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INFLUENCE OF COAGULATED WHEY AND TEXTURIZED SOY PROTEIN ON THE ACCEPTABILITY OF GROUND BEEF PATTIES

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A Thesis

Presented for the

Master of Science

Degree

The University of Tennessee, Knoxville

Shatha Khairy Toma

June 1980

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ABSTRACT

This study was designed to determine the effects that coagulated cottage cheese whey solids in combination with texturized soy protein have on sensory attributes, storage life, and composition of ground beef patties. Two extenders (whey and soy protein) were combined with beef lean and beef fat to form patties of the following total extender levels: 5, 10 and 15 percent. The total fat content of the control or basic ground beef block was approximately 22 percent. The extenders replaced an equal amount, by weight, of the ground beef.

Significant differences were noted for flavor score. All of the treatments were scored above the moderately full beef flavor level. All treatments were scored above the slightly dry level for juiciness. The addition of either soy protein or coagulated whey decreased the juciness of extended ground beef patties. All treatments were scored above the moderately tender level and above the acceptable level for overall acceptability.

An increase in psychrophile counts/gm was observed as soy level increased. No serious increase in psychrophile counts/gm were observed with increasing level of coagulated whey.

Significant differences ($P<0.001$) were noted in the pH values among treatments but no significant differences were observed in the titratable acidity within treatments. An increase in levels of whey or soy resulted in an increase in pH.

An increase in percent moisture and protein was noted in the raw patties with the addition of extenders. On the other hand, percent fat of the cooked patties decreased as levels of extenders increased.

Percent total cooking loss, drip loss and evaporation loss tended to decrease with an increased level of extenders.

Significant differences were not noted in lightness (L), redness (a) and yellowness (b) of the raw or cooked patties. Slight increase in lightness (L), redness (a) and yellowness (b) were noted among raw patties. Significant differences were noted between replications for Hunter a value of raw and cooked patties.

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CHAPTER I

INTRODUCTION

Vegetable proteins, especially soy proteins, have had a long history of association with meat products in the U.S.A. In recent years, soy extended meat products have become popular as a result of their increased use by the hotel, restaurant and institutional trades.

Textured soy proteins, containing approximately 50 percent protein, were initially used to extend ground meat products in an effort to reduce their cost while maintaining an equivalent amount of protein. Soy extended meat products continue to compete effectively with pure ground beef because of the district price advantage offered to the consumer without sacrifice of nutritional value.

Texturized soy products are available from several manufacturers. The products may be purchased as unflavored, uncolored and nonfortified, or they may be colored or flavored to blend with the product they replace. Some products are meat flavored and are available to be used specifically as substitutes for chicken, ham or pork. Caramel is the most acceptable color. Three basic components are derived from soybean for use as food products: protein, oil and lecithin. These products have been applied to various food systems to control absorption of fat, as aerating agents, thickening agents, emulsifiers, gelling agents, water binders, nutritional additives, meat analogs and meat extenders.

Use of whey for food has been the object of much research effort recently. Emphasis on this subject has largely been due to pollution abatement regulations, increased cheese production, economic conditions and future needs for food to ease world food storages.

About 56 percent of the whey solids produced are currently utilized for human and animal food, and the rest is disposed of by spraying onto fields or by dumping in sewage systems. Quite apart from environmental problems created by these methods of whey disposal, is an economic and value loss. Another possible source of protein to be added to meat products is cottage cheese whey solids. This product at the present time is a disposal problem for cheese plants and therefore profitable ways to utilize it are badly needed.

Heat coagulated whey solids contain about 83 percent water, 4.5 percent lactose and 12.5 percent protein. This approximates fairly closely the protein and water content of meat. The pH of nutralized cheese whey solids is around 6.7 whereas meat pH is about 5.6. Soy protein has a pH of 6.6 and thus when added to meat increases the overall pH which causes a more favorable environment for microbes. Therefore, research is needed to determine the effect of these two extenders on the sensory, cooking, microbiological and compositional properties of ground beef patties.

This study was conducted to determine the effects that coagulated cottage cheese whey solids in combinations with texturized soy protein have on sensory and composition of ground beef patties.

CHAPTER II

REVIEW OF LITERATURE

Textured Soy Protein as Ground Beef Extender

Various researchers have studied different quality characteristics of soy extended meats. Some of these are: tenderness, flavor, juiciness, aroma, appearance, cooking losses, mouthfeel and overall acceptability.

Kotula et al. (1976) reported ground beef patties containing 20 percent textured soy protein were rated about equal to all-beef patties. Patties containing soy concentrate at either 20 percent or 30 percent or patties with textured soy protein at 30 percent were less desirable than all-beef patties. Patties with 20 and 30 percent textured soy protein were more tender, followed by concentrates at 30 percent than 20 percent. The most desirable degree of tenderness might have been exceeded with the addition of the higher levels of soy protein, but in some cases they become too crumbly.

A study was conducted to evaluate the effect of two soya products on quality of ground beef patties. Judge et al. (1974) compared soy flour (40-60 percent protein) and soy protein concentrate (70 percent protein) in beef patties and noted that with increasing levels of textured soy protein, cooking shrinkage, and reflected light tended to decrease.

Soy companies advertise that the use of soy in meat system will cause an increase in juiciness and flavor and better shape retention (Rakosky, 1974). Soy products, however, often have a characteristic

off-flavor, which has been described as "beany" or "cereal-like." When the meat formulation is prepared with insufficient seasonings to mask the off-flavors, consumers often find these foods objectionable.

Some studies (Anderson and Lind, 1974, Wolf, 1970) have shown that textured soy protein increases retention of moisture and fat; other studies (Drake et al., Kotula and Rough, 1975) determined that textured soy protein only affects moisture retention.

A study was conducted to determine if a substantial decrease in cooking losses would occur with substitution of various levels of texturized soy protein (TSP) into a meat loaf system, Shafer and Zabik (1975) observed that the fat content of the raw meat loaves tended to decrease as the level of TSP substitution increased; however, the decrease which occurred was far smaller than had been expected for some of the levels of TSP substitution. No consistent relationship was shown between degree of TSP substitution and the moisture content in raw and cooked loaves.

Huffman and Powell (1970) found that there were no significant interactions among cooking rate, fat level, and soy level when 15, 25 and 35 percent fat levels were studied in ground beef patties. They also showed that patties containing approximately 15 or 20 percent fat with added soya were more acceptable than patties containing 35 percent fat. The protein levels were slightly higher for batches of patties containing added soya and had lower shear force values than those without extenders.

Comparison of seven brands of textured soy protein revealed differences among blended beef patties in cooking loss, appearance and palatability traits (Smith et al., 1976). Not all soy products were of equal efficacy for use in blended ground beef patties. Selection of an appropriate soy protein can overcome deficiencies in appearance and can materially reduce cooking shrinkage. If beef patties are to be sold in cooked form, the fat percentage should exceed 20 percent to optimize flavor desirability and overall palatability. If the products are to be sold at retail in the raw form, the combined proportion of fat plus textured soy protein should not exceed 50 percent of the final batch composition.

