 4 = good, 3 = fair, 2 = poor, 1 = very poor.

**Highly significant ($p \leq 0.01$)

N = 196

An F-test was conducted to determine if a significant difference existed between the two highest means for each factor. The two highest means were tested because they had the most similar values and they were the most acceptable for each factor. In each case a highly significant difference was found ($p \leq 0.01$) (Table 1).

Acceptability of Products by Factors

The members of the taste panel rated the acceptability of the four meat products on appearance, flavor, texture, moistness, and overall score for acceptability. The possible ratings ranged from scores of "very good" (score = 5) to "very poor" (score = 1). The data were analyzed by one-way analysis of variance which compared the product means for each of the five factors. The results of the analysis are presented in Appendix G.

Appearance. The appearance of the four meat patties varied after broiling. The IPD@ patty was lighter in color and slightly resembled a cooked sausage patty, and it is possible that the darker brown of the other patties may have been more appealing to the panel members. One panelist wrote that the IPD@ patty looked washed out and that it was not rich pink and brown in color like the ground beef patty. Another panelist wrote that the color of the IPD@ patty was slightly pale and detracted from the appearance of the patty.

A one-way analysis of variance of product across factors (Appendix G) indicated that there was a highly significant difference ($p \leq 0.01$) among the means of the four products with respect to appearance. The ground beef, PlusMeat@, and Soyburger@ patties had a mean score of 4.08 or higher (4 = good), and the mean score for IPD@ patties

was 3.41 (3 = fair) (Table 1). According to the panel ratings of the appearance factor (Appendix H), forty-three percent of the panelists rated the appearance of the IPD@ patties as "fair" (score = 3) and two percent rated it as "very poor" (score = 1). A higher proportion of panelists ranked the appearance of the other three patties in the "good-very good" categories (score = 4 or 5). The ground beef patty was rated the highest on appearance with fifty-seven percent of the panelists ranking it "very good". For the factor of appearance, the data supply evidence which indicates there was a difference in the acceptability of ground beef and ground beef with different amounts of soy protein added.

Flavor. The flavor of the four patties was judged to be highly significantly different ($p \leq 0.01$) by the panel members (Appendix G). The flavor of the patties was not always acceptable as indicated by mean scores ranging from 2.04 for Soyburger@ patties to 4.22 for ground beef patties (Table 1). Panel ratings on flavor varied (Appendix H) with more than seventy-five percent of the panelists ranking the flavor of the IPD@ patty and the ground beef patty as "good" or "very good". Eighty percent of the panelists ranked PlusMeat@ as having a flavor of "good" or "fair". However, the flavor of the patty with Soyburger@ was ranked as "poor" (score = 2) or "very poor" (score = 1) by seventy percent of the panelists. Eighteen panel members wrote comments on the Ranking Sheet (Appendix B) which indicated that flavor was the factor that affected their choice of what was rated most and least acceptable. The majority of comments made on the Score Sheet for Cooked Meat (Appendix A) were in relation to flavor. The data supply evidence that

there was a difference in the flavor of the four products.

Texture. The texture of the four patties varied after broiling. Analysis of variance (Appendix G) revealed a highly significant difference ($p \leq 0.01$) between the four patties in ratings on texture. The mean score on texture was 4.37 for ground beef patties, 3.98 for PlusMeat@, 3.18 for IPD@, and 3.37 for Soyburger@ (Table 1). Eighty-eight percent of the panel members rated the texture of ground beef patties as "good" or "very good"; eighty percent rated PlusMeat@ patties similarly, while only forty-four percent rated IPD@ and Soyburger@ patties as high (Appendix H). On the Score Sheet for Cooked Meat (Appendix A) several panel members wrote comments about the texture of the product, indicating that they thought the IPD@ patties were tough and rubbery. The data indicate that there was a difference in the texture of the products tested.

