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PROPERTIES OF BLENDS OF CHICKEN-PORK IN SUMMER SAUSAGES

by

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B.S., Fu Jen University, 1977

A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

in

Food Science

Department of Animal Sciences and Industry

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1980

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INTRODUCTION

The most popular comminuted meat products throughout the world are sausage-type products. Approximately one-tenth of all meat produced in the United States is consumed in the form of sausage (Wardlaw et al., 1973). To increase demand for poultry meat, there is a tremendous amount of interest in combining poultry meat with other meat in emulsion type meat products. Poultry meat has been incorporated into frankfurters by Blackshear et al. (1966), Froning et al. (1971), Baker and Darfler (1972), and Dhillon and Maurer (1975a,b).

Summer sausages keep well because of low pH, high salt content, and low moisture. It has become the most profitable segment of our meat packing industry. Baker et al. (1969), Dawson (1970), and Dhillon and Maurer (1975b) have assessed the acceptability of summer sausages prepared with various combinations of beef with chicken or turkey. However, little work has been reported on properties of pork and chicken summer sausage.

Soy proteins have hydrophilic properties which promote moisture retention and properties which promote fat absorption. Those properties enable soy protein to act as a binder in meat products. Although the use of various forms of soy protein in combinations with ground meats has been reported (Huffman and Powell, 1970; Judge et al., 1974; Molonon et al., 1976; Bowers and Engler, 1975; Seideman et al., 1977), there is little information on the effect of particle size of soy protein on the properties of chicken sausages.

Microwave ovens are extensively used as a rapid method for cooking. The most successful uses to date have been for cooking small uniform pieces of meat. Microwave ovens were used to reheat the chicken summer sausages in this study.

This research was undertaken to investigate: (1) the properties of summer sausages made from pork with hand deboned chicken meat added; (2) the effect of added soy protein on the properties of summer sausages; (3) the effect of particle size of protein (flour, minced or chunk) on the pork and chicken summer sausages; and (4) the effect of reheating (pan-frying and microwave oven) on the sensory properties of pork and chicken summer sausages.

REVIEW OF LITERATURE

Sausage is one of the oldest forms of processed food but, when or where it was developed is unknown. The word "sausage" is derived from the Latin "salus" meaning salted or preserved meat (Kramlich, 1971).

Sausage is comminuted meat and is usually formed into a symmetrical shape. Products differ primarily because of variations in how they are spiced and the methods of processing. Sausages may be loosely classified into three categories: fresh; cooked; and smoked and dry. Some sausages, especially the dry and semi-dry, depend upon bacterial fermentation for the production of their characteristic "tangy" flavor. The pH of such sausages usually range from 4.8 to 5.4 depending upon the tanginess desired.

Semi-dried sausages are called summer sausages because originally they were made in winter for summer consumption before the development of refrigeration. Summer sausages generally are heated in the smokehouse to an internal temperature of at least 63°C. This is necessary especially if they contain uncertified pork (pork which has not been certified by USDA as being free of trachiae).

The basic stages of sausage making involve preparation of the meat emulsion (mixing meat and salt together); addition of curing, seasoning ingredients, and starter culture; fermentation; stuffing into casing; smoking and thermal processing.

Preparation of the meat emulsion

Fat emulsification no doubt plays a large role in the formation of a good sausage emulsion, and subsequently a good finished product (Baker et al., 1969). In preparing sausage, the protein and water of meat functions to encapsulate the fat portion. A meat emulsion has the characteristics of an oil-in water emulsion (Kramlich, 1971). Investigation of meat emulsions (Hanson, 1960) indicated that fats exist in the emulsion partly in the form of dispersed fat globules enclosed in matrices formed by protein molecules. The factors which influence formation and stability of emulsions have been investigated. Hanson (1960), Swift et al. (1961), and Helmer and Saffle (1963) showed that salt-soluble protein is the major emulsifying agent in sausage emulsions. Salt-soluble protein can be extracted from the cell by salt together with mechanical agitation, such as chopping or mixing. Saffle and Galbreath (1964) studied the quantity of salt-soluble protein in various cuts of pork and beef and found that skeletal tissue was superior to smooth tissue and pork-cheek meat was the best. Kramlich (1960) mentioned that collagen did not dissolve and form a stable protein matrix around fat globules as did salt-soluble proteins. Maurer and Baker (1966) investigated the relationship between collagen content and emulsifying capacity of poultry meat and found collagen to be a detriment to emulsifying capacity. Hudspeth and May (1969) studied various parts of the poultry carcass and indicated that skin was the least desirable tissue in emulsification properties. Swift and Sulzbacher (1963) studied factors affecting meat protein as emulsion stabilizers and reported that salt-soluble protein increased as concentration of sodium chloride increased and that NaCl increased emulsifying capacity of water-soluble proteins by unfolding their structure to enclose a fat globule membrane. Other than meat, salt is the most critical ingredient in sausage manufacturing. The correct proportion of salt in meat sausage products is 2.5-3% (Rust, 1977).

Length of chopping time is known to influence emulsion stability (Pepper and Schmidt, 1975). If excess chopping occurs, the fat particles become smaller in size and total surface of the fat particles increase enormously. An uncoated or partially coated particle will simply be separated from the emulsion on heating in the smokehouse and a fat cap will form within the sausage mass.

Fat contributes greatly to the palatability of sausages. The source and composition of fat is important in obtaining good emulsions. Townsend et al. (1968) suggested that melting characteristics of meat fats could be the basis for differences in the maximum temperature at which meat formulas should be emulsified. Swift et al. (1961) mentioned that coordination of sufficiently rapid addition of fat most effectively increased emulsifying capacity.

Starter culture and effects of fermentation

The manufacture of fermented sausage has been described as an "art" and has traditionally been practiced by only a few specialists (Kramlich, 1971). Early processes required approximately 3-5 days for fermentation. The fermentation was accomplished by the lactic acid bacteria present as a part of the natural meat flora, introduced from the equipment, or introduced by adding back part of a freshly fermented meat batch (Deibel et al., 1961a,b; Everson, 1970; Niven, 1960). Production failures, such as the development of off-flavors and casing "explosion" were not uncommon when uncontrolled fermentations occurred (Jensen, 1954). Jensen and Paddock (1940) first introduced starter cultures for meat fermentation. The bacteria which have been proposed for starter cultures are Pediococcus cerevisiae (Deibel and Niven, 1957), and a number of species of Lactobacillus (Jensen and Paddock, 1940). Pediococcus cerevisiae belongs to the lactic acid group of bacteria and is homofermentative, thus producing largely lactic acid from sugar fermentation. The culture has achieved success as a starter culture for a number of fermented sausages, especially the semi-dried varieties.

