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I am submitting herewith a thesis written by Ibrahim Musa Tibin entitled "Addition of Vegetable Fat (Hydrogenated Soybean Oil and Palm Oil) to Ground Beef." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Food Technology and Science.

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ADDITION OF VEGETABLE FAT (HYDROGENATED SOYBEAN OIL AND PALM OIL) TO GROUND BEEF

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ABSTRACT

The research objective of this study was to determine how ground beef formulations of varying vegetable fat levels would affect the palatability, physical and chemical composition of ground beef patties. Seven treatments were formed from the combination of each of the two vegetable fats (hydrogenated soybean oil and palm oil) with beef lean and beef fat as follows: 20:0, 15:5, 10:10, 5:15, 10:5, 5:10 and 5:5 percent animal fat to vegetable fat, respectively.

Flavor was scored above the slightly full beefy level (Appendix A) for all the treatments except treatment 6 (5 percent animal and 10 percent vegetable fat). Treatment 2 (15 percent animal and 5 percent vegetable fat) was not significantly different from treatment 1, the control, in flavor. Generally the flavor scores decreased with an increase in vegetable fat content. There was no significant difference between the two vegetable fats in their effects on sensory, color, cooking or chemical data studied except in percentage moisture of the raw patties and total cooking loss.

The juiciness scores for all the treatments were above the slightly juicy level. All treatments containing vegetable fat and a total of 20 percent were scored higher than the control treatment in juiciness. Only treatment 6 (5 percent animal and 10 percent vegetable fat) was significantly different from the control treatment in juiciness. Treatment 6 was scored the lowest for both flavor and juiciness. All the treatments were scored above slightly tender. There was a general

increase in tenderness with the increase in vegetable fat content. Treatment 4 (5 percent animal and 15 percent vegetable fat) was the most tender. All the treatments were not significantly different from the control treatment in tenderness.

The treatments were all scored above slightly acceptable for overall acceptability. There was a decrease in acceptability with an increase in vegetable fat. Overall acceptability was more related to flavor than the other palatability characteristics studied. It was observed that treatment 2 was not significantly different from the control treatment in all the palatability characteristics studied and tended to have higher scores than the control in juiciness and tenderness. Generally the increase in vegetable fat content caused an increase in tenderness and a decrease in flavor.

There was a significant effect on the color of raw patties with an increase in vegetable fat. The increase in vegetable fat content caused an increase in the lightness, redness and yellowness of the raw patties. Cooking decreased the differences in color among the treatments.

The treatments differed significantly in percentage moisture, percentage protein and percentage fat. Percentage moisture and percentage protein decreased with an increase in percentage fat. There was an increase in percentage protein and decrease in percentage moisture with cooking. The percentage fat decreased slightly with cooking.

The treatments differed significantly in total cooking loss ($P < .01$) and drip loss ($P < .05$). Treatment 4 (5 percent animal and

15 percent vegetable fat) had the highest total loss and drip loss. With the exception of treatment 7 (5 percent animal and 5 percent vegetable fat) the drip loss increased with the increase of percentage total fat. Total loss, drip loss and evaporation loss for all the treatments, except treatment 4, were not significantly different from the control treatment.

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CHAPTER I

INTRODUCTION

Vegetable fats are generally cheaper and more abundant than animal fats. This is clearly observed in most of the developing countries where the animals in general, and sheep and cattle in particular, depend totally on forage as feed. The animals move for hundreds of miles seasonally to find sufficient water and forage. The majority of the cattle are slaughtered at advanced stages of maturity. These factors contribute to toughness of cooked meat, because of the lack of sufficient fat, an abundance of connective tissue and lower collagen solubility.

Holz (1979) mentioned that current downtrends in lard and tallow yields per animal suggest that future growth in animal fat output may fall short of past trends. Despite continued expansion in herds in a number of countries, animal-fat production growth may fall below the long-term linear trend.

On the other hand, a recent U.S. Department of Agriculture report, "Alternative Futures for World Food in 1985," presents projections under various assumptions, all of which indicate that the United States would likely continue to maintain a dominant share of the world market for oil cake. If correct, this would imply continued growth in the United States soybean output, which would bring with it a sizable volume of soybean oil. The increase in volume would likely exceed domestic needs and move largely into foreign markets.

Technological advances have made more vegetable fats available for use as foods. Therefore, research is needed to determine whether the vegetable fats can be substituted for animal fats in products such as ground beef which has typically been made with beef fat. This would be of great importance in countries where a shortage of beef fat exists. Also, this might be of importance to the Americans in the future since the beef prices are increasing rapidly. As the use of vegetable fats would increase the total pounds of meat available, it would be of economic importance if it does not affect the palatability of ground beef.

Information is needed as to the effect of different levels of vegetable fat combinations on the palatability of ground beef. Research on this subject is not available in the literature. Therefore, the objective of this study was to determine the effect of type and percentage of vegetable fat on certain palatability, physical and chemical traits of ground beef.

CHAPTER II

LITERATURE REVIEW

I. GROUND BEEF AND ITS CHARACTERISTICS

Ground beef is a popular form of beef and is consumed in large quantities in the United States. Nielsen et al. (1967) mentioned that ground beef of varying quality accounts for a large proportion of total meat purchases of many homemakers and institutions. Cross (1978a) reported that in the United States the consumption of ground beef had increased steadily over the past decade. Law et al. (1965) mentioned that 88 percent of consumers indicated that they served ground beef in some way two or more times per week. The survey also indicated that the fat content in ground beef had a definite effect on beef sales and consumer acceptance.

Huffman and Powell (1970) found that there were no significant interactions among cooking rate, fat level, and soya level when 15, 25, and 35 percent fat levels were studied in ground beef patties. They also mentioned that the acceptability of ground beef patties was similar when cooked from either the frozen or thawed state.

Cole et al. (1960) found that laboratory and family taste panels rated ground beef with 15 percent fat less acceptable than ground beef with 25, 35, and 45 percent fat.

In contrast to the findings of Cole et al. (1960), Law et al. (1965) found that consumers preferred ground beef with the lowest fat content. Of the three fat levels tested, 15 percent ground beef was rated best, followed in order by 25 percent and 35 percent levels.