Moistness. The four products tested did not have the same moisture content. The means of the moistness ratings of the four products were also highly significantly different ($p \leq 0.01$) (Appendix G). Mean scores for each product were as follows: Soyburger@, 3.29; IPD@, 3.43; PlusMeat@, 3.86; ground beef, 4.41 (Table 1). Ground beef patties were rated as "good" or "very good" (score = 4 or 5) by eighty-nine percent of the panel members, while only forty-four percent ranked Soyburger@ patties as high (Appendix H). One panel member wrote that the ground beef patty was "moist" and "cuts easily". The ratings on moistness for PlusMeat@ patties were similar to those of ground beef, while the ratings on IPD@ patties were similar to Soyburger@ patties. The data indicate that there was a difference in the moistness of the four products.

Overall Acceptability. Analysis of variance (Appendix G) indicated that there was a highly significant difference ($p \leq 0.01$) among the means of the four products with regard to overall score of acceptability. The ratings on the overall score indicated that ground beef was the most acceptable product and Soyburger@ patties the least acceptable. The mean of the overall score for ground beef was 4.31 and for Soyburger@ was 2.65 (Table 1). Seventy-three percent of the panel members rated ground beef patties as "good" or "very good"; whereas, forty-nine percent rated IPD@ patties with these scores, and only sixteen percent rated Soyburger@ patties this high (Appendix H). There is evidence from the data that there was a difference in the acceptability of the four products.

In each of the analyses of the four product means with respect to the five factors, a highly significant difference was found ($p \leq 0.01$) among the means. This evidence indicated that there is a difference in the acceptability of the ground beef and ground beef with soy protein added according to manufacturers' instructions.

Acceptability of Products by Session

Product means were examined by tasting session for the four products (Table 2). In all tasting sessions except the first one, ground beef patties received the highest means (ranging from 3.96 to 4.82) and in all sessions Soyburger@ patties received the lowest means (ranging from 2.94 to 3.20). The PlusMeat@ patties received the second highest ratings, followed by the ratings on IPD@ patties. Acceptability of various meat products based on the product means for each session yielded a consistent pattern of results.

Mean results of session indicate that ground beef was the most acceptable product and Soyburger@ the least acceptable product to the taste panel members. The relative ranking of rating means for the four products was consistent for all five sessions. Overall session means varied only slightly, ranging from 3.57 to 3.78.

Table 2. Product mean across all factors by tasting session.

	Mean for Each Tasting Session				
Product	1	2	3	4	5
Ground beef	3.96	4.28	4.40	4.50	4.82
PlusMeat@	4.00	3.70	3.48	3.74	3.86
IPD@	3.56	3.62	3.46	3.68	3.35
Soyburger@	3.20	3.02	2.94	3.18	3.08
Overall session means	3.68	3.65	3.57	3.78	3.78

Scale: 5 = very good, 4 = good, 3 = fair, 2 = poor, 1 = very poor.
N = 196

A two-way analysis of variance was conducted to test the difference between the product means (main effect) and the difference between the factor means (main effect) across each session. It was also conducted to test the combined effect (interaction) of product with factor on rating results. This combination makes it possible to examine product and factor at the same time. Results of the analysis indicated that for each of the five sessions there was a highly significant difference among the product means and factor means for each session ($p \leq 0.01$)

(Appendix I). These results denote that session did not affect the ratings of the taste panel members. Since each main effect (product and factor) was highly significant, interpretation of the interaction of the two was not of particular importance.

Weight Loss of Meat Products

Percent weight loss (38) was computed from information on the Cooking Test Data Sheet (Appendix C). Table 3 is a summary of the statistics for weight loss. The patties of IPD@ had the highest mean weight loss (thirty-three percent), but there was only a difference of one percent between this loss and that of the ground beef patties. The patties of ground beef with Soyburger@ had the lowest mean weight loss (twenty percent). It is possible that the IPD@ patties contained more fat than the ground beef patties, but the manufacturer of IPD@ would not reveal the percentage of fat. The patties of ground beef and IPD@ had the highest weight loss and patties of Soyburger@ had the lowest weight loss.