The primary advantage of using a starter culture lies in the uniform quality which can be achieved from batch to batch. Pediococcus cerevisiae was proposed as a starter culture in 1958 by the American Meat Institute Foundation. Starter cultures of Pediococcus cerevisiae are currently available as a frozen concentrate and are used at the rate of 2 oz per 100 lb of meat (Everson et al., 1970; Anonymous, 1972). Using the frozen concentrate, fermentation time requirements have been significantly reduced to 18-24 hr (Everson et al., 1970). These fermentation organisms grow best at temperatures of 27°C to 38°C. They are rendered inactive at about 49°C. The growth of the starter culture is limited by the acidity produced in the product. Kramlich (1971) stated that sausage pH, not time, was the chief factor determining the length of the ripening (fermentation) period.

Acton et al. (1972) reported that fermentation of summer sausage at either 22°, 30°, or 37°C did not significantly effect product flavor although less lactic acid was produced at 22°C than at 30° or 37°C. A longer lag phase for growth initiation of the lactic acid bacteria occurred at the lower temperature. Sajber et al. (1971) found that enzymes from the meat and from the bacterial starter cultures alter proteins in fermented sausage production, and they related that to the increase in free amino acids, thus showing a decrease in protein nitrogen. Wardlaw et al. (1973) studied changes in meat components during fermentation of a summer sausage and found no significant ($P<.05$) change in the quantity of moisture, protein, and fat, and that the sausage pH decreased from an initial value of 6.05 to 4.58 during fermentation, reflecting the production of lactic acid by the starter culture. An acid content of 0.5 to 1.5% is generally reported (Acton and Keller, 1974).

As the pH drops as a result of acid production, the meat approaches the iso-electric point, and hence is in a much better position to lose moisture, thus speeding up the drying process. The sausage became firmer as the pH dropped (Klement *et al*., 1973).

Changes in pH can affect both water binding capacity and emulsifying ability of meat (Hellerdorn, 1962; Swift and Sulzbacher, 1963). Hamm (1964) reported that a lower pH decreased the negative charge of muscle proteins thus decreasing the water-holding capacity of meat. Trautman (1964) developed a system to study the effect of pH on muscle protein extracts. He found the effect of decreasing pH was linear on the solubility of both water-soluble and salt-soluble proteins. Saffle and Galbreath (1964) reported that any rise in the pH would result in an increase in the amount of protein which could be extracted. In actual practice, higher pH values have been found to increase the water binding capacity and emulsifying ability of red meats used in sausage manufacture, while low pH tend to "sort out" meat which reduces its emulsifying qualities (Sair, 1965). Vadehra and Baker (1970) reported that at a lower pH, the cooking loss of the meat was much higher.

Regarding the effect of pH on quality of chicken frankfurters, Baker *et al*. (1970) showed more fat could be emulsified at higher pH, but tenderness of frankfurter was less. Samples below pH 5.4 were too soft and mushy to be cut up for serving. Acton and Deller (1974) studied the effect of fermented meat pH on beef summer sausage properties. They found that water holding capacity of sausage mixes during the fermentation phase rapidly decreased as sausage pH decreased, reaching a minimum at pH 5.2.

An increase in water holding capacity of from pH 5.2 to pH 4.6 was attributed to the combined effect of pH reduction and remaining functional protein.

Effect of smoking and heating on sausage

Smoking is generated by burning wood or sawdust. The combination of heat and smoke is usually effective in reducing significantly the surface bacterial population of the product. Surface dehydration, protein coagulation, and the deposition of a resinous material resulting from the condensation of formaldehyde and phenol produce a reasonably effective chemical and physical barrier against microbial growth and penetration of the finished product (Kramlich, 1971 and Rust, 1977).

The smoke flavor is largely due to phenol. During smoke generation, the greater the degree of oxidation of the smoke, the greater the quantity of organic acids and phenol and hence the better the quality of the smoke (Rust, 1977). The brownish color contributed by smoke is due to the carbonyl compounds in smoke. Those combine with free amino groups from the meat protein to form furfural compounds, which are brown in color (Kramlich, 1971).

Salt-soluble, heat coagulable protein (contractile proteins) are in a liquid form in the muscle. When extracted, the contractile proteins form a sticky substance, which help "glue" the chunks of meat together. Upon heating, those proteins coagulate, and thoroughly bind the pieces of meat together. Vedehra and Baker (1970) reported that poultry meat will not bind properly following heat denaturation. Kramlich (1971) reported that smokehouse loss resulted from fat drained and moisture loss during smoking and cooking. Wardlaw et al. (1973) reported that there was no significant change in the total N during fermentation and heat processing of the sausage. Saffle et al. (1964) reported that skin strength was developed by a migration of protein to the surface of frankfurters and subsequent denaturation during smoking.

Kako (1968) and Krylova et al. (1962) observed a decrease in pH of smoked meat. The pH of muscle tissue of various meat and poultry increased during heating (Hamm et al., 1960; Kauffman et al., 1964; Paul et al., 1966). Hamm (1965) suggested that increase of pH occurring during heating of meat may be caused by charges or hydrogen bonding or both within the myofibrillar proteins. The decrease of pH during smoking of meat may be caused by the penetration of smoke components, such as organic acids.

Soy protein in meat systems

Soy protein products have a long history of usage by the meat industry. They are considered a desirable addition to processed meat for several reasons. They have emulsifying and binding ability, they have an affinity for the meat juices. This not only results in less cooking loss, but the resulting product is more juicy and flavorful (Kiseph, 1974).

Four specific products are available for use by meat processors: soy flour, soy grits, soy protein concentrate, and isolated soy protein. The protein content of soy flour and grits varies from 40 to 60%. Soy protein concentrate is 70% protein while isolated soy protein contains approximately 90% protein.

Researchers have shown that increasing the amount of textured vegetable protein in ground beef mixtures decreased total cooking losses as compared with a 100% ground beef control (Yoon et al., 1974; Bower and Engler, 1975; Smith et al., 1976). Anderson and Lind (1975) found, in cooked beef patties, higher moisture retention and low fat retention to be directly proportional to the percent of textured vegetable protein in the mixture. According to Bauman (1972), the combination of 30% hydrated, fortified textured soy protein, with 70% ground turkey meat, resulted in 50% less cooking loss, but a definite soy flavor.

Huffman and Powell (1970) reported that ground beef patties containing 2% soybits were significantly ($P<.05$) more acceptable by the taste panel and had significantly ($P<.01$) higher tenderness scores than those with no soy.

Cunningham (1977) found composition of chicken patties varied with increasing flaked textured vegetable protein (FTVP). Protein was slightly increased; however, fat decreased.