Ford (1974) compared ground beef fabricated from two lean sources (domestic and foreign) and contained five levels of fat—16, 25, 30, 35, and 45 percent. A ten-family taste panel selected from high-income University personnel and low-income University personnel were used to evaluate paired samples and designate a preference. A six-member trained taste panel was also used to score flavor, tenderness, and juiciness and to declare a preference for all possible comparisons of both broiled and fried samples. He concluded that a wide range of fat percentage in ground beef is acceptable to the consumer.

In testing a consumer response to three fat levels—15, 25, and 35 percent—in ground beef, Law and Beeson (1966) reported that income had little effect on the acceptability of ground beef with a low-fat level. But at the highest level of fat, 35 percent, the higher income group expressed more dissatisfaction than the lower income group.

Fruin and VanDuyne (1961) studied the fat content of ground beef prepared from U.S. Commercial and U.S. Standard untrimmed and trimmed chucks and round, and they determined the effect of these grades, trims and cuts on the yield and palatability of cooked beef patties. They reported that significantly higher fat content was found in U.S. Commercial grade than in U.S. Standard, in chuck than in round, and in the untrimmed than in the trimmed samples. Moisture contents also differed significantly but in the reverse order.

Law et al. (1971) determined variations in cooking losses, water, fat, and protein content in regular ground beef samples obtainable at the retail level in Baton Rouge, Louisiana. They found differences in ground beef purchased from several retail stores. Moisture content varied inversely with the fat content.

Watson and Kilgore (1974) studied the fat moisture and protein content as well as the cooking losses, cost per pound, and cost per pound of protein of ground beef and ground chuck purchased from five supermarkets. They found that ground beef was higher for fat and lower for moisture than ground chuck whether cooked or raw. Ground chuck contained more protein than ground beef whether measured in raw or cooked samples. Ground beef was a more economical buy than ground chuck.

Cross et al. (1976a) studied the effect of ground beef formulations of varying quality grades and cuts on cooked ground beef palatability. They found that differences in palatability of ground beef patties between grades were significant and large enough to be important. Ground beef from Prime and Choice carcasses was consistently rated higher than that from Utility and Cutter. Good grade ground beef was usually intermediate. Ground beef from chuck was rated higher in palatability, except for juiciness than that from plates or chuck-plate combinations.

Randall and Larmonc (1977) compared grinding and flake-cutting as methods of comminuting meat for hamburger patties. They reported that, though drip after thawing, cooking losses and bacterial counts of patties were similar, trained sensory panels found that the ground patties had a finer grind, were more tender, less rubbery, and were more juicy and greasy than the flake-cut product.

Jaye et al. (1962) studied the effect of temperature and packing material on the storage life and bacterial flora of ground beef. They found that ground beef retained acceptability longer in an essentially air-impermeable film such as saran than in cellophane. Likewise, acceptability was maintained longer at -1°C than at 3°C.

Cross et al. (1978b) determined whether mechanical devices could accurately evaluate, with respect to human evaluations, the textural characteristics of cooked ground beef patties. Two shear and one compression devices were adapted to the Instron machine. They found that the shear force devices that they used for characterizing the texture of ground beef patties were acceptable and gave readings that were highly correlated with the senosry evaluation of patties.

Judge et al. (1974) reported that there are several criteria of quality in ground beef patties including low numbers of bacteria, brightness of color, and minimal cooking shrinkage. In frozen patties, the ease of removal of the interleaving paper is also important.

Cross et al. (1976a) reported that connective tissue was and is a major problem associated with the acceptance of ground beef. They found that meat from U.S. Utility or lower quality or from minor cuts of any grade produced a ground product that was unacceptably high in connective tissue.

Cross et al. (1976b) found that the method of grinding affected texture properties of ground beef, especially the amount of connective tissue remaining in the cooked product. The results indicated that the size of the plates in the initial grind was directly related to the amount of connective tissue in the cooked product.

Cross et al. (1978a) evaluated the effect of mechanical desinewing vs. grinding on textural properties of comminuted beef. They found that desinewing generally improved textural properties of beef patties with greatest effects on meat from mature animals.

II. PALATABILITY CHARACTERISTICS OF MEAT

Palatability Factors

Regardless of the nutritional excellence and adaptability of meat and meat products, meat will be consumed in adequate and increasing quantities only if it appeals to the palate.

Bratzler (1978) reported that meat palatability depends upon such qualities as aroma and flavor, color or appearance, tenderness and juiciness.

Flavor

Flavor is difficult to evaluate and many factors have been shown to affect it. In recent years, there has been a great deal of research leading toward the isolation and identification of the substances that contribute to the aroma and flavor of meat. Although gas-liquid chromatography, infrared, and mass spectroscopy have contributed to the rapid advances in detecting and characterizing the microquantities that are associated with meat flavors; nevertheless, the subjective judgment of a panel of tasters is generally relied upon to evaluate eating quality.

Gann (1977) mentioned that the water soluble components of meat which include free amino acids and free carbohydrates are important as flavor and odor precursors which develop cooked meat flavors upon heating.

Tenderness

Consumer studies have shown that tenderness is the most important palatability factor in the acceptance of beef and probably of other meats including poultry and game.

Bratzler (1978) reported that the overall impression of tenderness comes from at least three sources. The first is the ease with which the teeth sink into the meat when chewing begins; the second is the ease with which the meat breaks into fragments (friability or mealiness); and the third is the amount of residue remaining after chewing.

Anil (1971) reported that tenderness may be known to a consumer as a quality affected by different sensory perceptions, such as texture, juiciness, aroma, flavor, and appearance. When the food scientist refers to tenderness, he is talking about a physical quality such as the amount of force necessary to shear the muscle fibers.

Cover et al. (1962) described tenderness as: softness as judged by the sense of feel to the tongue and cheek, softness to tooth pressure as sensed by exerted muscular force, ease of fragmentation during cutting or breaking the muscle fibers across the grain, mealiness as judged by the quality of tiny and hard meat fragments adhering to the inner surfaces of the mouth, apparent adhesion between muscle fibers, and finally the amount and apparent hardness of connective tissue.

Parrish et al. (1973) reported that aging carcasses at 16°C offers a very practical method of accomplishing rapid improvement in tenderization without modification of carcass handling and use of costly refrigeration.

Williams and Harrison (1978) used hydroxyproline assay and sensory evaluation to study tenderizing effects of two oven temperatures (94°, 149°C) and two end point temperatures (70°, 80°C) on top round steaks, cooked in oven film bags. They found that hydroxyproline solubilized during cooking ranged from 1.47-1.80 percent, and did not differ significantly between oven temperatures or between end point temperatures. Sensory tenderness scores were higher ($P < 0.01$) for steaks cooked to 70° than for steaks cooked to 80°C. Time the internal temperature of steaks remained between 55° and 60°C was related to hydroxyproline solubilized, tenderness score and softness score.