Table 3. Percentage weight loss of meat products.

	Ground Beef	PlusMeat@	IPD@	Soyburger@
		Percentage Weight Loss		
Mean	32	26	33	20
Median	31.5	26	33	20
Range	21-45	15-38	23-42	12-30

N = 50

Most Acceptable and Least Acceptable Products

The Panel members indicated on the Ranking Sheet for Cooked Meat (Appendix B) their choice of most acceptable and least acceptable product. Table 4 shows number and percentages of these ratings. Ground beef patties were chosen as most acceptable sixty-seven percent of the time and Soyburger@ patties were chosen as least acceptable seventy-eight percent of the time. There was little difference in the number of ratings given to IPD@ and PlusMeat@ patties. Obviously, these data strongly indicate that ground beef was most acceptable and Soyburger@ the least acceptable product.

Table 4. Number and percentage of most acceptable and least acceptable ratings for each product.

Product	Most Acceptable No.	%	Least Acceptable No.	%
Ground beef	33	67.34	2	4.08
PlusMeat@	9	18.36	4	8.16
IPD@	7	14.28	5	10.20
Soyburger@	0	0	38	77.55

N = 49

Summary

The four products tested in this study varied in the degree of acceptability to the panel members. The ground beef patties received a mean score of "good" or higher on each factor, but the mean score of the patties with soy protein varied from "poor" to "good". The ground

beef that had been extended by forty-four percent, PlusMeat@, had higher mean scores than the ground beef extended by one hundred percent, Soyburger@. This coincides with the recommendations by Wolford (64) that a fresh ground beef mixture include seventy-five percent beef and twenty-five percent hydrated textured vegetable protein. Schweiger (46) found that ground meat products containing a lower percentage of soy protein (six and ten percent) were rated higher by a taste panel than ground meat products without added soy protein.

Flavor and appearance had the widest range of scores of the five factors. Flavor seemed to be a critical factor to the panel members in determining overall acceptability. Ground beef patties received the highest ratings on flavor and Soyburger@ patties the lowest ratings for this factor. Also ground beef was chosen most acceptable sixty-seven percent of the time and Soyburger@ patties were chosen least acceptable seventy-seven percent of the time. Analyses of data indicated that there was a highly significant difference ($p \leq 0.01$) among the means of the four products for each factor. Generally ground beef patties received the highest ratings, followed by PlusMeat@ patties, IPD@ patties, and Soyburger@ patties. Research conducted in the late 1960's and early 1970's indicated that a disadvantage in using soy protein products was the presence of undesirable flavors (26, 28). However, it was reported that by 1976 soy protein products could be produced that are flavorless or have a particular flavor (34, 56, 64). The soy protein products used in this study did have a particular flavor, and this characteristic seemed to affect how the panelists rated the products since ground beef was generally more acceptable than ground beef

with added soy protein.

Patties of Soyburger@ had the lowest mean weight loss and patties of IPD@ and ground beef had the highest mean weight loss. Previous studies have revealed that adding soy protein to ground beef decreases the weight loss of the cooked product (5, 30, 39, 46).

CHAPTER V

SUMMARY AND CONCLUSIONS

The consumer in the United States is faced with a vast number of different food products as well as with the rising costs of these products. Since it is predicted sources of animal protein will become more scarce by the year 2000, the cost of this protein will continue to take a large portion of the food dollar. One way of making animal protein serve more people and cost less per serving is by adding soy protein products. Soy protein products have the advantage of containing almost all the essential amino acids, and they can be produced so they are flavorless or have a particular desired flavor.