Total cooking loss can be reduced with the addition of Texturized Soy Protein (TSP) to ground beef patties. TSP did not have binding effects on the fat percentage in the products, but addition of TSP to ground beef patties resulted in a product higher in moisture, both before and after cooking. The amount of fat lost during cooking was directly related to the original level of fat in the patties and not to the level of TSP (Drake et al., 1975).

Shaner and Baldwia (1979) noted that an increase in soy flavor accompanied a decrease in beef flavor of meat loaves substituted with up to 30 percent textured soy protein. The moisture content of the raw mixture was 63.18 to 64.83 percent. Fat content of the loaves with TSP added was 9.30 percent, considerably lower than that of the control (11.93 percent). Protein contents of the control and TSP mixtures were 15.30 and 15.96 percent, respectively.

Nielsen and Carlin (1974) reported that the use of textured vegetable protein resulted in a 50 percent reduction in cooking loss in precooked, reheated beef-soy loaves compared with all-beef loaves. In loaves stored at 4° C for six months, flavor and juiciness of all-beef loaves were similar. Whether frozen raw or precooked before freezing, beef-soy loaves had a less intense beef flavor and were drier than all-beef loaves.

Seideman et al. (1979) concluded that the brand of TSP had statistically significant effects on raw patty color, cooking shrinkage and cooked patty appearance. Patties containing 20 percent or 30 percent TSP were significantly less desirable in flavor, juiciness, overall palatability and appearance than control (all-beef) patties. Raw patty color was affected by brand and level of TSP substitution. Addition of 1 percent plasma protein increased flavor desirability, texture desirability and overall palatability and increased cooking loss or cooking shrinkage in only three of 20 comparisons.

Williams et al. (1975) and Carlin et al. (1978) reported that increased levels of TSP caused a progressive decrease in total and drip losses. Soy flavor and aroma increased but beef flavor decreased as the level of TSP was increased.

Beef patties containing four soy and four salt levels were evaluated by both rating and flavor profile panels (Gardze et al., 1979). Textured soy protein decreased meaty aroma and flavor and saltiness in samples containing 1.2g salt but increased cereal-like aroma and flavor

as determined by the rating panel. Salt caused few changes in meaty and cereal-like aroma but generally increased meaty flavor, saltiness and desirability scores and decreased cereal flavor in several cases. Juiciness was not affected by adding salt or soy, salt masked the cereal flavor in some cases and increased it in others.

Yeo and Wellington (1974) have used soy curd as an extender in ground beef patties. Juiciness had a high positive correlation with percentage of moisture in the soy-beef patties and it seemed to depress the panel's sensitivity to differences in curd concentration levels. The optimum meat-soy curd combination was found to be 5 percent soy with regard to tenderness, juiciness, drip loss and cooking loss.

Microbiology of Soy Extended Ground Beef

Although the microbiology of ground beef has been studied extensively by many researchers, the bacteriological effects of adding textured soy protein to a fresh ground beef matrix have only been investigated briefly.

Judge et al. (1974) compared soy flour (40-60 percent protein) and soy protein concentrate (70 percent protein) in beef patties and noted the bacteriology of the food system at 4^{o} C over a seven day storage period. Significant increases in bacterial numbers were observed after seven days of storage, but no differences were detected among the soy extended samples.

Stansbury (1975) noted highly significant increases in aerobic and psychrophilic-mesophilic counts in soy textured vegetable protein

(TSP) during storage at 0° C and 6° C. The total effect was a reduction in shelf life from seven to four days at refrigerator temperatures (3-6° C).

Ground beef and soy-beef mixtures were stored at 3° C, and microbiological enumerations measurements conducted to investigate the effect of soy protein concentrate on ground beef shelf life (Thompson et al., 1978). Soy-beef formulations had lower oxidation rates than the ground beef mixtures as indicated by lower thiobarbituric acid (TBA) values. At the end of six storage days, the soy-beef formulations had higher numbers of stapylococci, coliforms, proteolytics and total organisms, but this was not generally statistically significant.

Meat spoilage bacteria were shown to increase in number more rapidly in TSP extended (up to 30 percent) ground beef than ground beef containing 25 percent fat (Keeton and Melton, 1978). Total bacterial numbers increased significantly as days of storage progressed and in proportion to added TSP. Coliforms increased during storage, but not proportional to increased levels of soy protein. Spoilage in soy extended samples, as determined by off-odors and bacterial numbers, was evident by day four as total bacterial counts approached 10^8 bacteria/g.

The availability and microbial quality of retail beef-soy blends were investigated by Bell and Shelef (1978). Samples were stored at 4° C and microbial populations, pH, hydration and organoleptic qualities were studied from purchase day to spoilage. The rate of microbial growth in the soy-beef blends (25 percent soy) was faster than in beef, and spoilage

was detected after 5-6 days at 4° C. The spoilage microflora were similar to that of fresh beef, consisting predominantly of Gram negative psychrophiles.

Cheese Whey As Meat Extender

Smith et al. (1976) indicated that among non-meat protein additives, insoluble protein produces a high protein hot dog (over 30 percent protein) with greater emulsion stability than its soluble form.

Fresh pork sausage extended with 20 percent whey protein concentrate (WPC) was rated slightly higher than the same sausage without the WPC (Jelen, 1974). The potential of heat-precipitated WPC as a meat extender was demonstrated by both objective and subjective evaluation. However, it appeared that with deep-fried meat balls made from plain ground beef the WPC could be used only in small amounts without negatively affecting quality attributes such as appearance, texture or mouthfeel. The main value of the curd would be in decreasing cost without appreciable effect on nutritive or sensory qualities.

Due to the high moisture content, the fresh curd would not be suitable as a water-binding agent; in fact, mixing with certain established dry meat additives, such as texturized protein or non fat dry milk, might have been desirable to avoid the higher moisture losses and resulting dryness observed with the meat balls. Cooking methods other than deep frying may also have helped to eliminate this problem.

Jelen and McIntyre (1977) have evaluated the sensory properties of beef, pork and turkey meat loaves and beef patties containing

heat-coagulated WPC by hedonic scale taste panel procedures. Beef products showed significant linear regressions between decreasing hedonic scores and increasing percent WPC when served under normal light, but not under red light. Pork and turkey loaves containing 0, 5 or 10 percent WPC did not differ significantly. They also found that products containing 20 percent WPC were significantly inferior compared to the other levels of WPC or all meat control. Poor appearance of beef products containing WPC may have influenced their low ratings. Ground pork and ground turkey appeared more compatible with the whey protein concentrate than ground beef.