The effect of particle size, percentage of textured soy protein (TSP) on cooking and sensory properties of chicken-soy patties were evaluated by Moloncn et al. (1976). Particle size had no effect on total cooking loss or moisture content. Minced particles with more surface area than other forms should absorb more moisture, but if surface area of all TSP forms were adequate to retain available moisture, the difference would not be detected. Drip loss was significantly lower ($P<.05$) for patties containing minced TSP particles than for those containing flake or chunk particles. Perhaps, larger surface area enabled minced TSP to bind more lipids than flake or chunk TSP. Patties with flake or chunk TSP particles scored higher in meat flavor ($P<.05$) and firmness ($P<.01$) than those with minced TSP particles. Total cooking loss decreased as soy increased ($P<.01$).

Soy flour, the finely ground soy protein, has been used in cooked sausage for several years. It was recognized early that soy flour has the advantage of holding both the meat juices and the fat. In federally inspected plants, soy protein is permitted alone or in combination up to 3.5% in sausage (Kiseph, 1974).

Tenderness and juiciness of sausage

The tenderness and juciness of sausage are considered by the consumer to be the most important quality characteristics. Tenderness of meat is a complex sensation. It is determined principally by the mechanical strength of the muscle fibers and connective tissue. However, the sensation of tenderness or toughness may also be influenced by the juiciness of the meat, the water-holding capacity of the proteins, and the amount and distribution of fat (Briskey and Kauffman, 1971). The force required to shear animal muscle has been extensively used as a measurement of tenderness. Presently, the Warner-Bratzler and L.E.E.-Kramer shear presses are the most widely used physical method of measuring the shear force of muscle. According to Sharrah et al. (1965), sensory scores for tenderness correlated better with the Warner-Bratzler than with the L.E.E.-Kramer instrument. Warner-Bratzler shear measures the amount of force required to shear through a sample core of meat of a specific diameter.

Juiciness of meat was related to amount of water and by the ease with which it can be expressed from meat as it is chewed (Briskey and Kauffman, 1971). In most of the methods for determining water holding capacity, water is released by pressing the sample between two plates (e.g., the "filter-paper" press method) (Hamm, 1975). Pearson (1960) stated that the best method for evaluating juiciness was by panel evaluation. Baker et al. (1969) mentioned that juiciness was not necessarily related to the amount of expressible or free liquids in the product.

The tenderness and juiciness of comminuted meat is influenced by the level of fat and/or moisture in relation to meat protein (Mills et al., 1958).

Firmness in a sausage product is dependent on the amount of lean meat in the formulation. Fat tends to soften the product and make it more tender (Kiseph, 1974). To comply with federal government regulations, moisture in finished cooked sausages must not exceed four times the meat protein (by analysis) plus 10%. The fat and moisture contents of cooked sausages such as frankfurters, bologna (from beef and pork), were varied.

It was reported that increasing proportions of fat or moisture were related to increases in juiciness and tenderness (Kramlich, 1971). Juiciness and tenderness varied more with changes in moisture content than in fat content and appeared to be principally dependent on the former (Swift et al., 1954). Simon et al. (1965) devised a method for measuring "toughness-firmness" of the frankfurters and they reported that firmness of the frankfurter increased as the meat protein content was increased.

A frankfurter made from chicken, generally has a somewhat softer texture than one made from red meat, and lacks "snap." In an attempt to ascertain the reason for this difference, the effect of various levels of skin on the quality of those products was studied (Baker et al., 1968). They found that skin apparently was not the principal reason for this difference in texture. Baker et al. (1969) investigated the influence of different levels of fat and protein and type of fat on the quality of chicken franks. They found that beef fat and cottonseed oil produced significantly firmer frankfurters than chicken fat when unheated but not when heated; as the level of fat in the formula was increased, the frankfurters became less tender when raw and less juicy regardless of the type of fat used; and increasing the level of protein from 9 to 18% produced significantly firmer frankfurters as determined by taste panel and Kramer shear press. Dhillon and Maurer (1975a) evaluated the quality of summer sausages from hand deboned chicken meat (HDCM) and beef with different proportions and found that the HDCM/beef combination, of a 15/85 ratio, provided firmer texture than the pure beef sausage; and the ratio of 65/35 also had a reasonably acceptable texture. Summer sausages containing 66.7% turkey and 33.3% pork were as acceptable as those comprised of the usual 90% beef, 10% pork combination (Korschegen and Baldwin, 1978).

Influences of microwave cooking on the quality of chicken items

The microwave oven supplies energy as electromagnetic waves. The alternating electric field causes vibration of the polar molecules in the food and the molecular motion heats the food. Vedehra (1970) compared total weight loss of microwave cooked whole chicken and conventionally cooked whole chicken and he found there was a nonsignificant difference between these two cooking methods. A shallow open pan will maximize evaporation and surface changes in the sample (Paul, 1975). Cooking losses were significantly less in most products reheated in a microwave oven as compared to the deep fat fryer or pan-frying method. Reheating methods did not influence flavor or texture score of chicken weiners (Cunningham and Lohmeyer, 1973). Shear press values of patties cooked by pan-frying were significantly greater than for those cooked by microwaves (Cunningham, 1977).

MATERIALS AND METHODS

Sources and portions of meat

Fresh pork (shoulder) and baking hens[1] were purchased from a local supermarket. Both products were deboned, cubed, and then coarsely ground once through a 3/8 in.-plate, mixed, and reground through a 1/8 in.-plate using a Hobart meat grinder. Wing tips and giblets were discarded but the adhering skin was retained. All ground meat was packed in polyethylene bags and held in a freezer at -18°C until used for sausage making and proximate analysis (pH, moisture, fat, and protein).

Sausage preparation and processing

A summer sausage formulation (Table 1) developed at Kansas State University was used in this study.

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[1] Snow Hills baking hens, obtained from Matu Inc., Walter Valley, Miss.

THIS BOOK CONTAINS NUMEROUS PAGES WITH DIAGRAMS THAT ARE CROOKED COMPARED TO THE REST OF THE INFORMATION ON THE PAGE.

THIS IS AS RECEIVED FROM CUSTOMER.

Table 1

Summer sausage formulation

Ingredients	Quantity (g)
Meat[1]:	1135
Pork meat	
Chicken meat	
Pork fat[a]	
Flour soy protein[b]	
Minced soy protein[c]	
Chunk soy protein[d]	
Curing agents:	
Sodium erythrobate[2]	1
Prague powder[2]	1.3
Salt	31.75
Seasonings:	
Coarse ground pepper	3.75
Whole mustard seed	0.7
Ground coriander	1.4
Ground nutmeg	0.35
Ground allspice	0.35
Starter materials:	
LACTACEL-43991 (diluted)[3]	2.5
Dextrose	50

[1]The percentage of each ingredient is presented in Table 2.