Summary

This study was undertaken to determine acceptability and weight loss of ground beef prepared with soy protein products added according to manufacturers' instructions. Meat patties were shaped from ground beef, ground beef with soy protein added by the manufacturer (IPD@), ground beef mixed with PlusMeat@, and ground beef mixed with Soyburger@. The ground beef, PlusMeat@, and IPD@ were purchased from local grocery stores. The Soyburger@ was purchased from a store selling what are commonly called "health foods". The PlusMeat@ and Soyburger@ were added to ground beef according to the manufacturer's instructions. The ten member taste panel consisting of students, staff, and faculty of the University of North Carolina at Greensboro, rated the acceptability of the meat patties during five separate sessions. The factors rated

were appearance, flavor, texture, and overall score of acceptability. At each preparation session, each patty was weighed before and after broiling. Analyses of the data were made by a one-way and two-way analysis of variance, and by computation of the percentage weight loss.

Results of the one-way analysis indicated that there were highly significant differences ($p \leq 0.01$) in the acceptability of ground beef products prepared with amounts of soy protein product added according to manufacturers' instructions; ground beef was the most acceptable, and ground beef with Soyburger@ was the least acceptable. This was evident in all five testing sessions. Some of the panel members commented that flavor was the most important factor in determining acceptability. Results of the two-way analysis indicated that session did not affect the ratings of the panel members. Although no statistical tests were conducted on weight loss, the descriptive data showed that weight loss of ground beef was greater than weight loss of the ground beef with Soyburger@.

Conclusions

The results obtained from this study led to the following conclusions:

A. There was a highly significant difference in the acceptability of ground beef prepared with amounts of soy protein added according to manufacturers' instructions.

1. Ground beef patties were judged most acceptable by the panel members.

2. Ground beef patties with soy protein added to increase the weight by forty-four percent, PlusMeat@, were ranked second in

acceptability by the panel members.

3. Ground beef patties with soy protein added to increase the weight by one hundred percent, Soyburger@, were ranked least acceptable by the panel members.

4. Session did not affect the ratings of the panel members, in that similar results were received for each session.

B. There was a difference in the weight loss of ground beef prepared with amounts of soy protein products added according to manufacturers' instructions.

1. Ground beef patties prepared with Soyburger@ had the lowest weight loss of the four products tested.

2. Patties of ground beef and of IPD@ had the highest weight loss of the four products tested.

Recommendations for Further Study

The results of this study led to several recommendations for further investigation. A similar study could be conducted in which the patties were broiled in the frozen state or to which salt or other seasonings had been added. Another study could include ground beef patties and patties with soy protein that are pre-shaped by the manufacturer, as well as products that are totally soy protein. A taste panel with members from a broader cross section of consumers might reveal different indications of acceptability. Since consumers often eat meat other than beef, a study of the acceptability of added soy protein to lamb or pork might be appropriate. Food products such as meat loaf or meat balls with added textured soy protein products or with other types of soy protein could be investigated for consumer

acceptability. In order to reduce the influence of the outward appearance of the patties, a portion of each patty could be used with a red light during the tasting sessions. Since a review of the literature revealed that an increase in the use of soy protein products could help stretch the world food supply as well as lower food costs, it is important that food manufacturers know what soy protein products consumers will accept.

BIBLIOGRAPHY

1. Abel, M. 1969. Soy proteins work for homemakers. Soybean Digest. 30(1):29.

2. Adolphson, L., and F. Horan. 1974. Textured vegetable protein products as meat extenders. Cereal Sci. Today. 19:441.

3. Altschul, A. 1966. World protein resources. American Chemical Society Press, Washington, D. C.

4. Amerine, M., R. Pangborn, and E. Roessler. 1965. Principles of sensory evaluation of food. Academic Press, New York.

5. Anderson, R., and K. Lind. 1975. Retention of water and fat in cooked patties of beef and of beef extended with textured vegetable protein. Food Tech. 29(2):44.