CHAPTER III

MATERIALS AND METHODS

Ground Beef

Regular beef trimmings were purchased from a U.S.D.A. inspected packing company. These trimmings were differentiated into lean and fat groups by visual evaluation and separately ground through a coarse one-quarter-inch plate in a 10° C room. A sample was obtained from each group and the approximate fat content determined by the Modified Babcock Method. The remainder of the ground beef lean and ground fat were wrapped with freezer paper and frozen at -17.8° C.

Texturized Soy Protein (TSP)

Texturized soy protein used in this research was supplied by Central Soya Company, Ft. Wayne, Indiana. The textured soy protein, containing about 50 percent protein on a dry weight basis, was rehydrated to a 2:1 ratio of cold tap water to TSP prior to combining with the ground beef.

Cottage Cheese Whey Solids

Cottage cheese whey was obtained from a local dairy plant. Cottage cheese whey solids was prepared by Dr. Bob DeMott of the Food Technology Department, The University of Tennessee. The raw whey was heated to a temperature of 95° C for 20 minutes and then neutralized with NaOH to pH 6.7. The heated whey was cooled to room temperature (about 25° C)

and the supernant decanted. The neutralized precipitated solids were then centrifuged at 1000 x g and the supernant again removed. The sediment was collected and stored at 0^{o} C until used. The pH of the cottage cheese whey solids was 6.70, protein was 3.96 percent and the total solids in the whey precipitate was 13.24 percent.

Preparation of Ground Beef Patties

The ground samples of beef lean and fat were thawed overnight in a 0.6^{o} C cooler then ground once through a 0.38 in plate. Fat was adjusted to about 22 percent using the Pearson square method of formulation. The two extenders (TSP and whey) were combined with ground beef in proportion amounts (as outlined in Table 1) and first were mixed by hand and blended further by grinding through a 0.12 inch plate. Then each treatment was pressed into patties of about 4 oz. in weight. Within each replication four patties were prepared and wrapped with freezer paper, marked as to the whey and TSP levels and frozen at -17.8^{o} C until evaluations were made.

Sensory Evaluation

The sensory evaluation was conducted in the sensory laboratory of the Food Technology Department. Ten persons were used to score flavor intensity, tenderness, juiciness and overall acceptability of the ten treatments (see Table 1). The panelists were not specifically instructed as to the kind of products being tasted other than that they were extended meat products. A six point scale was used to score flavor. A nine point hedonic scale was used to score tenderness, juiciness and overall

TABLE 1

TREATMENT COMBINATION DESIGNATION

Treatment	TSP	Whey
	%	
	5% Total Extenders	
1	5	0
2	0	5
	10% Total Extenders	
3	10	0
4	5	5
5	0	10
	15% Total Extenders	
6	15	0
7	10	5
8	5	10
9	0	15
	All Meat Control	
10	0	0

acceptability for the ten treatments (Larmond, 1970). See Appendix A for designation of hedonic scale numbers.

Patties were thawed overnight in a 0.6° C cooler prior to cooking. The samples were cooked in a presto-burger hamburger cooker; each patty was cooked two minutes on each side. Each patty was divided into eight portions which were kept warm on a heated serving tray. Portions approximately were served on a coded white plate under red light to each panelist.

The scores of ten panelists were averaged and this average represented the quality attribute of that particular parameter.

Microbial Assays

Samples for microbial determination were collected at the time patties were made and frozen at -17.8° C for three days. The samples were thawed overnight in 0.6° C cooler. A 25 gram meat sample was aseptically weighted into a sterile blender jar and blended with 225 ml of a sterile water solution for two minutes. Serial dilutions (1:1000 to 1:1,000,000) were plated with standard plate count (SPC) agar and stored in a 4° C cooler for seven days to determine psychrophiles. Two observations per sample were made. Total bacterial numbers were determined using a Quebec Colony Counter according to the guide lines suggested in Standard Methods (1972) and reported as log numbers of bacteria per g of sample.

pH and Titrable Acidity

The pH was determined by blending a 5 g raw meat sample in 50 ml of distilled water for two minutes (Ockerman, 1972). Two observations

per sample were made and pH read using pH meter.

Blended samples from the pH measurement were titrated with a 0.0973 N NaOH titrant. The number of milliliters required to reach phenophthaline end point were recorded.

Proximate Analysis

Percentage fat was determined by the anhydrous ethyl ether extraction method according to Ockerman (1969). The moisture was determined by drying the samples in a vacuum oven 97-100^{0} C and overnight according to A.O.A.C. (1975) procedures. Percentage protein was determined by the Kjeldahl procedure according to the A.O.A.C. procedures (1975). Each sample was done in duplicate and two replications were done for each raw and cooked treatment.

Cooking Losses

Total cooking losses were calculated as differences between raw and cooked weight of the patty. Drip loss was calculated from the differences in the weight of the cooker and weight of cooker and dripping after cooking. Evaporation loss was calculated as the differences between total loss and drip loss (see Appendix B). Two replications were done for each treatment.

Color Measurements

Color of the raw and cooked patties was measured with a Hunter Lab Color Difference Meter Model D25D2M/L. Each patty was put in a

white plate, covered with Good Year Prime Wrap and the color was measured from two sides of the patty. The two values were averaged to give one reading. Two replicates were done for each raw and cooked patty.

Statistical Analysis

Data for sensory evaluation, pH and titrable acidity, proximate analysis, cooking losses and color measurement were analyzed by analysis of variance with a completely randomized design to determine treatment effects. Duncan's Multiple Range Test (1955) was used to identify significant mean differences.

CHAPTER IV

RESULTS AND DISCUSSION

Sensory Evaluation

Analysis of variance of the effect of combinations of texturized soy protein and coagulated whey on sensory attributes (flavor, juiciness, tenderness and overall acceptability) of ground beef patties is shown in Table 2. There was a significant difference among treatments for flavor scores ($P<0.05$). Mean flavor values for the ten treatments are shown in Table 3. The flavor score for all treatments was above the moderately full beef flavor level except treatment 8 (5 percent soy and 10 percent whey) which received the lowest flavor score, while treatment 1 (5 percent soy and 0 percent whey) received the highest score. Treatment 10, the control (all beef) was not significantly different from other treatments with the exception of Treatment 8 which contained 5 percent soy and 10 percent whey. With the exception of treatment 1, which contained 5 percent soy, the flavor scores closest to treatment 10, the all beef treatment, were treatments 9, 5 and 2 which contained 15, 10 and 5 percent whey respectively. The combinations of whey and soy did not improve flavor scores.

Several panelists commented that there was cereal-like aroma in treatment 3 and treatment 6 (Table 1, page 13). Bowers and Engler (1975) reported that cereal-like flavor and aroma increased ($P<0.01$) as amount of soy increased. Heating had no effect on cereal-like flavor or aroma in their study.