[1a] Used to adjust the fat level of meat portion.

[1b] Toasted nutrisoy flour, Archer Daniels Midland Co., Decatur, Ill.

[1c] TVPU-118 minced 180, Archer Daniels Midland Co., Decatur, Ill.

[1d] TVPU-110 chunk 10, Archer Daniels Midland Co., Decatur, Ill.

[2]Dissolved in 30 ml H_2O.

[3]A frozen concentrate of _Pediococcus cerevisiae_ prepared by Merck and Co., Rohway, N.J. A culture suspension was prepared by diluting 2.5 g concentrate with 30 ml H_2O.

Sixteen products were prepared by combining various proportions of chicken meat (0, 25, 50, 75%) and pork, with or without 3% soy protein. Three types of soy protein[2] were used; flour, minced, or chunk. Quantities of salt, curing agents, seasoning agents, dextrose, and starter culture were the same for all sixteen batches. Percentages of pork, chicken, and soy protein are shown in Table 2.

Based on the fat concentration of the raw pork and chicken (Table 3), pork fat[3] was added to each batch to adjust the fat concentration of the blended raw pork and chicken to 25%.

Soy protein was rehydrated 1:3 with water and added to the meat portion. The meat was placed in a Kitchen Aid Model K 4-B mixer, salt was sprinkled on the meat, and the blend mixed at speed 4 for 3 min. During an additional 2 min of mixing, sugar and seasonings were sprinkled onto the meat, and solutions of prague powder[4] and erythrobate were added. LACTACEL-43991[5] (a frozen concentrated starter culture of _Pediococcus_ _cerevisiae_) was added by sprinkling over the meat and then mixing at speed 2 for 2 min.

After each lot was thoroughly mixed, the sausage mixes were held in an incubation room at 32°C for fermentation. They were frequently stirred with a rubber spatula (to shorten the fermentation period) until the pH reached 4.9 (this required about 18 hr). They then were placed in a cooler (4°C) to stop the growth of lactic acid bacteria. Each sausage preparation was then stuffed into Visking Nojax casings[6], size 25, with a mechanical stuffer. The sausage was transferred to a smokehouse, smoked at 68°C to an internal temperature of 63°C (about 2 hr). At the conclusion of smoking, all sausages

[2] Obtained from Archer Daniels Midland Company, Decatur, Ill.

[3] Obtained from the meat lab, Animal Sciences and Industry, Kansas State University.

[4] A commercial form of nitrite, contains 6.25% nitrite.

[5] Prepared by Meck and Company, Rahway, NJ.

[6] Union Carbide, Chicago.

Table 2

Percentage of ingredients in meat portions.

Treatment	Pork	Chicken	Flour soy	Minced soy	Chunk soy
1	100				
2	75	25			
3	50	50			
4	25	75			
5	97		3		
6	72.75	24.25	3		
7	48.50	48.50	3		
8	24.25	72.75	3		
9	97			3	
10	72.75	24.25		3	
11	48.50	48.50		3	
12	24.25	72.75		3	
13	97				3
14	72.75	24.25			3
15	48.50	48.50			3
16	24.25	72.75			3

Table 3

Composition of deboned chicken and pork meat.

	Chicken	Pork
pH	6.1	6.2
Moisture %	64.4	58.4
Fat %	16.7	25.0
Protein %	17.3	14.6

Each value is the mean of six observations.

were chilled in a cooler overnight and then stored at -18°C until samples of each batch were taken for analysis and/or reheating in a microwave oven (95 sec) or by pan-frying (4 min) for shear press, Carver lab press, and sensory evaluation.

Proximate analysis

Percentage of moisture, fat, and protein were determined (AOAC, 1975) for pork, chicken meat, and each batch of finished sausage. Moisture content was determined using a drying oven technique, fat by the ether extractables method (Soxhlet), and crude protein by the Kjeldahl nitrogen method (N X 6.25).

pH determination

The pH was measured periodically during fermentation until a pH of 4.9 was obtained. To determine pH, 10-g samples of the raw sausage blends were mixed with 90 ml of distilled water in a blender (Dhillon et al., 1974). The pH of the slurry was measured with a Coleman Metrion II pH meter.

Smokehouse loss

Loss in the smokehouse was determined by weighing the individual sausages before and after processing and expressing the change as percentage smokehouse loss.

$$\% \text{ smokehouse loss} = \frac{\text{original wt.} - \text{wt. after smoking}}{\text{original wt.}} \times 100$$

Shear press

For shear press determinations, samples reheated in a microwave oven or by pan-frying were cut into approximately 1 X 1 cm pieces and weighed to exactly 2.50 g. A 500 lb ring was attached to the hydraulic ram of a L.E.E.-Kramer shear press, and with the instrument set in the 100-1000 range and a 15 sec downstroke, the total force required to shear each meat portion was recorded electronically and reported as Kg of force/g of sample.

Carver lab press

Meat samples weighing 0.5 g (reheated in a microwave oven or by pan-frying) were placed on a Plexiglass plate and subjected to 1,000 lb pressure for 5 min in a Carver laboratory press. The unit was removed from the press and an outline of the boundary of the spread of meat was made with a soft pencil. The area of the pressed meat sample and the area of the pressed meat plus expressed moisture (juice) were measured with a compensating polar planimeter. The area of expressed moisture was determined by subtracting the area of the meat from the area of the meat plus expressed moisture (Miller and Earrison, 1965).

$$\text{Expressible liquid index (ELI)} = \frac{\text{area of pressed meat}}{\text{area of spread of juice}}$$

The magnitude of the expressible liquid index is inversely related to the amount of liquid expressed from the sample, the larger the value for water holding capacity (WHC), the greater the amount of liquid expressed.

$$\text{WHC} = 1 - \text{ELI}$$

Subjective evaluations

The summer sausages were reheated by two different methods (microwave oven and pan-frying) and were evaluated for flavor, juiciness, tenderness, and overall acceptability by an 8 member experienced preference taste panel. To prevent sample bias, a representative sample (pure pork sausage) was served at the beginning of each panel. Treatments were randomly assigned to order of preparation and serving. The samples were scored on a seven-point Hedonic scale with higher values denoting better quality (Appendix).

Statistical analyses

Analysis of variance was run on all data, and Duncan's multiple range test (1955) was used to determine the significance of treatment (percentage of chicken, types of soy protein, or reheating method) means for the subjective and objective measurements. All computations were run under release 79.2B of SAS at the Department of Statistics, Kansas State University.