6. Are soy protein foods for you? Food Protein Council, Chicago.

7. Armstrong, J. 1975. Improving consumer confidence and satisfaction. Food Tech. 29(10):40.

8. Baker, S. 1972. What consumers and consumerists want. Food Tech. 26(4):7.

9. Bates, M. 1970. Protein in the age of aquarius. Soybean Digest. 31(1):9.

10. Ben-Gera, I., and A. Kramer. 1969. The utilization of food industries wastes. Advances in Food Res. 17:77.

11. Bird, K. 1974. Plant proteins: progress and problems. Food Tech. 28(3):31.

12. Bressani, R., and G. Klias. 1968. Processed vegetable protein mixture for human consumption in developing countries. Adv. in Food Res. 16:1.

13. Bressani, R., F. Yitari, L. Elias, S. de Zaghi, J. Alvarado, and A. Odell. 1967. Protein quality of a soybean protein textured food in experimental animals and children. J. Nutrition. 93:349.

14. Burket, R. 1974. Blending animal and vegetable proteins for today's market. Soybean Digest. 34(4):16.

15. Chen, P., and H. Chen. 1962. Soybeans for health, longevity, and economy. The Chemical Element Press, South Lancaster, Massachusetts.

16. Dimler, R. 1970. Soy food opportunities through research. Soybean Digest. 31(1):17.

17. Farthing, M. 1974. Acceptability of selected convenience chicken products. Ph. D. Dissertation. Univ. of North Carolina at Greensboro.

18. Fischer, R. 1974. Future of soy protein food in the market place. J. Am. Oil Chemists' Soc. 51:178A.

19. Frank, S., and S. Circle. 1959. The use of isolated soybean protein for non-meat, simulated sausage products, frankfurter and bologna types. Food Tech. 13:307.

20. Fujimake, M., M. Jamashita, J. Okazawa, and S. Arai. 1970. Applying proteolytic enzymes on soybeans. No. 3. Diffusable bitter peptides and free amino acids in peptic hydrolyzate of soybean protein. J. of Food Sci. 35:215.

21. Fujimake, M., H. Kato, S. Arai, and E. Tamaki. 1968. Applying proteolytic enzymes on soybeans. No. 2. Effect of aspergillopeptidase A preparation on removal of flavor from soybean products. Food Tech. 22:889.

22. Griswold, R. 1962. The experimental study of foods. Houghton Mifflin Company, Boston.

23. Gutcho, M. 1973. Textured foods and allied products. Noyes Data Corporation Press, Park Ridge, New York.

24. Guy, R., R. Jayaram, and C. Wilcox. 1973. Analysis of commercial soya additives in meat products. J. Sci. Food Agric. 24:1551.

25. Hafmer, F. 1964. Adapting soy protein products to food use. Cereal Sci. Today. 9:163.

26. Hammonds, T., and D. Call. 1970. Utilization of protein ingredients in the United States food industry. Part II. Cornell University Agricultural Experimental Station, Ithaca, New York.

27. Hartman, W. 1966. Vegetarian protein foods. Food Tech. 20:39.

28. Honig, D., D. Bessa, R. Hoffman, and J. Rackis. 1969. Lipids of defatted soybean flakes: extraction and characterization. Food Tech. 23:803.

29. Howell, R. 1975. Golden beans from China. Now our number one cash crop. *In* That we may eat, 1975 yearbook of agriculture. U. S. Government Printing Office. Washington, D. C.

30. Judge, J., G. Haugh, G. Zachariah, C. Parmelee, and R. Pyle. 1974. Soya additives in beef patties. J. of Food Sci. 39:137.

31. Kieh, K. 1970. Consumer marketing of textured vegetable protein products. Soybean Digest. 31(11):28.

32. Kiplinger Washington Editors. 1976. Kiplinger agricultural letter. 47(6):1.

33. Koury, S., and R. Hodges. 1968. Soybean proteins for human diets. Am. Diet. Assoc. J. 52:480.

34. Laine, I. 1971. Soy goes to school. School Lunch J. 25(7):41.

35. Laine, I. 1975. Soy protein fact sheet. Food Protein Council, Chicago.

36. Lockmiller, N. 1973. Increased utilization of protein in foods. Cereal Sci. Today. 18:77.

37. Lockmiller, N. 1972. What are textured protein products? Food Tech. 26(5):56.

38. Meadows, J. 1974. Determination of palatability, tenderness, and vitamin retention of meat and poultry cooked in a selected film. Ph. D. Dissertation. Univ. of North Carolina at Greensboro.