TABLE 2

ANALYSIS OF VARIANCE OF THE EFFECT OF EXTENDERS (TEXTURIZED SOY PROTEIN AND WHEY) ON SENSORY ATTRIBUTES OF GROUND BEEF PATTIES

		Mean Squares			
Source	DF	Flavor Score	Juiciness Score	Tenderness Score	Overall Acceptability Score
Treatment (T)	9	0.34*	1.38	0.55	0.48
Replicate (R)	1	0.02	1.92	0.26	0.04
T X R	9	0.08	0.69	0.48	0.31
Total	19				

*P<0.05.

TABLE 3

MEAN SENSORY SCORES[a] OF GROUND BEEF PATTIES EXTENDED WITH COAGULATED WHEY AND TEXTURIZED SOY PROTEIN

Treatment[b]	Flavor Score	Juiciness Score	Tenderness Score	Overall Acceptability Score
% Soy: % Whey				
1 (5:0)	4.30[a]	6.20	6.50	6.50
2 (0:5)	3.80[ab]	5.25	5.55	6.00
3 (10:0)	3.30[bc]	5.75	6.30	6.20
4 (5:5)	3.50[bc]	6.45	6.55	5.60
5 (0:10)	3.80[ab]	5.75	6.35	6.00
6 (15:0)	3.35[bc]	5.85	6.85	5.80
7 (10:5)	3.40[bc]	4.45	5.50	5.30
8 (5:10)	2.80[c]	4.35	5.50	5.10
9 (0:15)	3.60[ab]	4.45	5.45	5.55
10 (0:0)	3.95[ab]	6.50	6.20	6.60

[a]Means which showed significant differences by Analysis of Variance were separated by Duncan's Multiple Range Test (1955). Such means followed by the same letter or letters are not significantly different ($P<0.05$).

[b]Treatments are combinations of ground beef and extenders (texturized soy protein and whey).

No significant differences were noted among treatments in tenderness (Table 2, page 18). All the treatments received scores above the slightly dry level (Table 3). Treatment 10, (all beef) received the highest juiciness score. Treatment 8 which contained a combination of soy and whey was scored lowest of all treatments. These data showed that the addition of either texturized soy protein or coagulated whey slightly decreased the juiciness of ground beef patties at the 15 percent extended level. This may be due to the binding of water by the whey and soy protein thus not allowing it to contribute to a juicy mouth feel. The rather large differences in means that did not appear significant indicate a need for further replication.

There were no significant differences among treatments in tenderness (Table 2, page 18). All treatments were scored above the moderately tender level (Table 3). Treatment 6 (15 percent soy and 0 percent whey) received the highest tenderness score. Treatment 9 (0 percent soy and 15 percent whey) received the lowest tenderness score. Huffman and Powell (1970) reported that frozen ground beef patties containing 20 percent soy protein have shown to be significantly ($P<0.01$) more tender than pure beef patties when evaluated by taste panels. The difference in their results and those of the present study could be due to differences in composition (water, fat and soy protein) and in cooking procedures. Whey protein may be binding with meat protein in such a way as to increase the chewiness of the blended matrix.

Only slight differences were noticed between treatments in overall acceptability scores (Table 2, page 18). All the treatments were scored above the acceptable level. Treatment 10, all beef, received the highest score, and treatment 8 (5 percent soy and 10 percent whey) received the lowest score (Table 3, page 19). These sensory evaluation data suggest that texturized soy protein and coagulated whey together can successfully be added to ground beef patties. Further research is needed to determine the best combinations.

Effect of Soy Protein and Whey on Bacterial Counts

The effect of soy protein and coagulated whey individually and in combinations, on the logarithmic counts of organisms growing at 4^{o} C in ground beef is shown in Figure 1. The samples containing neither soy nor whey contained log 5.1 psychrophiles/gram sample. The addition of 5-15 percent whey did not increase bacterial numbers appreciably. At the 5-15 percent soy levels, addition of whey resulted in approximately log 5.3 - log 5.5 bacteria/gram sample.

The microbiological results indicate that a high quality product can be prepared by the addition of soy protein or whey in combinations with ground beef. The meat-whey-soy product contained log 5.3 to log 5.5 bacteria/gram or less. Log 6 bacteria/gram of uncooked meat products has been suggested as a legal limit (Plvnick et al., 1976). Since bacterial counts were low, they had no effect on organoleptic evaluations.

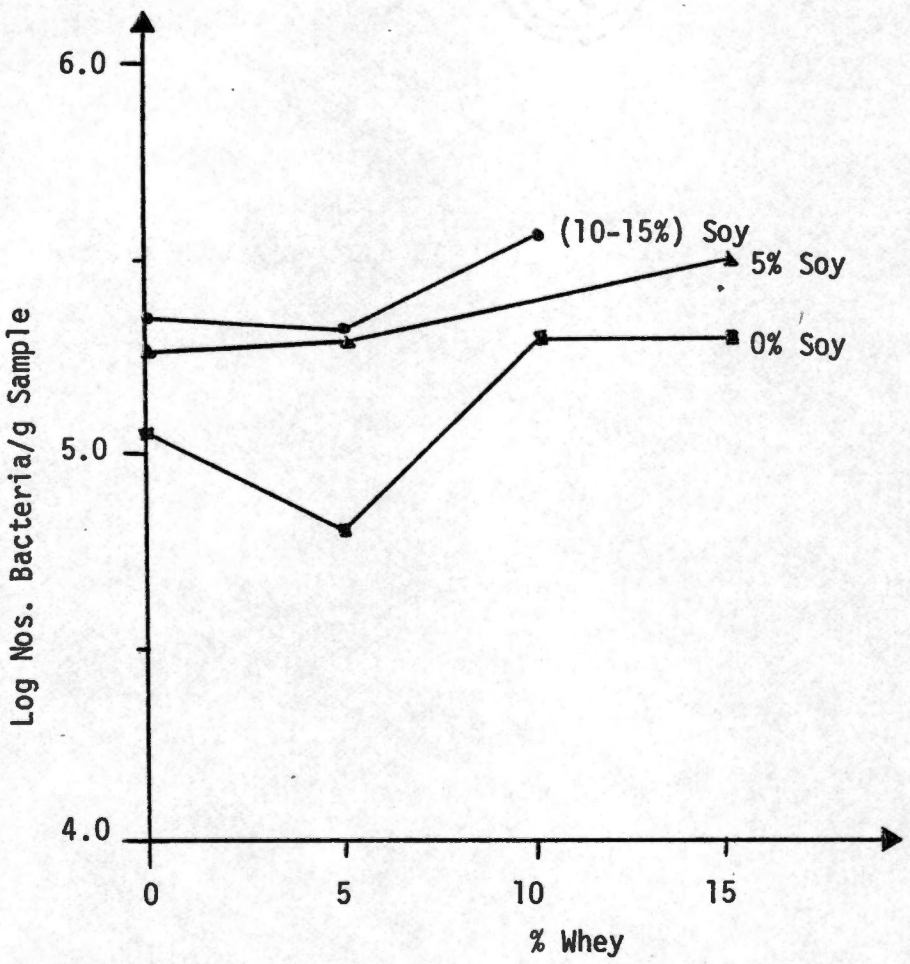


Figure 1. Logarithmic Bacterial Counts (Standard Plate Count) for Different Levels of Soy Protein in Ground Beef Extended with Different Levels of Whey at the Time of Formulation.