RESULTS AND DISCUSSION

It was observed that as pH dropped during fermentation, moisture retention and the capacity to emulsify fat decreased. These observations were consistent with Sair (1965). Loss of moisture and the draining of fat were also observed during smoking and reheating. Similar losses during smoking of fermented sausages (pork and beef) were reported by Wardlaw et al. (1973). Concentrations of moisture, fat, and protein, as well as smokehouse loss of the finished sausages are presented in Table 4 and Fig. 1-4. The physical properties (water holding capacity and shear press) and sensory properties (flavor, juiciness, tenderness, and overall-acceptability) of smoked sausages reheated in a microwave oven or by pan-frying are shown in Table 5 and Fig. 5a-10b.

Effect of altering the chicken to pork ratio

There were significant differences ($P<.01$) in chemical and physical properties of sausages as the chicken to pork ratio was altered (Table 6, 7, and 8).

Calculated amounts of fat in the fresh sausage blends were the same, but the fat retained in the finished sausages after smoking and cooking varied (Table 4). With increasing concentrations of chicken and less pork, irrespective of types of soy protein, fat content of the smoked sausages

Table 4

Moisture[a], protein[a], fat[a], and smokehouse loss[b] of smoked sausages.

Percentage of chicken	Moisture %	Protein %	Fat %	Smokehouse loss %
		No soy protein added		
0	51.64	19.61	26.36	9.43
25	53.56	20.46	24.50	10.61
50	55.37	21.24	22.42	12.36
75	56.43	22.06	19.50	14.56
		Flour soy protein added		
0	52.73	19.77	26.16	8.65
25	54.47	20.57	24.27	10.02
50	55.96	21.38	22.24	11.85
75	56.58	22.18	19.38	14.37
		Minced soy protein added		
0	52.53	19.73	26.12	8.72
25	54.31	20.53	24.34	10.11
50	55.82	21.34	22.28	11.89
75	56.49	22.13	19.43	14.42
		Chunk soy protein added		
0	51.92	19.68	26.22	9.26
25	53.71	20.50	24.40	10.42
50	55.43	21.30	22.32	12.23
75	56.41	22.11	19.46	14.50

[a]The value is the mean of 6 observations.

[b]The value is the mean of 3 observations.

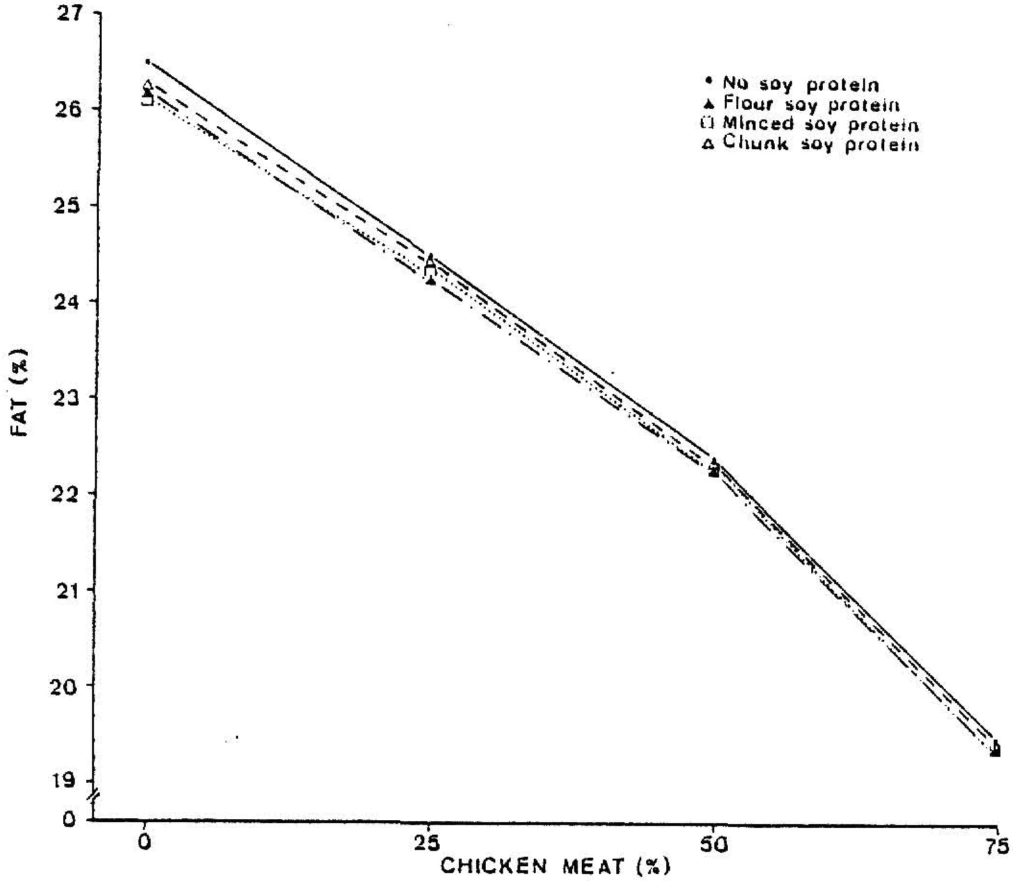

Fig. 1 - Fat content of smoked sausages.

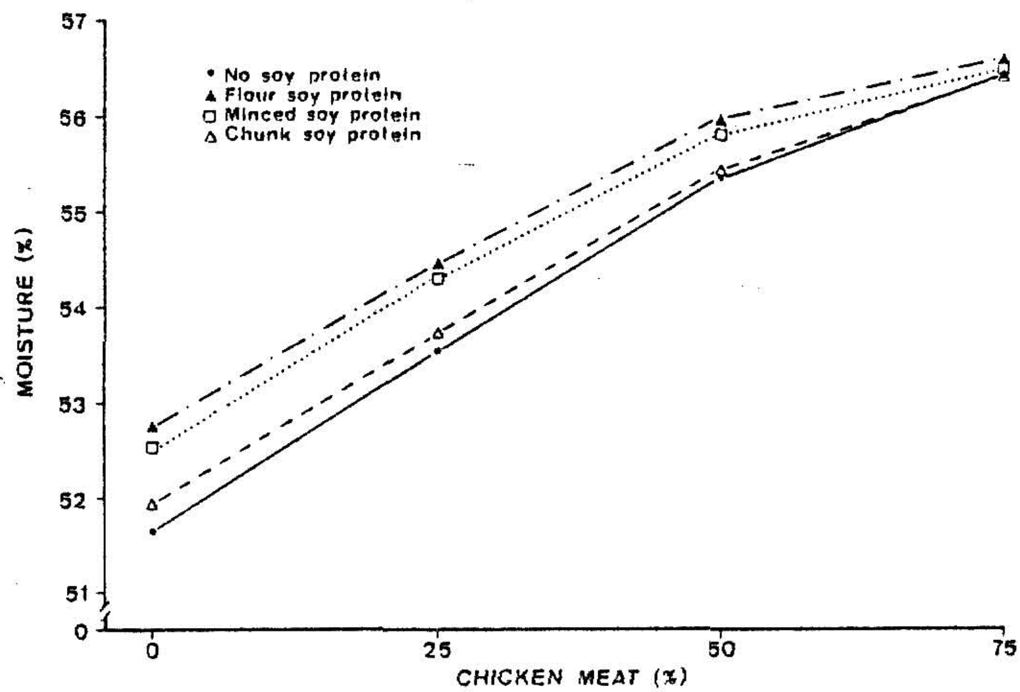

Fig. 2 - Moisture content of smoked sausages.