39. Mustakas, C., W. Albrecht, G. Bookwaiter, J. McGhee, W. Kwolek, and K. Griffin, Jr. 1970. Extruder processing to improve nutritional quality, flavor and keeping quality of full-fat soy flour. Food Tech. 24:1290.

40. Nielsen, L., and A. Carlin. 1974. Frozen precooked beef and beef-soy loaves. Am. Diet. Assoc. J. 65:35.

41. Noguchi, M., S. Arai, H. Kato, and M. Fujimake. 1970. Applying proteolytic enzymes. No. 1. Proteolytic enzyme treatment of soybean protein and its effect on flavor. J. of Food Sci. 35:211.

42. Nollman, D., and D. Pratt. 1972. Protein concentrates and cellulose as additives in meat loaves. Am. Diet. Assoc. J. 61:658.

43. Register, U., and L. Sonnenberg. 1973. The vegetarian diet. Am. Diet. Assoc. J. 62:253.

44. Robinson, R. 1972. What is the future of textured protein products? Food Tech. 26(5):59.

45. Schaal, A. 1952. Consumer trends in new food products for homemakers. Food Tech. 6:13.

46. Schweiger, P. 1974. Soy protein concentrates and isolates in comminuted meat systems. J. Am. Oil Chemists' Soc. 51:192A.

47. Scott, W., and S. Aldrich. 1970. Modern soybean production. The Farm Quarterly Press, Cincinnati, Ohio.

48. Shemer, M., L. Wei, and E. Perkins. 1973. Nutritional and chemical studies of three processed soybean foods. J. Food Sci. 38:112.

49. Smith, A. 1965. Fifty years of progress in soybean protein research. Cereal Sci. Today. 10:345.

50. Smith, A., and W. Wolf. 1961. Food uses and properties of soybean protein. Food Tech. 15:4.

51. Soy protein fact sheet. Central Soya Chemuray, Chicago.

52. Standal, B. 1967. Amino acids in oriental soybean foods. Am. Diet. Assoc. J. 50:397.

53. Sterner, M. 1974. Low-cost protein foods: increasing their supply and acceptance in developing countries. Cereal Sci. Today. 19:14.

54. Terrill, R. 1960. Soybeans and soybean products. Cereal Sci. Today. 5:8.

55. Textured soy proteins "beef up" meat. 1972. Food Engr. 44(2):44.

56. They've come a long way. 1975. Soybean Digest. 35(13):10.

57. Thomas, M., P. Baumgartner, P. Board, and P. Gipps. 1973. Evaluation of some non-meat proteins for use in sausage. J. Food Tech. 8:175.

58. Turk, R., P. Cornwell, M. Brooks, and C. Butterworth. 1973. Adequacy of spun-soy protein containing egg albumin for human nutrition. Am. Diet. Assoc. J. 62:519.

59. U. S. Government Printing Office. 1962. Proceedings of conference on soybeans for protein in human foods. Washington, D. C.

60. Watson, L., and L. Kilgore. 1974. Fat, moisture and protein in "ground beef" and ground chuck. Am. Diet. Assoc. J. 65:545.

61. What's ahead for soy protein? 1971. Soybean Digest. 32(1):11.

62. Wilding. M. 1974. Textured proteins in meats and meat-like products. J. Am. Oil Chemists' Soc. 51:128A.

63. Wolf, W. 1972. What is soy protein? Food Tech. 26(5):44.

64. Wolford, K. 1974. Beef/soy: consumer asseptance. J. Am. Oil Chemists' Soc. 51:131A.

65. Ziemba, J. 1969. Simulated meats.....how they're made. Food Engin. 41(11):72.

APPENDIX A

Score Sheet for Cooked Meat

SCORE SHEET FOR COOKED MEAT

Instructions: Circle the number which best describes the factor being judged.