Marsh (1977) reported that two muscle components, collagen, and contractile apparatus determine tenderness. The collagen contribution to toughness is due to the presence of intermolecular crosslinks while toughness due to contractile proteins is determined by conditions during the first few postmortem hours when rapid chilling causes "cold shortening" of the muscles and consequently very appreciable toughening.

Juiciness

The juiciness of cooked meat may be separated into two effects: the first is the impression of wetness during the first chews produced by the rapid release of meat fluids; the second is one of sustained juiciness apparently because of the slow release of serum and the stimulating effect of fat on saliva flow.

Cross et al. (1979) reported that juiciness and cooking losses were found to be affected by the cooking method. Roasted steaks were rated higher in juiciness, had lower cooking losses, and required longer cooking times to achieve the desired temperatures end point than broiled steaks.

Savell et al. (1977) reported that electrical stimulation may increase desirability of palatability attributes other than tenderness (juiciness, flavor, and overall satisfaction) even though the exact mechanisms for such improvements are not known.

Nielsen et al. (1967) compared cooking losses, tenderness, juiciness, flavor, and overall acceptability of hamburger and ground round purchased from two supermarkets in Seattle. No significant differences were found between the two meats in any of the eating qualities compared.

Color

The chemistry of the color of meat is the chemistry of the heme pigments. More specifically, it is primarily the chemistry of one pigment myoglobin. Although the other pigment hemoglobin also contributes to fresh meat color, it has a minor role because it is almost removed with the blood during slaughter and bleeding of the animals.

Myoglobin is a complex muscle protein similar in function to the blood pigment hemoglobin, in that both serve to complex with the oxygen required for metabolic activity of the animal. Although their functions are similar, their roles are different. Hemoglobin acts as an oxygen carrier in the blood stream and myoglobin is essentially a storage mechanism for oxygen in the cell.

Clydesdale et al. (1971) reported that the color cycle in fresh meats is reversible and dynamic with the three pigments oxymyoglobin, myoglobin, and metamyoglobin being constantly interconverted. Therefore, in the presence of oxygen, the purple myoglobin may be oxygenated to the bright red oxygenated pigments, oxymyoglobin, producing the familiar "bloom" of fresh meats, or it may be oxidized to metamyoglobin, producing the undesirable brown of less acceptable meats.

Govindarajan (1973) mentioned that the measurement of meat color has proved to be a difficult task due to two major reasons: the complexity of myoglobin distribution in the muscle, and the dynamic nature of the pigment. Further complicating the situation is the presence of intramuscular fat which tends to interfere with the color measurement.

Reed Brown et al. (1978) reported that rapid color change shortens the time that meat can be held in a display case before it is sold. Presently, much of the meat in a retail display is packaged in air-permeable films. Free exchange of oxygen taking place makes the meat susceptible to oxidation of lipids and pigments.

III. COOKING LOSSES

The cooking losses of meat are composed mainly of the drip loss and the evaporation loss. The drip loss normally increases as the fat content of the raw meat increases while the evaporation loss decreases with the increase of the fat content of the raw meat.

Law et al. (1971) reported that as the fat content of ground beef was increased, the amount of fat lost in the cooking increased. However, high total weight losses consisted mainly of moisture.

Anderson and Lind (1975) found that regardless of fat and moisture levels of raw patties, patties composed of a mixture of 25 percent by weight of hydrated textured vegetable protein (TP) with beef, retained a greater percentage of moisture and a lesser percentage of fat in cooking than all beef patties of comparable fat levels.

Irmiter et al. (1967) compared the effect of fat content on the rate of temperature rise during roasting of beef. They found that at the early stages of cooking, meat with the least fat heated most rapidly, while in the later stages of cooking, meat with the least fat heated most slowly. The meat with the least fat required the longest total cooking time. Total cooking losses were not correlated with the fat content of the raw meat, but evaporation loss correlated negatively and drip loss correlated positively with the fat content of the raw meat.

IV. HYDROGENATION OF OILS

Hydrogenation of vegetable oils has been practiced since the discovery of Norman some 77 years ago, and it is the major chemical process in the fat and oil industry. Hydrogenation changes a liquid oil to a semisolid fat which has more utility and better flavor stability. The reaction is not a simple saturation of double bonds with hydrogen, but is an extremely complex series of reactions that result in a myriad of products.

Allen (1978) reported that there are two reasons to hydrogenate oils. First, since the number of double bonds is reduced, the opportunity for oxidation is reduced and thus the flavor stability is increased. Second, the physical characteristics are changed so the product has more utility. Products such as margarines, shortenings, coating fats, and frying fats all result from hydrogenation of oils. By control of the reaction conditions, pressure, temperature, agitation, and catalyst type and concentration, the desired product may be obtained.

Albright (1967) mentioned that hydrogenation of the double bonds in triglycerides causes the following changes in physical properties: an increase in the melting temperature, a decrease in color, reduction of odor and improvement in the stability of oil.

Bolton (1927) defined hydrogenation as a process whereby a part or, in some cases, nearly all the unsaturated acids in an oil are caused to combine with hydrogen under the influence of a catalyst.

CHAPTER III

MATERIALS AND METHODS

I. SOURCE OF DATA

Beef fat and beef lean used in this study were purchased from a local packing company. USDA Choice short plates were used as the source of beef fat. The plates were boned and then ground through a coarse .6 cm plate in a cold place. The beef lean was trimmed to a minimum amount of fat and ground through a .6 cm plate in a cold place. Following the initial grind the beef lean and beef fat were mixed separately for about two minutes in a mechanical mixer. Random samples were taken for fat content determination by the Modified Babcock procedure. The remainder of the ground meat and ground fat were wrapped with freezer papers and frozen at -18°C.

The two vegetable fats (hydrogenated soybean oil and palm oil) were supplied by a local company. The two oils were processed to have similar hardness values as beef tallow. The hydrogenated soybean oil has a melting point of 46°C, while the palm oil has a melting point of 41°C. Each of the two vegetable fats was ground through a .6 cm plate in a cold place, wrapped with freezer papers and stored at -18°C.