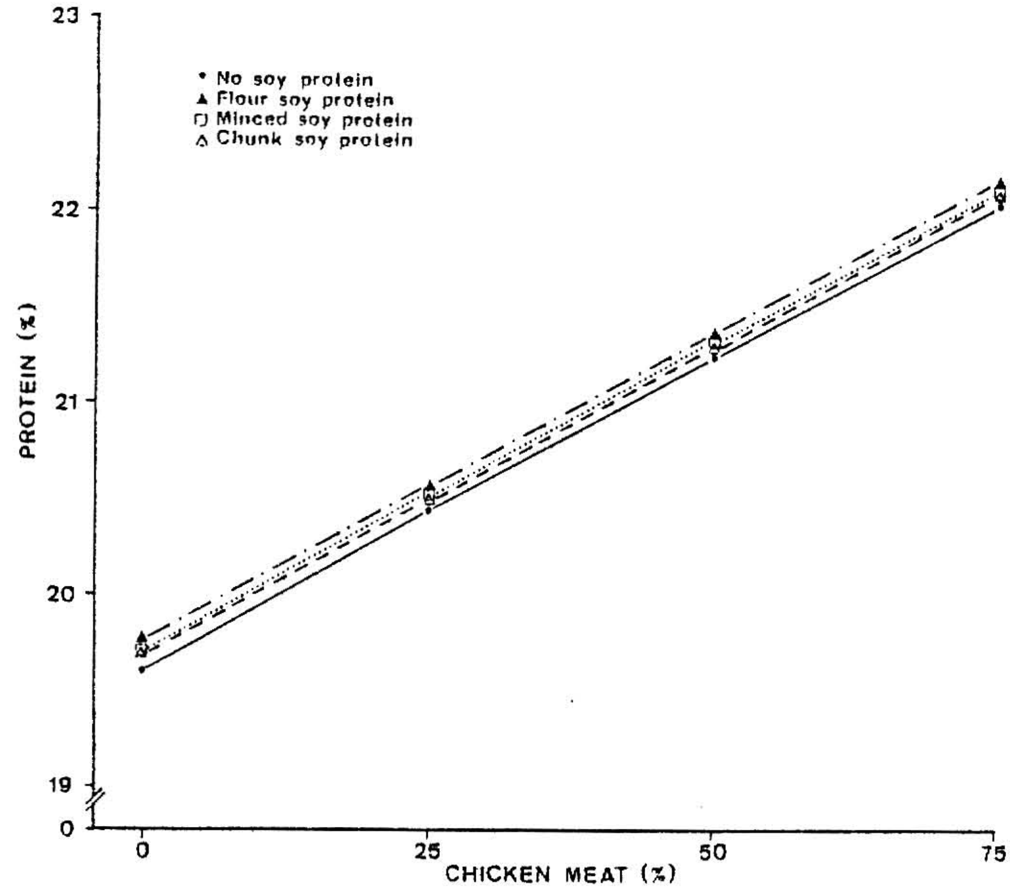

Fig. 3 - Protein content of smoked sausages.

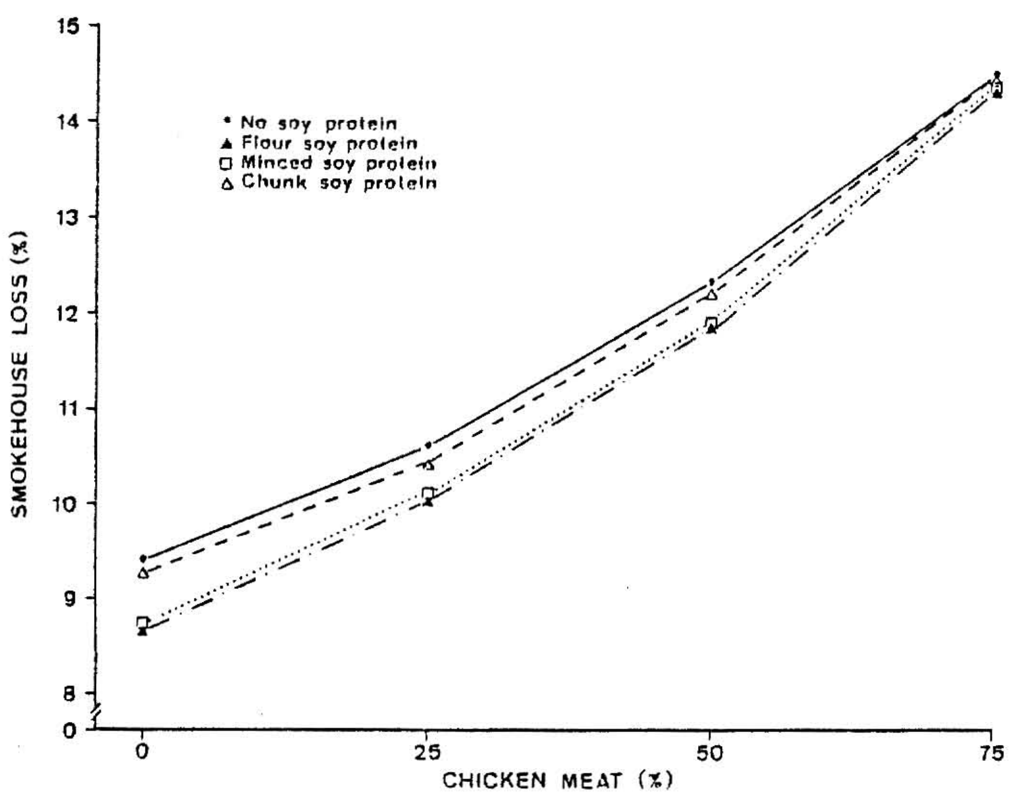

Fig. 4 - Smokehouse loss of smoked sausages.