Sample Number:_____ Date:_____

Name:_____

Factor	Very Good	Good	Fair	Poor	Very Poor
Appearance	5	4	3	2	1
Flavor	5	4	3	2	1
Texture	5	4	3	2	1
Moistness	5	4	3	2	1
Overall Score	5	4	3	2	1

Comments:

APPENDIX B

Ranking Sheet for Cooked Meat

RANKING SHEET FOR COOKED MEAT

Instructions: Please rank the samples in order of overall acceptance.

Name:_____ Date:_____

Most Acceptable _____

Least Acceptable _____

Comments:

APPENDIX C

Ingredients of Commercial Products

INGREDIENT INFORMATION AS LISTED ON PRODUCT LABELS

IPD@: Beef, water, textured vegetable protein (soy flour), salt, hydrolyzed vegetable protein, monosodium glutamate, disodium inosinate, disodium guanylate.

PlusMeat@: Soy flour with caramel color added.

Soyburger@: Soy flour, caramel color, ferrous sulphate (iron), calcium, panthothenate (pantothenic acid), vitamin B_6, riboflavin, vitamin B_1, vitamin B_{12}.

APPENDIX D

Cooking Test Data Sheet

COOKING TEST DATA SHEET

Test Number_____ Batch Number_____ Date_____

Sample	Random Number	Position on Broiling Pan
control	_____	_____
premixed	_____	_____
Meat Plus	_____	_____
granules	_____	_____

Sample	Raw Weight	Cooked Weight	*Weight Loss %
control	_____	_____	_____
premixed	_____	_____	_____
Meat Plus	_____	_____	_____
granules	_____	_____	_____

$$\text{Weight Loss \%} = \frac{(\text{Raw Meat} - \text{Cooked Meat} \times 100)}{\text{Raw Meat}} \quad (38).$$

APPENDIX E

Information Read at First Tasting Session

INFORMATION READ AT FIRST TASTING SESSION

At each taste session there will be four patties to evaluate using the score sheet. (Go over parts of score sheet.) Please fill out one score sheet for each patty by circling the number you feel best describes the factor. Be sure to score each five factors. In order to have enough meat to complete the testing, taste a portion of each patty first so that you may taste it again if necessary. It is suggested to take a drink of water when changing samples. Please use the area under comments if you wish to make any explanations or express any opinions. On the ranking sheet write down the number of the patty you find most acceptable and least acceptable. If the degree of doneness or degree of seasonings affect your decision, please be sure and indicate this under comments. Take all the time you need to sample and score the patties. Feel free to eat all the meat that you need to in order to evaluate the patties.

Please be on time so the samples will be at the proper temperature for tasting. If you cannot come, call me here at school - 379-5332 or at home - 274-3512.

Do you have any questions?

If you have any during your sampling, please ask me.

APPENDIX F

Instructions for Panel Members

INSTRUCTIONS FOR PANEL MEMBERS

At each taste session you will have four patties to evaluate. There will be five score sheets to be filled out - one score sheet for each patty - as well as a ranking sheet for all the patties. Be sure to score each factor on the score sheet. The five descriptive terms can be interpreted as follows:

Very good - in all respects; you know of no improvement.

Good - enjoyed it; minor improvement desirable.

Fair - could eat it without enthusiasm; improvement needed.

Poor - edible.

Very poor - inedible.

Please do not discuss your opinions of the products being tasted in order not to influence the scoring of other panel members.