II. PREPARATION OF GROUND BEEF PATTIES

The ground samples of beef lean, beef fat and vegetable fats were thawed overnight in a 1°C cooler; then by the use of the Pearson Square Method, the proper ratios of fat to lean were calculated and fourteen treatments were prepared as outlined in Table I.

Each treatment was thoroughly mixed, ground through a .3 cm plate and pressed into patties—each of about 1.5 cm thick, 10-11 cm in diameter and 110-120 g in weight. The patties were wrapped with freezer paper, marked as to fat levels and frozen at -18°C to await sensory evaluation, chemical analysis, color measurements and cooking losses determinations.

III. SENSORY EVALUATION

The sensory evaluation was done in the sensory evaluation facility of the Food Technology and Science Department. An eight-member trained taste panel was used to score flavor intensity, tenderness, juiciness and overall acceptability of the different treatments (see Table I). Flavor intensity, tenderness, juiciness and overall acceptability were scored on a scale of one to eight. Eight was extremely full (rich or beefy) flavor, extremely tender, extremely juicy and extremely desirable while one was extremely weak flavor, extremely tough, extremely dry and extremely undesirable, respectively (see Appendix A).

Panelists were selected and trained by procedures outlined by Cross et al. (1978c). The method developed for selecting, training and testing a meat-descriptive panel was based on an informal interview to

TABLE I

TREATMENT COMBINATION DESIGNATION

Treatment No.	% Total Fat	% Animal Fat	% Vegetable Fat
Group 1:[a]			
1 (Control)	20	20	0
2	20	15	5
3	20	10	10
4	20	5	15
5	15	10	5
6	15	5	10
7	10	5	5
Group 2:[b]			
1 (Control)	20	20	0
2	20	15	5
3	20	10	10
4	20	5	15
5	15	10	5
6	15	5	10
7	10	5	5

[a]Indicates treatments with beef lean, beef fat and palm oil.

[b]Indicates treatments with beef lean, beef fat and hydrogenated soybean oil.

Note: Because the two vegetable fats were found to be statistically nonsignificant except in two parameters measured, the results of the fourteen treatments were averaged to give seven treatments on subsequent tables.

each candidate to see his or her interest and availability. Then the selection of the available candidates was done by triangle tests in which candidates who were not able to detect the odd samples were screened. The triangle tests were used to check the candidate's ability to distinguish repeatedly between three samples; two were similar and the third one was different. The triangle tests were done in such a way that they started with samples that had wide differences of fat level between them and the differences decreased gradually with time. The panelists who were able to distinguish repeatedly the odd samples were selected. Half of the panelists selected were professors at the Food Technology and Science Department and the rest were graduate students.

After selection the training period started. During training the panelists discussed and understood methods, scales, score sheets and terminology to be used in the tests. The panelists were free to swallow or expectorate the samples during training and the actual tests. Each panelist rinsed his or her mouth with room temperature water between samples.

The patties to be used for sensory evaluation were thawed overnight in 1°C cooler prior to cooking. The samples were cooked in a Presto Burger Hamburger cooker; each patty was cooked for three minutes—two minutes for one side and then turned on the other side and cooked for another minute. The cooker was preheated for one minute before each cooking.

Each cooked patty was then divided into eight portions and kept warm (approximately 54°C) on a heated serving tray. Each panelist was served one-eighth of the cooked patty on a coded white plate under red lights in individual booths.

Panelists evaluated three sensory attributes (tenderness, juiciness and flavor intensity) that had been previously determined during training to characterize the products. In addiation, a scale to reflect overall acceptability of the produce was included.

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

IV. COLOR MEASUREMENTS

Color of the raw and cooked patties was measured with a Hunter Lab Color Difference Meter Model D25 which was standarized with the white calibrated standard No. C_2-136 (L = +93.4, a = -1.1 and b = +1.9). Each patty was put in styroform meat tray, covered with Good Year prime wrap and then the color was measured from two sides. The two values were averaged to give one reading. Four replications were done for each raw and cooked patty treatment.

V. CHEMICAL ANALYSIS

The moisture determinations for the raw and cooked treatments were determined according to A.O.A.C. (1970) procedures by drying the samples in a vacuum oven. Percentage protein was determined by the Kjeldahl procedure according to Ockerman (1969). Percentage fat was determined by the anhydrous ethyl ether extraction method according to Ockerman (1969). Each sample was done in duplicate and four replications were done for each raw and cooked treatment.

VI. 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 drippings after cooking. Evaporation loss was calculated as the difference between total loss and drip loss (see Appendix B). Four replications were done for each treatment. All cooking losses were expressed as percentages of the raw weight.

Data for the chemical analysis, sensory evaluation, color measurements and cooking losses were analyzed by analysis of variance with a completely randomized design to show the effects of vegetable fat, treatments, replication and their interactions; and, where applicable, significant difference among means was identified by Duncan's Multiple Range Test (1955).

CHAPTER IV

RESULTS AND DISCUSSION

I. SENSORY EVALUATION

Analysis of variance of the effect of percentage and type of vegetable fat on flavor, juiciness, tenderness and overall acceptability of ground beef patties is shown in Table II. Patties containing the two vegetable fats did not differ significantly in flavor. There was a significant difference, however, between the treatments (percentage vegetable fat) in flavor score ($P < .01$). The seven treatments in Table II and the subsequent tables were the result of the combinations of the two fat groups found in Table I, because the two vegetable fats were found to be statistically nonsignificant in the parameters measured except percentage moisture for the raw beef patties and total cooking loss.

With the exception of treatment 6, the flavor scores for all the treatments were at and above the slightly full beef flavor level (Table III). Treatment 1, the control, received the highest flavor score while treatment 6 (5 percent animal and 10 percent vegetable fat) had the lowest flavor score. Treatment 2 (15 percent animal and 5 percent vegetable fat) was not significantly different from treatment 1, the control which contained 20 percent animal fat and no vegetable fat. This showed that the combination of 15 percent animal fat with 5 percent vegetable fat was not different in flavor than all beef (control)

TABLE II

ANALYSIS OF VARIANCE OF THE EFFECT OF VEGETABLE FAT TYPE AND PERCENTAGE ON SENSORY ATTRIBUTE OF BEEF PATTIES

		Mean Squares			
Source	DF	Flavor Score	Juiciness Score	Tenderness Score	Overall Acceptability Score
Vegetable Fat	1	0.29	0.001	0.22	0.01
Treatment	6	1.39**	0.88**	0.66**	0.59*
Replicate	3	0.59	0.94*	0.25	0.43
Vegetable Fat × Treatment	6	0.42	0.37	0.16	0.21
Vegetable Fat × Replicate	3	0.75	0.55	0.48*	0.16
Treatment × Replicate	18	0.34	0.38	0.28	0.24
Error	18	0.30	0.24	0.13	0.21
Total	55				