pH and Titratable Acidity of Raw Patties

Analysis of variance for pH and titratable acidity is summarized in Table 4. Significant differences ($P<0.001$) were noted among the treatments for pH. Mean pH values are shown in Table 5. The patties containing no soy or whey had the lowest ($P<0.05$) pH value (5.86). Those containing whey at a level of 5, 10, and 15 percent had the highest pH values of 6.31 to 6.41 but were not different from each other. Patties containing 5, 10, and 15 percent soy protein were grouped at a pH of 5.93 to 6.08 and were different ($P<0.05$) than patties containing whey or no extender. The treatments containing a combination of soy and whey had pH values intermediate between those containing soy or whey only. Shelef and Jay (1969) and Kotula et al. (1976) reported that ground beef patties containing 20 to 30 percent soy protein had slightly higher pH values than all beef patties. The pH values observed in the present study are not unexpected as the pH of the coagulated whey was 6.70 and the rehydrated soy protein was around 6.60.

Differences were observed among the treatments for titratable acidity (Table 5). There was no definite trend corresponding to whey, soy or combinations of the two extenders as to the acidity of the patties.

Proximate Analysis of Raw Patties

Analysis of variance for percentage moisture, fat and protein of raw ground beef patties is shown in Table 6. Differences but not

TABLE 4

ANALYSIS OF VARIANCE OF THE EFFECT OF EXTENDERS (TEXTURIZED SOY PROTEIN AND WHEY) ON pH AND TITRATABLE ACIDITY OF RAW GROUND BEEF PATTIES

Source	DF	Mean Squares	
		pH	Titratable Acidity
Treatment (T)	9	0.069***	0.305
Replicate (R)	1	0.002	0.444
T X R	9	0.005	0.131
Total	19		

***P<0.001.

TABLE 5

MEAN[a] VALUES OF THE EFFECT OF EXTENDERS (TEXTURIZED SOY PROTEIN AND WHEY) ON pH AND TITRATABLE ACIDITY OF RAW GROUND BEEF PATTIES

Treatment[b]	Soy:Whey (%)	pH	Titratable Acidity (ml. 0.1 N NaOH/5g)
1	(5:0)	5.93[cd]	3.73
2	(0:5)	6.31[a]	3.61
3	(10:0)	6.08[cb]	3.77
4	(5:5)	6.24[ab]	3.35
5	(0:10)	6.33[a]	3.85
6	(15:0)	6.08[cb]	3.63
7	(10:5)	6.25[ab]	4.54
8	(5:10)	6.35[a]	3.40
9	(0:15)	6.41[a]	3.38
10	(0:0)	5.86[d]	3.55

[a]Means which showed significant differences by Analysis of Variance were separated by Duncan's Multiple Range Test (1955).

[b]Treatments are combinations of ground beef and extenders (texturized soy protein and whey).

TABLE 6

ANALYSIS OF VARIANCE OF THE EFFECT OF EXTENDERS (TEXTURIZED SOY PROTEIN AND WHEY) ON PERCENTAGE MOISTURE, PROTEIN, AND FAT OF RAW GROUND BEEF PATTIES

		Mean Squares		
Source	DF	Percent Moisture	Percent Fat	Percent Protein
Treatment (T)	9	3.05	3.21	0.72
Replicate (R)	1	0.22	0.05	4.19
T X R	9	2.10	1.92	0.89
Total	19			

significant were observed between treatment 9 (15 percent whey) and treatment 8 (5 percent soy and 10 percent whey) for percent moisture. There was a trend for patties containing whey to have more moisture than those containing soy or the all beef patties. The slight increase in moisture for the extended patties is due to the higher moisture and lower fat in the soy and whey products. Keeton (1977) reported higher moisture in soy extended patties ($P<0.01$).

Mean values for percentage fat in raw patties (Table 7) show only slight differences, but they were not significant, again indicating need for additional replications. Due to the lower amount of fat in the two extenders the patties containing more extender contained less fat. The all beef patty had more fat than treatments 7 and 6 which contained 10 percent soy: 5 percent whey and 15 percent soy respectively. Wilding (1974) stated that one important contribution of adding texturized soy protein to meat is fat control. These data in the present study suggest that coagulated whey is equally as effective in lowering fat in meat blends.

As shown in Table 7 the mean values for percentage protein were not significantly different but there was a trend for soy extended patties to have slightly higher protein than whey extended or all beef patties. Normally large variation in percentage fat and water are necessary to cause significant changes in percent protein.

TABLE 7

MEAN VALUES FOR THE EFFECT OF EXTENDERS (TEXTURIZED SOY PROTEIN AND WHEY) ON PERCENTAGE MOISTURE, FAT, AND PROTEIN OF RAW GROUND BEEF PATTIES

Treatment[a]	Soy:Whey	Moisture	Fat	Protein
		%		
1	(5:0)	59.615	21.450	15.155
2	(0:5)	61.170	21.040	15.065
3	(10:5)	60.375	19.775	15.707
4	(5:5)	60.325	20.705	15.113
5	(0:10)	61.985	20.545	15.221
6	(15:0)	60.190	19.165	16.991
7	(10:5)	61.490	18.995	15.803
8	(5:10)	58.780	21.875	15.711
9	(0:15)	62.560	19.815	15.903
10	(0:0)	59.090	23.045	15.045

[a]Treatments are combinations of ground beef and extenders (texturized soy protein and whey).

Proximate Analysis of Cooked Patties

Analysis of variance of the effects of soy and whey extenders on the percentage moisture, fat and protein of the cooked ground beef patties is shown in Table 8. Significant treatment differences ($P<0.05$) were observed for both moisture and fat but not for protein.

The means of moisture, fat and protein percentage for patties after cooking are shown in Table 9. Generally there was a slight decrease in both moisture and fat for the soy and whey extended patties but a large decrease ($P<0.05$) in moisture was observed for the all beef control patties. Protein percentage was 2-3 percent higher in the cooked patties. These data suggest that extension of ground beef with whey, soy or combinations of the two can be made without changing the overall protein, fat or moisture content of the cooked patties by a large amount because the composition of whey and soy are close to the ground beef composition except their fat contents.

Cooking Losses

Table 10 shows the analysis of variance of the effects of extenders (soy protein and whey) on cooking losses. The 10 different treatments were not influenced by addition of soy or whey on total cooking loss but both fractions, drip and evaporation losses, were significantly effected by treatment. Even though the statistical analysis indicated mean differences (Table 11) these data do not show consistent trends for cooking losses for either whey or soy although there was a slight indication that addition of whey caused greater

TABLE 8

ANALYSIS OF VARIANCE OF THE EFFECT OF EXTENDERS (TEXTURIZED SOY PROTEIN AND WHEY) ON PERCENTAGE MOISTURE, FAT AND PROTEIN OF COOKED GROUND BEEF PATTIES

		Mean Squares		
Source	DF	Percent Moisture	Percent Fat	Percent Protein
Treatment (T)	9	10.05*	10.01*	0.54
Replicate (R)	1	0.50	3.29	1.11
T X R	9	2.67	2.32	6.85
Total	19			

*P<0.05.