APPENDIX G

One-way Analysis of Variance of Product Across Factors

ONE-WAY ANALYSIS OF VARIANCE
OF PRODUCT ACROSS FACTORS

Factor	Source of Variance	Degrees of Freedom	Sum of Squares	Mean of Squares
Appearance	Product	3	31.71	10.57**
	Error	192	110.98	.58
Flavor	Product	3	139.57	46.52**
	Error	192	146.53	.76
Texture	Product	3	44.02	14.67**
	Error	192	131.10	.68
Moistness	Product	3	36.51	12.17**
	Error	192	128.14	.67
Overall Score	Product	3	67.41	22.35**
	Error	192	137.88	.72

**Highly Significant ($p \leq 0.01$)

APPENDIX H

Number and Percentages of Panel Ratings

NUMBER AND PERCENTAGES OF PANEL RATINGS
ON ACCEPTABILITY FACTORS
AND THE OVERALL SCORE

Factor	Ratings: Very Good = 5 No.	%	Good = 4 No.	%	Fair = 3 No.	%	Poor = 2 No.	%	Very Poor = 1 No.	%
Ground Beef (N = 49)										
Appearance	28	57.14	20	40.81	1	2.04	0	0	0	0
Flavor	24	48.98	15	30.61	7	14.19	3	6.12	0	0
Texture	24	48.98	19	38.78	6	12.24	0	0	0	0
Moistness	26	53.06	18	36.73	4	8.16	1	2.04	0	0
Overall Score	24	48.97	18	36.73	5	10.20	2	4.08	0	0
PlusMeat@ (N = 49)										
Appearance	17	34.69	27	55.10	5	10.20	0	0	0	0
Flavor	1	2.04	20	40.81	20	40.81	5	10.20	3	6.12
Texture	10	20.41	29	59.18	9	18.37	1	2.04	0	0
Moistness	7	14.28	29	59.18	12	24.49	1	2.04	0	0
Overall Score	3	6.12	25	51.02	12	24.49	9	18.36	0	0

APPENDIX H. Continued

Factor	Ratings: Very Good = 5 No.	%	Good = 4 No.	%	Fair = 3 No.	%	Poor = 2 No.	%	Very Poor = 1 No.	%
IPD@ (N = 49)										
Appearance	5	10.20	18	36.73	21	42.86	4	8.16	1	2.04
Flavor	11	22.45	26	53.06	9	18.37	2	4.08	1	2.04
Texture	3	6.12	19	38.78	14	28.57	10	20.41	3	6.12
Moistness	7	14.29	17	34.69	15	30.61	10	20.41	0	0
Overall Score	3	6.12	24	48.98	17	34.69	5	10.20	0	0
Soyburger@ (N = 49)										
Appearance	18	36.73	21	42.86	7	14.29	2	4.08	1	2.04
Flavor	0	0	1	2.04	13	26.53	21	42.86	14	28.57
Texture	3	6.12	19	38.78	21	42.86	5	10.20	1	2.04
Moistness	2	4.08	20	40.82	19	38.78	7	14.29	1	2.04
Overall Score	0	0	8	16.33	23	46.94	11	22.45	7	14.29

APPENDIX I

Two-way Analysis of Variance of Product by Factor

TWO-WAY ANALYSIS OF VARIANCE
OF PRODUCT BY FACTOR

Session	Source of Variation	Degrees of Freedom	Sum of Squares	Mean of Squares
One	Product	3	21.28	7.09**
	Factor	4	16.52	4.13**
	Interaction	12	25.72	2.14**
	Error	180	138.00	.77
Two	Product	3	39.86	13.29**
	Factor	4	15.47	3.87**
	Interaction	12	27.97	2.23**
	Error	180	125.90	.70
Three	Product	3	55.30	18.43**
	Factor	4	13.12	3.28**
	Interaction	12	20.00	1.68*
	Error	180	154.60	.86
Four	Product	3	44.50	14.83**
	Factor	4	13.05	3.26**
	Interaction	12	15.83	1.32*
	Error	180	117.50	.65
Five	Product	3	78.82	26.27**
	Factor	4	11.80	2.95**
	Interaction	12	23.71	1.98**
	Error	160	108.22	.68

*Significant ($p \leq 0.05$)

**Highly Significant ($p \leq 0.01$)