**P < .01

*P < .05

TABLE III

MEAN[a] VALUES FOR THE EFFECT OF PERCENTAGE VEGETABLE FAT ON SENSORY ATTRIBUTE OF BEEF PATTIES

Treatment[b]	Flavor[c] Score	Juiciness[c] Score	Tenderness[c] Score	Overall[c] Acceptability Score
1 (20:0)	6.08a	5.69ab	5.89bc	5.81a
2 (15:5)	5.52ab	5.95a	5.97abc	5.61ab
3 (10:10)	5.20bc	5.91a	6.22ab	5.47abc
4 (5:15)	5.08bc	5.78a	6.33a	5.34abc
5 (10:5)	5.09bc	5.59abc	5.56c	5.22bc
6 (5:10)	4.84c	5.09c	5.66c	5.02c
7 (5:5)	5.00bc	5.22bc	5.72c	5.20bc

[a]Means of eight determinations. Means in column groups followed by the same letter are not significantly different ($P < .05$).

[b]Treatments are combinations of percentage animal fat to vegetable fat.

[c]Flavor, juiciness, tenderness and overall acceptability scored on an 8 point scale; 8 = extremely full, extremely juicy, extremely tender and extremely desirable; 1 = extremely weak, extremely dry, extremely tough and extremely undesirable, respectively.

patties. With the increase in percentage vegetable fat and a decrease in percentage of total fat the flavor scores tended to decrease. Although treatment 4 (5 percent animal and 15 percent vegetable fat) had more percentage of vegetable fat than treatment 6 (5 percent animal and 10 percent vegetable fat), it was scored higher in flavor by the panelists, possibly because it contained more total fat (Table I, page 16). Treatment 7 contained only 10 percent total fat (5 percent animal and 5 percent vegetable fat) but was similar in flavor to all other treatments except treatment 1, the all beef (control) patty.

The two vegetable fats were not significantly different as to their effect on juiciness scores (Table II). There were significant differences ($P < .01$) for treatments (percentage vegetable fat) and replicate ($P < .05$). Panelists differ in salivary secretion rates, therefore juiciness is a very difficult palatability trait to measure subjectively. Cross (1978c) found low correlation coefficients between panelists for juiciness scores but high relationships for tenderness.

All the treatments were scored above the slightly juicy level (Table III). With the exception of treatment 6, it appears that vegetable fat has an effect on juiciness of beef patties. The juiciness scores for treatments 2, 3 and 4 were slightly higher than that for treatment 1 even though they contained vegetable fat. Treatment 5 which contained 15 percent total fat (10 percent animal and 5 percent vegetable) was as juicy as the all beef (control) patty, as was treatment 7 (5 percent animal and 5 percent vegetable fat). Further research is needed to determine this effect.

Type of vegetable fat did not significantly affect tenderness scores of the patties (Table II). There was a significant difference, however, due to percentage of vegetable fat and total fat in the patties ($P < .01$). All the treatments were above the slightly tender level with a general increase in tenderness as percentage of total fat and vegetable fat increased. Treatment 4, which had the highest percentage of vegetable fat and a total percentage of 20, was scored the most tender. Treatments 3 and 2 were scored next most tender. They also contained the next highest percentage of vegetable fat. This trend of vegetable fat influencing tenderness was also observed at the 15 percent total fat level. Treatment 7 (5 percent animal and 5 percent vegetable fat) was as tender as the all meat control and all but two of the other treatments.

These sensory data indicate that flavor scores very strongly influenced the overall acceptability scores. The general trend was for lower scores with increased vegetable fat and lower total fat percentages. One point of interest, however, is that all the scores were above the slightly desirable level. It appears that from a sensory standpoint vegetable fat can successfully be added to ground beef patty formulations. With a seasoning blend added, much of the flavor difference could probably be masked.

II. COLOR MEASUREMENTS

Table IV shows the effects of vegetable fat type and percentage on the color of raw ground beef patties. The two vegetable fats did not

TABLE IV

ANALYSIS OF VARIANCE OF THE EFFECT OF VEGETABLE FAT TYPE AND PERCENTAGE ON THE COLOR[a] OF RAW BEEF PATTIES

Source	DF	Mean Squares L	a	b
Vegetable Fat	1	0.20	4.32	0.78
Treatment	6	40.93**	10.66	12.48*
Replicate	3	16.45	0.88	4.87
Vegetable Fat × Treatment	6	16.28	2.84	1.37
Vegetable Fat × Replicate	3	10.30	6.41	2.44
Treatment × Replicate	18	5.79	5.23	1.33
Error	18	7.07	4.66	2.03
Total	55			

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

**P < .01

differ significantly in their effects on the color of raw ground beef patties. There was a significant difference among the treatments for lightness (L) and yellowness (b) of color ($P < .01$). There were no significant differences among the interactions. Treatment 4 had the highest lightness value which reflects that with an increase in vegetable fat there was an increase in lightness of the color. On the other hand, treatment 7 (Table V), which contained the lowest total fat, had the lowest lightness value. Treatment 4 (5 percent animal and 15 percent vegetable fat) was the only treatment which was significantly different from the control treatment (Table V). This may show that, when the percentage of vegetable fat represents about 75 percent of the total fat, a significant change in lightness of color will occur.

Treatments 3 and 4 were significantly higher ($P < .05$) from treatment 1, the control, in (a) value (redness). The addition of vegatable fat appears to significantly increase the redness of the raw patties at the 20 percent total fat level. Treatment 4 had the highest (b) value which indicated its yellowness and it was significantly different from all the other treatments in yellowness. Therefore, addition of vegetable fat at this level to ground beef affects the color of raw patties.