TABLE 9

MEAN[a] VALUES OF THE EFFECT OF EXTENDERS (TEXTURIZED SOY PROTEIN AND WHEY) ON PERCENTAGE MOISTURE, FAT, AND PROTEIN OF COOKED GROUND BEEF PATTIES

Treatment[b]	Soy:Whey	Moisture	Fat	Protein
		%		
1	(5:0)	58.380^{ab}	19.165^{b}	18.89
2	(0:5)	57.265^{bc}	20.095^{b}	18.53
3	(10:0)	57.175^{bc}	19.095^{b}	18.95
4	(5:5)	60.055^{ab}	18.475^{bc}	18.25
5	(0:10)	59.280^{ab}	19.535^{b}	18.45
6	(15:0)	59.460^{ab}	17.420^{bc}	19.88
7	(10:5)	61.395^{a}	15.345^{c}	18.90
8	(5:10)	60.795^{ab}	17.090^{bc}	18.38
9	(0:15)	60.090^{ab}	19.195^{b}	18.51
10	(0:0)	53.755^{c}	23.002^{a}	18.02

[a]Means which showed significant differences by Analysis of Variance were separated by Duncan's Multiple Range Test (1955). Such means followed by the same letter or letters are not significantly different ($P<0.05$).

[b]Treatments are combinations of ground beef and extenders (texturized soy protein and whey).

TABLE 10

ANALYSIS OF VARIANCE OF THE EFFECT OF EXTENDERS (TEXTURIZED SOY PROTEIN AND WHEY) ON PERCENTAGE TOTAL LOSS, DRIP LOSS AND EVAPORATION LOSS OF COOKED BEEF PATTIES

		Mean Squares		
Source	DF	Total Loss Percent	Drip Loss Percent	Evaporation Loss Percent
Treatment (T)	9	7.95	32.79***	27.38*
Replicate (R)	1	0.86	5.15	10.25
T X R	9	9.93	1.70	6.59
Total	19			

*P<0.05.

***P<0.001.

TABLE 11

MEAN[a] VALUES OF THE EFFECT OF EXTENDERS (TEXTURIZED SOY PROTEIN AND WHEY) ON TOTAL LOSS, DRIP LOSS, AND EVAPORATION LOSS OF COOKED GROUND BEEF PATTIES

Treatment[b]	Soy:Whey	Total Loss	Drip Loss	Evaporation Loss
			%	
1	(5:0)	14.023	2.308[b]	11.715[ab]
2	(0:5)	14.760	2.462[b]	12.299[ab]
3	(10:0)	16.258	3.197[b]	13.061[ab]
4	(5:5)	10.952	2.483[b]	8.469[b]
5	(0:10)	16.313	1.571[b]	14.742[ab]
6	(15:0)	15.527	2.214[b]	13.313[ab]
7	(10:5)	12.308	1.827[b]	10.481[b]
8	(5:10)	15.175	2.181[b]	12.994[ab]
9	(0:15)	16.348	1.571[b]	15.247[a]
10	(0:0)	17.397	8.829[a]	12.568[ab]

[a]Means which showed significant differences by Analysis of Variance were separated by Duncan's Multiple Range Test (1955). Such means followed by the same letter or letters are not significantly different ($P<0.05$).

[b]Treatments are combinations of ground beef and extenders (texturized soy protein and whey).

evaporation loss while soy caused more drip loss. All the treatments had significantly less drip loss than all meat patties.

Other researchers have shown less cooking losses for meats which had been extended with soy protein (Wolf, 1970; and Williams and Zabik, 1974, Nielsen and Carlin, 1974).

Color of Raw Patties

The data showing the effects of the addition of soy, whey and soy-whey combinations on the color of raw beef patties are shown in Tables 12 and 13. The Hunter L, a, and b, values which represent degrees of lightness, redness, and yellowness respectively were different but not significant among certain of the treatment groups. No differences were observed for the a value (degree of redness). A significant ($P<0.01$) replication effect was observed for redness (a value). The freezing and thawing times prior to reading the color values were not controlled closely between replicates and probably influenced the redness value. Exposure time to the oxygen during thawing may influence the redness value because the purple myoglobin may be oxygenated to the bright red oxygenated pigments, oxymyoglobin.

Patties containing 15 percent whey, soy or combinations of whey and soy had higher L values than the all meat patties but these differences were not significant. The all meat patty expressed less yellowness as shown by a lower Hunter b value, than the patties containing 15 percent soy, 10 percent soy and 5 percent whey, and 5 percent soy and 10 percent whey. The lower levels of soy and whey did not influence yellow color as much.

TABLE 12

ANALYSIS OF VARIANCE OF THE EFFECT OF EXTENDERS (TEXTURIZED SOY PROTEIN AND WHEY) ON THE COLOR[a] OF RAW GROUND BEEF PATTIES

Source	DF	Mean Squares		
		L	a	b
Treatment (T)	9	6.61	2.58	1.80
Replicate (R)	1	5.72	35.64**	1.45
T X R	9	2.55	2.89	0.74
Total	19			

[a]L = lightness; a = redness +, gray 0, green -; b = yellowness + gray 0, blueness -; in Hunter color measurements

**P<0.01.

TABLE 13

MEAN VALUES FOR THE EFFECT OF EXTENDERS (TEXTURIZED SOY PROTEIN AND WHEY) ON COLOR[a] OF RAW GROUND BEEF PATTIES

Treatment[b]		L	a	b
	Soy:Whey (%)			
1	(5:0)	42.75	10.10	9.95
2	(0:5)	45.55	12.10	9.05
3	(10:0)	44.05	11.00	9.25
4	(5:5)	45.00	11.10	10.60
5	(0:10)	44.05	11.30	9.75
6	(15:0)	45.80	12.00	11.05
7	(10:5)	47.70	13.35	11.20
8	(5:10)	46.45	12.00	11.05
9	(0:15)	45.10	11.05	10.20
10	(0:0)	40.30	9.25	8.40

[a]L = lightness; a = redness -; b = yellowness +, gray 0, blueness -; in Hunter Color Measurement.

[b]Treatments are combinations of ground beef and extenders (texturized soy protein and whey).

Color of Cooked Patties

The analysis of variance for the effect of soy and whey extenders on color of the cooked beef is shown in Tables 14 and 15. Variations in cooking time and presence of oxygen caused this slight difference ($P<0.05$) between replications for a value. Cooking appeared to remove the differences in lightness and redness observed in the raw beef patties. In general the addition of whey increased the yellowness value above that of the soy extended and all beef patties although the difference was significant only between the 15 percent whey and 15 and 10 percent soy patties. The sensory panelists did not record any objectional comments concerning the color of the cooked patties.