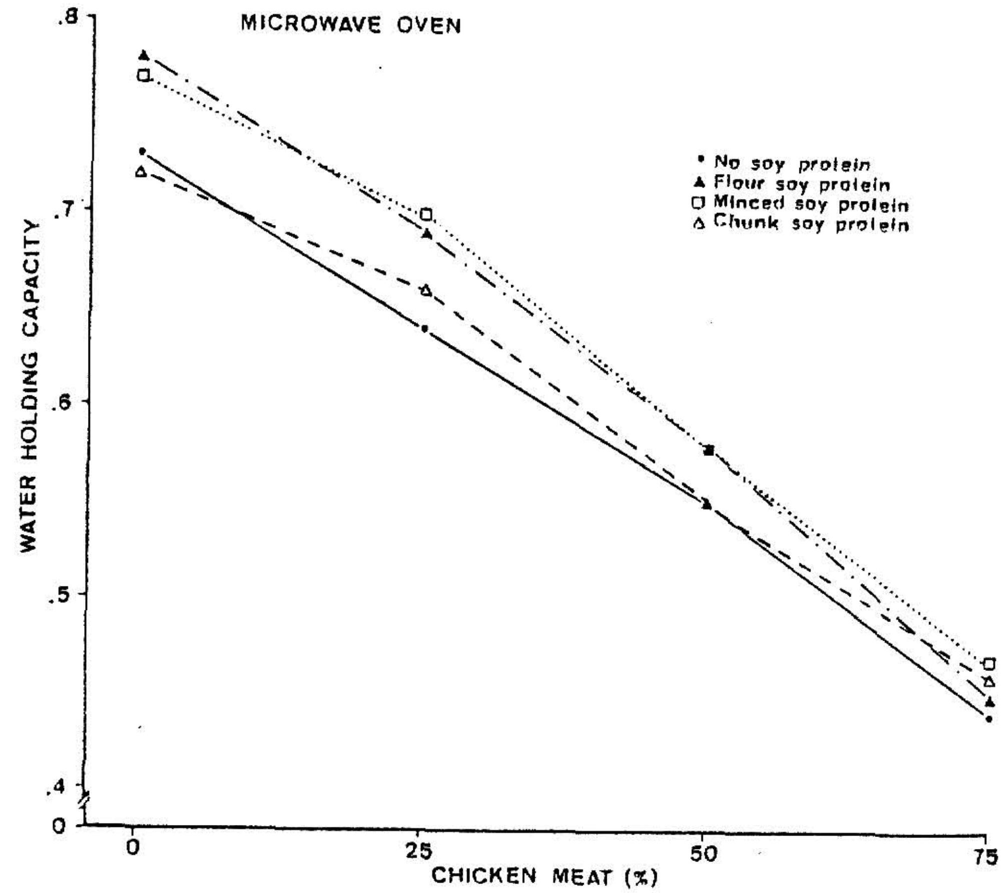

Fig. 5a - Water holding capacity (WHC) of sausages reheated in microwave oven.

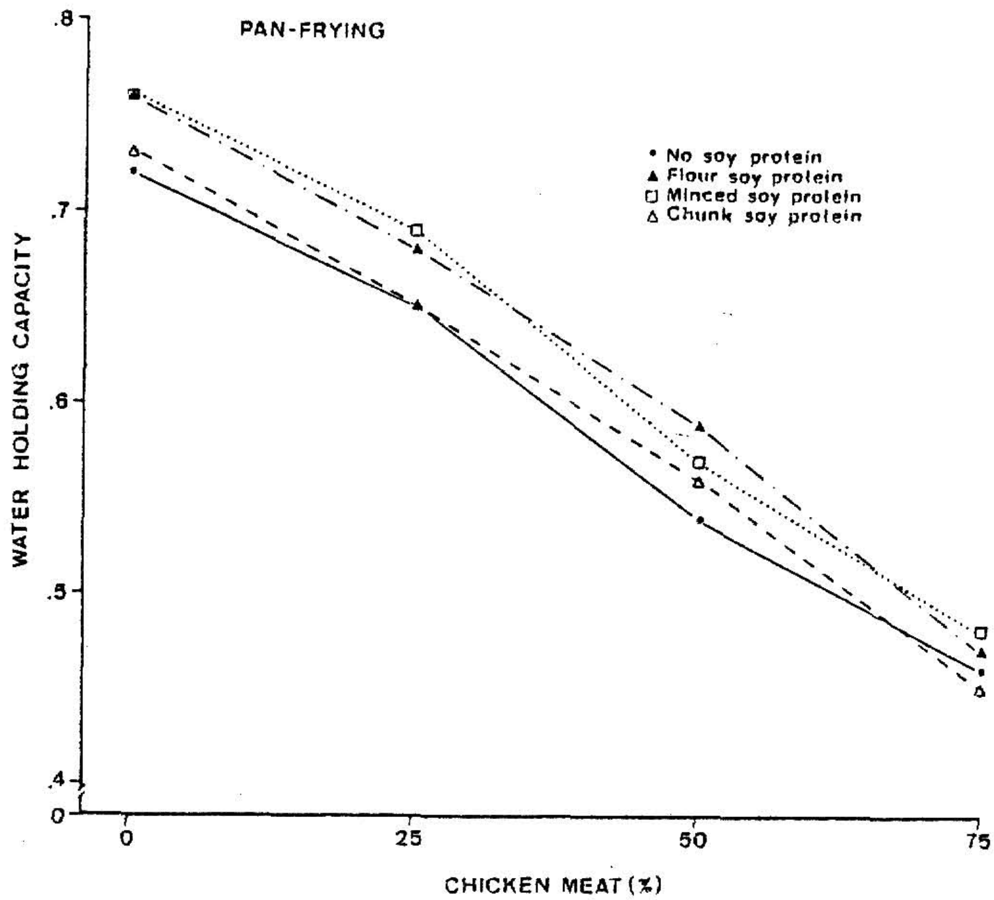

Fig. 5b - Water holding capacity (WHC) of sausages reheated by pan-frying.