Table VI shows the effect of type of vegetable fat and percentage on the color of cooked ground beef patties. The two vegetable fats did not differ significantly as to their effects on the color of the cooked ground beef. There was a significant difference ($P < .05$) in the replicates for the L value and the interaction of vegetable fat type

TABLE V

MEAN[a] VALUES FOR THE EFFECT OF PERCENTAGE VEGETABLE FAT ON THE COLOR[b] OF RAW BEEF PATTIES

Treatment[c]	L	a	b
1 (20:0)	35.88bcd	9.79c	10.66b
2 (15:5)	37.56b	11.39abc	10.19b
3 (10:10)	38.39ab	12.43ab	11.16b
4 (5:15)	40.61a	13.48a	13.46a
5 (10:5)	34.54cd	11.65abc	10.84b
6 (5:10)	37.34c	10.95bc	10.28b
7 (5:5)	34.16d	11.80abc	9.57b

[a]Means of eight determinations. Means in column groups followed by the same letter are not significantly different ($P < .05$).

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

[c]Treatments are combinations of percentage animal fat to vegetable fat.

TABLE VI

ANALYSIS OF VARIANCE OF THE EFFECT OF VEGETABLE FAT TYPE AND PERCENTAGE ON THE COLOR[a] OF COOKED BEEF PATTIES

Source	DF	Mean Squares L	a	b
Vegetable Fat	1	0.49	0.11	1.54
Treatment	6	1.00	2.50	1.29
Replicate	3	29.25*	1.91	0.16
Vegetable Fat × Treatment	6	0.97	1.03	0.22
Vegetable Fat × Replicate	3	1.92	0.28	2.20*
Treatment × Replicate	18	5.86	0.85	0.71
Error	18	9.12	1.10	0.67
Total	55			

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

*P < .05

and with the replicates for the (b) value. The significant difference between the raw treatments was removed by cooking. This is shown in Table VI where the treatments no longer differed in color.

Although the analysis of variance in Table VI showed no significant difference in the color between the treatments, Duncan's test in Table VII showed differences (P < .05) in redness and yellowness between the treatments but all the treatments did not differ significantly from treatment 1, the control, in the different colors measured. Treatments 3 and 4 were no longer significantly different from the control treatment in color after cooking. Therefore, cooking reduced the differences in color between the treatments to the minimum.

III. CHEMICAL ANALYSIS

Analysis of variance of the effect of vegetable fat type and percentage on percentage moisture, protein and fat of raw ground beef patties is shown in Table VIII. The two vegetable fats differed significantly (P < .001) in their effects on the percentage moisture of the raw ground beef. Patties containing palm oil had higher moisture content than those containing hydrogenated soybean oil. The percentage moisture, protein and fat differed significantly (P < .001) among the treatments. Treatment 7 had the highest percentage moisture while treatment 2 had the lowest percentage moisture (Table IX). In all the treatments the moisture content increased as the percentage total fat decreased. The relationship between percentage fat and moisture was in agreement with the findings of Ford (1974) and Law et al. (1971).

TABLE VII

MEAN[a] VALUES FOR THE EFFECT OF PERCENTAGE VEGETABLE FAT ON THE COLOR[b] OF COOKED BEEF PATTIES

Treatment[c]	L	a	b
1 (20:0)	40.73a	3.38ab	9.60ab
2 (15:5)	39.81a	3.84a	9.26ab
3 (10:10)	39.96a	2.95ab	9.74ab
4 (5:15)	39.84a	2.37b	10.18a
5 (10:5)	39.99a	3.01ab	9.15b
6 (5:10)	40.36a	2.68ab	9.00b
7 (5:5)	40.47a	3.82a	9.62ab

[a]Means of eight determinations. Means in column groups followed by the same letter are not significantly different ($P < .05$).

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

[c]Treatments are combinations of percentage animal fat to vegetable fat.

TABLE VIII

ANALYSIS OF VARIANCE OF THE EFFECT OF VEGETABLE FAT TYPE AND PERCENTAGE ON PERCENTAGE MOISTURE, PROTEIN AND FAT OF RAW BEEF PATTIES

Source	DF	Mean Squares Percent Moisture	Percent Protein	Percent Fat
Vegetable Fat	1	9.22***	1.29	2.26
Treatment	6	53.92***	5.80***	88.98***
Replicate	3	1.02	0.34	0.83
Vegetable Fat × Treatment	6	1.46*	0.88	3.74*
Vegetable Fat × Replicate	3	0.79	0.42	0.39
Treatment × Replicate	18	1.00	0.23	1.01
Error	18	0.47	0.38	1.12
Total	55			

***P < .001

*P < .05

TABLE IX

MEAN[a] VALUES FOR THE EFFECT OF PERCENTAGE VEGETABLE FAT ON PERCENTAGE MOISTURE, PROTEIN AND FAT OF RAW BEEF PATTIES

Treatment[b]	Percent Moisture	Percent Protein	Percent Fat
1 (20:0)	61.15d	18.93bc	19.89a
2 (15:5)	60.77d	18.89c	20.02a
3 (10:10)	63.74b	19.17bc	17.13c
4 (5:15)	62.46c	19.15bc	18.62b
5 (10:5)	64.30b	19.56bc	15.95d
6 (5:10)	64.39b	19.63b	15.27d
7 (5:5)	68.50a	21.34a	10.45e

[a]Means of eight determinations. Means in column groups followed by the same letter are not significantly different ($P < .05$).

[b]Treatments are combinations of percentage animal fat to vegetable fat.

The percentage protein also increased with the decrease in percentage fat. The average protein (Table IX) was in agreement with that found in the literature. Nielsen (1967) mentioned that the average protein for ground beef was 19 percent.

Table X shows the effect of vegetable fat type and percentage on the percentage moisture, protein and fat of cooked ground beef patties. The two vegetable fats did not differ significantly in percentage moisture, protein or fat. There was a significant difference among the treatments in the proximate analysis (Table X). Treatment 7 had the highest moisture content and the lowest fat content. There was a decrease in the percentage moisture of the cooked compared to the raw patties. The range of percentage moisture for the raw patties was 60.77 to 68.5, while it was 55.4 to 59.8 percent for the cooked patties (Table XI). Law (1971) mentioned that the average percentages moisture for ground beef were 61.4 and 56 percent for raw and cooked hamburger, respectively. The higher values in this study were mainly due to the lower percentage fat used.

There was an increase in the percentage protein of the cooked patties. The range of percentage protein for the raw patties was 18.89 to 21.34, while it was 24.81 to 27.95 percent for the cooked patties. There was a slight decrease in percentage fat after cooking. The range of percentage fat for the raw patties was 10.45 to 20.02, while the range of percentage fat for the cooked patties was 11.95 to 19.08 (Table XI).