TABLE 14

ANALYSIS OF VARIANCE OF THE EFFECT OF EXTENDERS (TEXTURIZED SOY PROTEIN AND WHEY) ON THE COLOR[a] OF COOKED GROUND BEEF PATTIES

Source	DF	Mean Squares		
		L	a	b
Treatment (T)	9	9.71	0.62	5.89
Replicate (R)	1	7.32	15.66*	0.42
T X R	9	9.39	2.65	2.32
Total	19			

[a]L = lightness; a = redness +, gray 0, green -; b = yellowness +, gray 0, blueness -; in Hunter Color Measurements.

*P<0.05.

TABLE 15

MEAN VALUES FOR THE EFFECT OF EXTENDERS (TEXTURIZED SOY PROTEIN AND WHEY) OF COLOR[a] OF COOKED GROUND BEEF PATTIES

Treatment[b]		L	a	b
	Soy:Whey (%)			
1	(5:0)	38.25	7.90	6.35
2	(0:5)	43.55	6.80	9.25
3	(10:0)	38.20	6.56	5.70
4	(5:5)	42.80	6.50	9.25
5	(0:10)	40.45	7.20	9.35
6	(15:0)	40.40	6.10	6.35
7	(10:5)	40.55	7.75	9.25
8	(5:10)	43.95	6.90	9.00
9	(0:15)	43.45	6.55	11.10
10	(0:0)	39.25	6.90	8.05

[a]L = lightness; a = redness +, gray 0, green -; b = yellow +, gray 0, blueness -; in Hunter Color Measurement.

[b]Treatments are combinations of ground beef and extenders (texturized soy protein and whey).

CHAPTER V

SUMMARY

Several studies have shown that texturized soy protein and cheese whey can be used as ground beef patties extender. The objective of this study was to determine the effects that coagulated cottage cheese whey solids alone and in combinations with texturized soy protein had on sensory, chemical composition, cooking losses, color and storage life of ground beef patties. These two extenders (coagulated whey and soy protein) were combined with beef lean and beef fat to form patties of the following total extender levels: 5, 10, 15 percent. The extenders replaced equal amounts by weight, of the ground beef.

There was a significant difference ($P<0.05$) among treatments in flavor score. All the treatments were scored above the moderately full beef flavor level except treatment 8 (5 percent soy and 10 percent whey). Treatment 10, all beef control, was not significantly different ($P<0.05$) from all other treatments except treatment 8. Treatment 1 (5 percent soy 0 percent whey) received the highest flavor score.

All treatments were scored above the slightly dry level (Appendix A). The addition of either soy protein or coagulated whey decrease the juiciness of extended ground beef patties. No significant differences were noted among treatments in tenderness. All the treatments were scored above the moderately tender level. Treatment 10 (all beef)

received the highest score, while treatment 8 (5 percent soy and 10 percent whey) received the lowest tenderness score. All the treatments were scored above the acceptable level.

There was an increase in the psychrophile counts/gm of ground beef patties extended with combinations of textured soy protein and coagulated whey as soy level increased. However there was no increase in psychrophile counts/gm with increasing levels of coagulated whey beyond the 5 percent level.

Significant differences ($P<0.001$) were noted in the pH values among treatments, but no significant differences were observed in titratable acidity within treatments. Treatment 10, all beef, had the lowest pH value. pH values increased slightly as either soy or whey increased.

No significant differences were shown for percent moisture, fat, and protein of raw ground beef patties. There was an increase in percent moisture among treatments with the addition of extenders. On the other hand percent fat decreased in the raw patties with the addition of extenders. Slight increases in percent protein were noticed with increased extenders levels. After cooking, the patties had lower fat and moisture percentage but about 3 percent higher protein. No differences were observed in protein due to whey or soy extenders.

No significant differences were noted in percent total cooking loss among treatments. Significant differences were observed among treatments in percent drip loss and percent evaporation loss. The extenders tended to decrease percent total cooking loss, drip loss and

evaporation loss. Beef patties extended with combinations of soy protein and whey had lower percentage total cooking loss than those patties extended with either soy protein or whey only.

Raw patties containing whey and soy extenders were lighter and showed more yellowness in color as determined by the Hunter Color Meter. Treatment 7 (10 percent soy and 5 percent whey) had the highest yellowness value. No significant differences were observed in Hunter (L) or redness (a) values of the cooked patties but the yellowness (b) value increased with the addition of whey to the patties.

Significant differences were observed in replications for a value of raw and cooked patties.

Further investigation and research need to be conducted in this area to determine the effects of whey when mixed with other processed meat products.

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LITERATURE CITED

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APPENDICES

APPENDIX A.

GRADING CHART FOR GROUND BEEF

APPENDIX A

SCORECARD FOR EVALUATING THE PALATABILITY OF GROUND BEEF PATTIES

NAME_____ DATE_____

Sample Code	Flavor Intensity	Juiciness	Tenderness	Over-All Acceptability	Comments

Key:

Flavor Intensity	Juiciness	Tenderness	Over-All Acceptability
6 Extremely full (rich or beefy)	9 Extremely juicy	9 Extremely tender	9 Extremely desirable
5 Very full and rich	8 Juicy	8 Tender	8 Desirable
4 Full	7 Moderately juicy	7 Moderately tender	7 Moderately desirable
3 Moderately full	6 Slightly juicy	6 Slightly tender	6 Slightly desirable
2 Slightly weak	5 Acceptable	5 Acceptable	5 Acceptable
1 Weak	4 Slightly dry	4 Slightly tough	4 Slightly undesirable
	3 Moderately dry	3 Moderately tough	3 Moderately undesirable
	2 Dry	2 Tough	2 Undesirable
	1 Extremely dry	1 Extremely tough	1 Extremely undesirable

APPENDIX B

DATA ON COOKING LOSSES

APPENDIX B

DATA ON COOKING LOSSES

Product: Date:

A. Before cooking:

1. Weight of raw patty
2. Weight of cooker

B. After cooking:

1. Weight of cooked patty
2. Weight of cooker and drippings
3. Weight of drippings ($B_2 - A_2$)
4. Total cooking loss ($A_1 - B_1$)
5. Weight of loss due to evaporation ($B_4 - B_3$)