TABLE X

ANALYSIS OF VARIANCE OF THE EFFECT OF VEGETABLE FAT TYPE AND PERCENTAGE ON PERCENTAGE MOISTURE, PROTEIN AND FAT OF COOKED BEEF PATTIES

		Mean Squares		
Source	DF	Percent Moisture	Percent Protein	Percent Fat
Vegetable Fat	1	2.83	2.01	0.19
Treatment	6	18.55***	9.63**	51.19***
Replicate	3	3.37	2.21	1.33
Vegetable Fat × Treatment	6	1.36	0.66	4.41**
Vegetable Fat × Replicate	3	1.23	0.45	1.28
Treatment × Replicate	18	1.30	1.92	1.27
Error	18	3.15	1.72	1.17
Total	55			

***$P < .001$

**$P < .01$

TABLE XI

MEAN[a] VALUES FOR THE EFFECT OF PERCENTAGE VEGETABLE FAT ON PERCENTAGE MOISTURE, PROTEIN AND FAT OF COOKED BEEF PATTIES

Treatment[b]	Percent Moisture	Percent Protein	Percent Fat
1 (20:0)	55.40d	25.63c	19.08a
2 (15:5)	55.95cd	25.30c	18.27ab
3 (10:10)	57.50bc	24.81c	17.61bc
4 (5:15)	56.26cd	26.26bc	16.68cd
5 (10:5)	57.31bcd	26.26bc	15.59d
6 (5:10)	58.38ab	27.25ab	13.93e
7 (5:5)	59.80a	27.95a	11.95f

[a]Means of eight determinations. Means in column groups followed by the same letter are not significantly different ($P < .05$).

[b]Treatments are combinations of percentage animal fat to vegetable fat.

IV. COOKING LOSSES

Analysis of variance of the effect of vegetable fat type and percentage on the total loss, drip loss and evaporation loss of cooked ground beef patties is shown in Table XII. There was a significant difference ($P < .01$) in the percentage total loss between the two vegetable fats. The treatments differed significantly in percentage total loss ($P < .01$) and percentage drip loss ($P < .05$). There were significant differences among the replicates in the percentage total loss ($P < .05$) and percentage evaporation loss ($P < .001$). The errors in the cooking losses were mainly due to the problems of some samples sticking to the cooker during cooking. With the exception of treatment 7, percentage drip loss increased with percentage total fat. Percentage total loss for treatment 4 was the highest compared to the other treatments (Table XIII). The average values for the percentage total loss of the 20 percent total fat treatments were in between the values found in literature. Irmiter (1967) found the percentage total loss for 20 percent total fat treatments equal to 36.28 percent; while Nielsen (1967) found total cooking loss, drip loss and evaporation loss were 29.5 percent, 14.3 percent and 15.2 percent, respectively, for 20 percent total fat hamburger. The drip loss was higher than those reported by Nielsen (1967) for the 20 percent total fat; they were 20 percent in this study compared to 14 percent. On the other hand the evaporation loss was lower—about 12 percent compared to 15 percent reported by Nielsen (1967). These differences might be due to the methods of cooking. Cross et al. (1979) reported that the cooking

TABLE XII

ANALYSIS OF VARIANCE OF THE EFFECT OF VEGETABLE FAT TYPE AND PERCENTAGE ON TOTAL LOSS, DRIP LOSS AND EVAPORATION LOSS OF COOKED BEEF PATTIES

		Mean Squares		
Source	DF	Total Loss Percent	Drip Loss Percent	Evaporation Loss Percent
Vegetable Fat	1	59.82**	26.47	6.42
Treatment	6	37.61**	22.09*	9.81
Replicate	3	26.40*	5.48	46.37***
Vegetable Fat × Treatment	6	5.70	6.60	5.78
Vegetable Fat × Replicate	3	2.52	1.12	4.33
Treatment × Replicate	18	5.79	3.55	3.86
Error	18	6.93	6.78	3.88
Total	55			

***P < .001

**P < .01

*P < .05

TABLE XIII

MEAN[a] VALUES FOR THE EFFECT OF PERCENTAGE VEGETABLE FAT ON TOTAL LOSS, DRIP LOSS AND EVAPORATION LOSS OF COOKED BEEF PATTIES

Treatment[b]	Total Loss Percent	Drip Loss Percent	Evaporation Loss Percent
1 (20:0)	31.60b	19.25b	12.35ab
2 (15:5)	31.53b	19.40b	12.17ab
3 (10:10)	29.78b	19.34b	10.44b
4 (5:15)	36.11a	22.87a	13.23a
5 (10:5)	29.75b	17.75b	11.94ab
6 (5:10)	31.12b	18.25b	12.87a
7 (5:5)	30.60b	20.23ab	10.40b

[a]Means of eight determinations. Means in column groups followed by the same letter are not significantly different ($P < .05$).

[b]Treatments are combinations of percentage animal fat to vegetable fat.

method had a significant effect on cooking losses. Treatment 4 had the highest drip loss while treatment 5 had the lowest drip loss (Table XIII). Treatment 7 was supposed to have the lowest drip loss according to Irmiter (1967) as it contained the lowest percentage total fat. The same abnormality was observed in the case of evaporation loss regarding treatment 7.

Table XIV shows the mean values for the effect of vegetable fats on the percentage moisture of the raw beef patties and percentage total loss of cooked beef patties. As mentioned earlier, the two vegetable fats did not differ in any of the parameters measured except for percentage moisture of raw patties and total cooking loss.

TABLE XIV

MEAN[a] VALUES FOR THE EFFECT OF VEGETABLE FAT TYPE ON PERCENTAGE MOISTURE OF THE RAW BEEF PATTIES AND PERCENTAGE TOTAL COOKING LOSS OF COOKED BEEF PATTIES

Vegetable Fat	Percent Moisture	Percent Total Loss
Palm oil	64.02a	32.53a
Soybean oil	63.21b	30.46b

[a]Means of 28 determinations. Means in column groups followed by the same letter are not significantly different ($P < .05$).

The two vegetable fats exerted significant differences ($P < .05$) on the percentage moisture of the raw patties. Palm oil treatments were found to have more percentage moisture than soybean oil treatments (Table XIV). It is clear from the table that the difference was not large—about 0.81 percent. As mentioned earlier, the fat content is inversely related to the moisture content of meat. Therefore, I think that the difference in moisture might be due to the difference in the percentage fat of the different treatments because of slight formulation errors.