C. Percentage cooking losses:

1. Total loss

$$\frac{A_1 - B_1}{A_1} \times 100$$

2. Loss due to drippings

$$\frac{B_2 - A_2}{A_1} \times 100$$

3. Loss due to evaporation

$C_1 - C_2$

APPENDIX C

TABLES

TABLE 16

SENSORY EVALUATION SCORES FOR FLAVOR, JUICINESS, TENDERNESS, AND THE OVERALL ACCEPTABILITY OF TREATMENTS

Treatment	Replication	Flavor Score	Juiciness Score	Tenderness Score	Overall Acceptability
1	1	4.2	5.1	5.7	6.1
2	1	3.7	5.2	5.8	6.2
3	1	3.7	5.2	6.4	6.8
4	1	3.2	7.3	6.8	5.9
5	1	3.7	6.0	6.8	6.2
6	1	3.4	5.4	6.7	5.2
7	1	3.2	4.5	5.3	4.9
8	1	2.8	3.9	5.7	5.2
9	1	3.9	3.6	5.3	5.5
10	1	3.7	5.7	5.1	5.9
1	2	4.4	7.3	7.3	6.9
2	2	3.9	5.3	5.3	5.8
3	2	2.9	6.3	6.2	5.6
4	2	3.8	5.6	6.3	5.3
5	2	3.6	5.5	5.9	5.8
6	2	3.3	6.3	7.0	6.1
7	2	3.6	4.4	5.7	5.7
8	2	2.8	4.8	5.3	5.0
9	2	3.7	5.3	5.6	5.6
10	2	4.2	7.3	7.3	7.3

TABLE 17

PROXIMATE ANALYSIS DATA FOR COOKED GROUND BEEF PATTIES

Treatment	Replication	Percent Moisture	Percent Fat	Percent Protein
1	1	59.33	18.11	20.03
2	1	57.84	18.94	20.20
3	1	57.05	19.34	19.05
4	1	59.61	18.51	19.64
5	1	60.68	18.35	19.97
6	1	57.89	18.60	16.19
7	1	61.63	14.78	19.19
8	1	61.42	16.12	17.53
9	1	61.79	17.26	17.28
10	1	52.00	23.47	15.35
1	2	57.43	20.22	17.75
2	2	56.69	21.25	16.86
3	2	57.30	18.85	18.85
4	2	60.50	18.44	16.88
5	2	57.88	20.72	16.94
6	2	61.03	16.24	23.59
7	2	61.16	15.91	18.62
8	2	60.17	18.06	19.24
9	2	58.39	21.13	19.75
10	2	55.51	22.35	20.68

TABLE 18

PROXIMATE ANALYSIS DATA FOR RAW GROUND BEEF PATTIES

Treatment	Replication	Percent Moisture	Percent Fat	Percent Protein
1	1	59.61	21.35	13.98
2	1	61.62	20.37	15.07
3	1	59.68	21.22	15.68
4	1	62.23	19.27	14.52
5	1	62.19	20.95	13.49
6	1	20.30	19.57	15.92
7	1	62.50	18.33	15.52
8	1	57.18	23.10	15.64
9	1	61.52	20.72	16.25
10	1	59.81	22.04	14.89
1	2	59.62	21.55	16.33
2	2	60.72	21.71	15.07
3	2	61.07	18.33	15.55
4	2	58.42	22.14	15.70
5	2	61.78	20.14	16.95
6	2	60.08	18.76	18.07
7	2	63.48	19.66	16.09
8	2	60.38	20.65	15.78
9	2	63.60	18.91	15.55
10	2	58.37	24.05	15.20

TABLE 19

COOKING LOSSES DATA OF COOKED GROUND BEEF PATTIES

Treatment	Replication	Total Cooking Loss Percent	Drip Loss Percent	Evaporation Loss Percent
1	1	15.480	2.758	12.722
2	1	14.336	3.078	11.258
3	1	15.776	2.922	12.854
4	1	8.888	2.400	6.488
5	1	12.023	1.410	10.613
6	1	18.856	3.217	15.639
7	1	12.206	1.482	10.724
8	1	13.290	2.695	10.595
9	1	16.424	1.652	14.772
10	1	19.696	4.610	15.092
1	2	12.566	1.858	10.708
2	2	15.185	1.846	13.339
3	2	16.741	3.473	13.268
4	2	13.016	2.566	10.450
5	2	20.602	1.732	18.870
6	2	12.197	1.211	10.986
7	2	12.410	2.172	10.238
8	2	17.059	1.667	15.392
9	2	16.271	0.548	15.723
10	2	15.098	5.048	16.038

TABLE 20

COLOR MEASUREMENT DATA FOR RAW GROUND BEEF PATTIES

Treatment	Replication	L	a	b
1	1	43.1	11.8	11.6
2	1	47.6	15.3	9.3
3	1	44.0	13.0	9.5
4	1	45.3	12.6	11.2
5	1	47.1	12.7	9.5
6	1	45.3	12.6	11.2
7	1	45.7	15.2	10.7
8	1	46.1	13.9	11.1
9	1	45.1	11.6	10.9
10	1	40.8	7.9	8.2
1	2	42.4	8.4	8.3
2	2	43.5	8.9	8.8
3	2	44.1	9.0	9.0
4	2	44.7	9.6	10.0
5	2	41.0	9.9	10.0
6	2	46.3	11.4	10.9
7	2	45.7	11.5	11.7
8	2	46.8	10.1	11.0
9	2	45.1	10.5	9.5
10	2	39.8	10.6	8.6

TABLE 21

COLOR MEASUREMENT DATA OF COOKED GROUND BEEF PATTIES

Treatment	Replication	L	a	b
1	1	35.0	8.5	6.9
2	1	44.3	8.7	9.4
3	1	38.4	5.7	3.8
4	1	45.2	6.9	9.0
5	1	40.3	8.5	9.9
6	1	42.9	6.0	4.3
7	1	38.8	9.4	9.0
8	1	40.2	9.5	10.4
9	1	41.2	8.4	11.1
10	1	38.5	6.5	8.4
1	2	41.5	7.3	5.8
2	2	42.8	4.9	9.1
3	2	38.0	7.6	7.6
4	2	40.4	6.1	9.5
5	2	40.6	5.9	8.8
6	2	37.9	6.2	8.4
7	2	42.3	6.1	9.5
8	2	47.7	4.3	7.6
9	2	45.7	4.7	11.1
10	2	40.0	7.3	7.7

TABLE 22

pH AND TITRATABLE ACIDITY DATA FOR RAW GROUND BEEF PATTIES

Treatment	Replication	pH	Titratable Acidity
1	1	5.97	3.83
2	1	6.36	3.72
3	1	6.10	4.28
4	1	6.31	3.15
5	1	6.28	4.25
6	1	6.05	3.90
7	1	6.19	4.98
8	1	6.31	3.52
9	1	6.50	4.25
10	1	5.85	3.40
1	2	5.89	3.63
2	2	6.26	3.50
3	2	6.05	3.25
4	2	6.16	3.55
5	2	6.37	3.44
6	2	6.10	3.35
7	2	6.30	4.10
8	2	6.38	3.28
9	2	6.32	4.50
10	2	5.87	3.70

VITA

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She started her graduate work at The University of Tennessee, Knoxville in the fall of 1977. She received her Masters degree in Food Technology and Science in June 1980.

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