The two vegetable fats also exerted significant differences on the total cooking loss of the treatments ($P < .05$). Palm oil treatments had more total cooking loss than soybean oil treatments (Table XIV). The two vegetable fats had different melting points. The hydrogenated soybean oil had a melting point of 46°C while the palm oil had a melting point of 41°C. The lower melting point of palm oil most likely contributed to more fat being lost during drip. More moisture was expected to be lost during evaporation from palm oil treatments. The two vegetable fats have different Solid Fat Index (SFI). These might have affected the total cooking loss and resulted in the differences observed.

Total cooking loss, drip loss and evaporation loss of all the treatments, except treatment 4, were not significantly different from treatment 1, the control. Treatment 4 had the highest percentage of vegetable fat (Table I, page 16). Therefore, the increase in vegetable fat to 15 percent in case of the 20 percent total fat combinations will have a significant effect on the cooking losses of ground beef patties.

CHAPTER V

SUMMARY

The purpose of this study was to determine the effect of vegetable fats (hydrogenated soybean oil and palm oil) on palatability characteristics, chemical composition and cooking losses of ground beef patties when they were substituted for part of the animal fat fraction. Seven treatments were formed from the combination of each of the two vegetable fats with beef lean and beef fat as follows: 20:0, 15:5, 10:10, 5:15, 10:5, 5:10 and 5:5 percent animal fat to vegetable fat, respectively (Table I, page 16).

There was no significant difference between the two vegetable fats in their effects on the sensory, cooking, color or chemical data studied except in percentage moisture of the raw patties and total cooking loss. The flavor scores were above slightly full (Appendix A) for all the treatments except treatment 6 (5 percent animal and 10 percent vegetable fat). Treatment 2 (15 percent animal and 5 percent vegetable fat) was not significantly different from treatment 1, the control, in flavor. Generally, the flavor scores decreased with an increase in vegetable fat content.

All the treatments were scored above slightly juicy (Appendix A). All treatments containing vegetable fat and a total of 20 percent fat were scored higher than the control treatment in juiciness. Only treatment 6 (5 percent animal and 10 percent vegetable fat) was significantly different from the control treatment in juiciness.

Treatment 6 was scored the lowest for both flavor and juiciness. All the treatments were scored above slightly tender (Appendix A). There was a general increase in tenderness with an increase in vegetable fat content. Treatment 4 (5 percent animal and 15 percent vegetable fat) was the most tender. All the other treatments were not significantly different from the control treatment in tenderness.

All the treatments were scored above slightly acceptable for overall acceptability (Appendix A) with a decrease in acceptability as the percentage vegetable fat increased. Overall acceptability was more related to flavor than the other palatability characteristics studied.

Treatment 2 (15 percent animal and 5 percent vegetable fat) was not significantly different from the control in any palatability characteristics studied, and tended to have higher scores than the control in juiciness and tenderness. Generally, the increase in vegetable fat content caused an increase in tenderness and a decrease in flavor. It appears that from a sensory standpoint vegetable fat can successfully be added to ground beef patty formulations at low levels. With a seasoning blend added, much of the flavor difference attributed to vegetable fat could be masked.

The increase in vegetable fat had a significant effect on the color of raw patties. There was a general increase in lightness, redness and yellowness of the patties with an increase in vegetable fat content (Table V, page 27). This was clear in the case of treatment 4, which of the total fat 15 percent was vegetable fat; it was significantly different in color from the control. Cooking decreased the differences in raw color among the treatments.

The treatments differed significantly in percentage moisture, protein and fat. Percentage moisture and percentage protein decreased with an increase in percentage fat. There was an increase in percentage protein, a decrease in percentage moisture and a slight decrease in percentage fat with cooking.

There was a significant difference between the treatments in total cooking loss ($P < .01$) and drip loss ($P < .05$). Treatment 4 had the highest total loss and drip loss. With the exception of treatment 7, the drip loss increased with the increase of percentage total fat. Total loss, drip loss and evaporation loss for all the treatments except treatment 4 were not significantly different from the control treatment. Treatment 4 had the highest percentage vegetable fat, 75 percent of the percentage total fat. Therefore, the increase in vegetable fat to 75 percent of the total in case of the 20 percent total fat combinations will have a significant effect on the cooking losses of ground beef.

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APPENDIXES

APPENDIX A

GRADING CHART FOR GROUND BEEF

GRADING CHART FOR GROUND BEEF

DIRECTIONS:

You will be given 5 samples of ground beef to test for flavor intensity, tenderness, juiciness and overall acceptability. SNIFF each sample before tasting. You do not have to swallow samples, expectorate in empty cup provided. Rinse mouth with water between each sample.

Use the scale on scorecard for each attribute. Do not use fractional numbers. THANK YOU FOR YOUR COOPERATION.

NAME_______________ DATE_______________

Sample Code	Flavor Intensity	Juiciness	Tenderness	Overall Acceptability	Comments

KEY:

Flavor Intensity	Juiciness	Tenderness	Overall Acceptability
8 Extremely full (rich or beefy)	8 Extremely juicy	8 Extremely tender	8 Extremely desirable
7 Very full and rich	7 Very juicy	7 Very tender	7 Very desirable
6 Moderately full	6 Moderately juicy	6 Moderately tender	6 Moderately desirable
5 Slightly full	5 Slightly juicy	5 Slightly tender	5 Slightly desirable
4 Slightly weak	4 Slightly dry	4 Slightly tough	4 Slightly undesirable
3 Moderately weak	3 Moderately dry	3 Moderately tough	3 Moderately undesirable
2 Very weak	2 Very dry	2 Very tough	2 Very undesirable
1 Extremely weak	1 Extremely dry	1 Extremely tough	1 Extremely undesirable

APPENDIX B

DATA ON COOKING LOSSES

DATA ON COOKING LOSSES

Product: Date:

A. Before Cooking:

1. Wt. of raw patty

2. Wt. of cooker

B. After Cooking:

1. Wt. of cooked patty

2. Wt. of cooker and drippings

3. Wt. of drippings ($B_2 - A_2$)

4. Total cooking loss ($A_1 - B_1$)

5. Wt. 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

$$C_1 - C_2$$

VITA

The author was born January 1, 1950, in Abukuu, Sudan. He graduated from Khor Tagget High School, in Elobeid, in April 1969. In July 1969, he enrolled at the University of Khartoum, Sudan, and graduated with an Honored Bachelor of Science degree in Agriculture in October 1974.

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