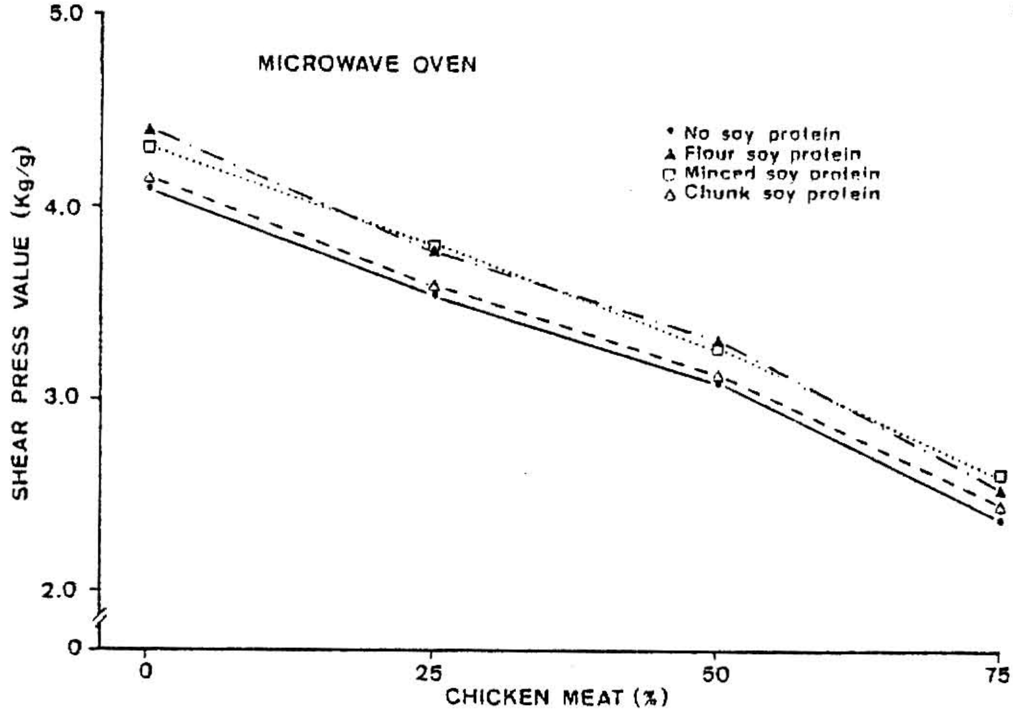

Fig. 6a - Shear press value of sausages reheated in microwave oven.

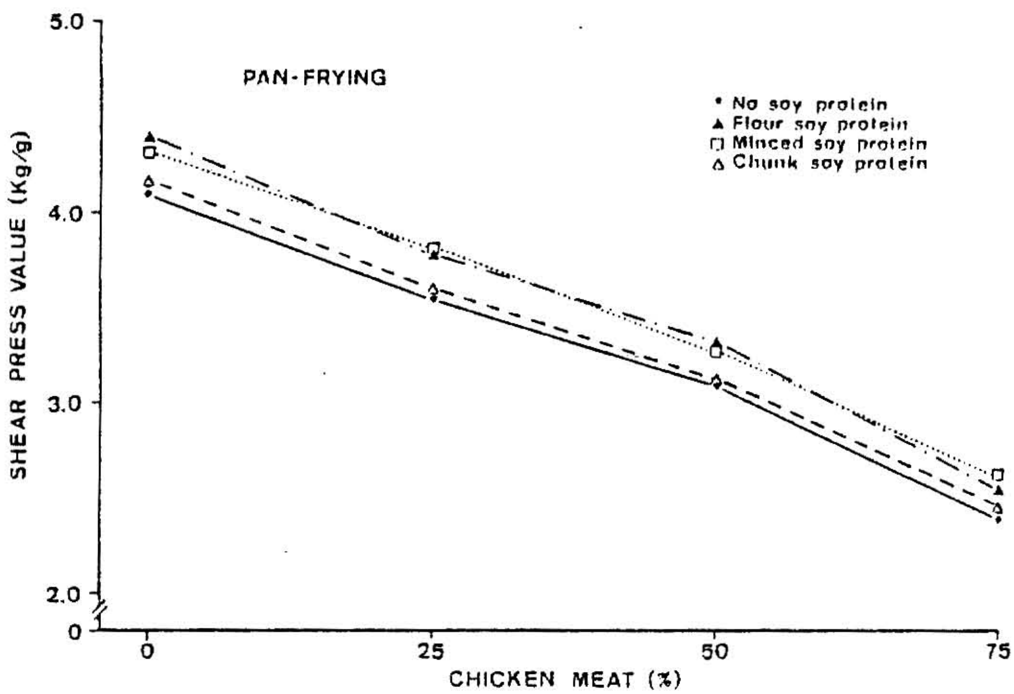

Fig. 6b - Shear press value of sausages reheated by pan-frying.

Table 5

Physical properties and sensory evaluations of finished sausages reheated by microwave or pan-frying.

Percentage of chicken	Objective measurement[a]				Sensory evaluation[b]							
	Shear press (Kg/g)		WHC		Flavor		Juiciness		Tenderness		Overall-accept.	
	Micro.	Pan-fry	Micro.	Pan-fry	Micro.	Pan-fry	Micro.	Pan-fry	Micro.	Pan-fry	Micro.	Pan-fry
					No soy protein added							
0	4.06	4.09	0.73	0.72	6.3	6.3	5.8	5.8	5.2	5.0	6.2	6.3
25	3.43	3.54	0.64	0.65	5.8	5.9	5.5	5.4	5.5	5.3	5.5	5.5
50	3.00	3.10	0.55	0.54	5.3	5.3	5.2	5.1	6.1	5.8	4.7	4.8
75	2.34	2.38	0.44	0.46	4.6	4.6	4.7	4.7	6.7	6.5	3.8	3.9
					Flour soy protein added							
0	4.31	4.39	0.78	0.76	6.2	6.2	5.8	5.9	4.8	4.6	6.1	6.2
25	3.70	3.78	0.69	0.68	5.8	5.9	5.6	5.6	5.2	5.0	5.5	5.6
50	3.26	3.33	0.58	0.59	5.2	5.2	5.2	5.1	5.8	5.5	4.9	4.8
75	2.51	2.55	0.45	0.47	4.5	4.6	4.6	4.6	6.3	6.1	3.9	3.9
					Minced soy protein added							
0	4.29	4.32	0.77	0.76	6.3	6.3	5.8	5.7	4.8	4.6	6.1	6.1
25	3.74	3.80	0.70	0.69	5.9	5.8	5.5	5.5	5.1	4.9	5.5	5.6
50	3.25	3.31	0.58	0.57	5.2	5.3	5.1	5.0	5.8	5.6	4.8	4.9
75	2.54	2.63	0.47	0.48	4.6	4.5	4.6	4.5	6.3	6.0	3.8	3.9
					Chunk soy protein added							
0	4.11	4.16	0.72	0.73	6.2	6.3	5.7	5.8	5.1	4.9	6.1	6.2
25	3.50	3.58	0.66	0.65	5.6	5.6	5.5	5.4	5.5	5.3	5.6	5.7
50	3.04	3.13	0.55	0.56	5.2	5.2	5.1	5.1	6.0	5.8	4.8	4.9
75	2.40	2.45	0.46	0.45	4.5	4.4	4.7	4.6	6.6	6.3	3.8	3.8

[a]The value is the mean of 3 observations.

[b]The value was the mean of 3 observations done by 8 judges in Hedonic scale of 1 through 7, with higher value denoting better quality and 4 being the average acceptable value.

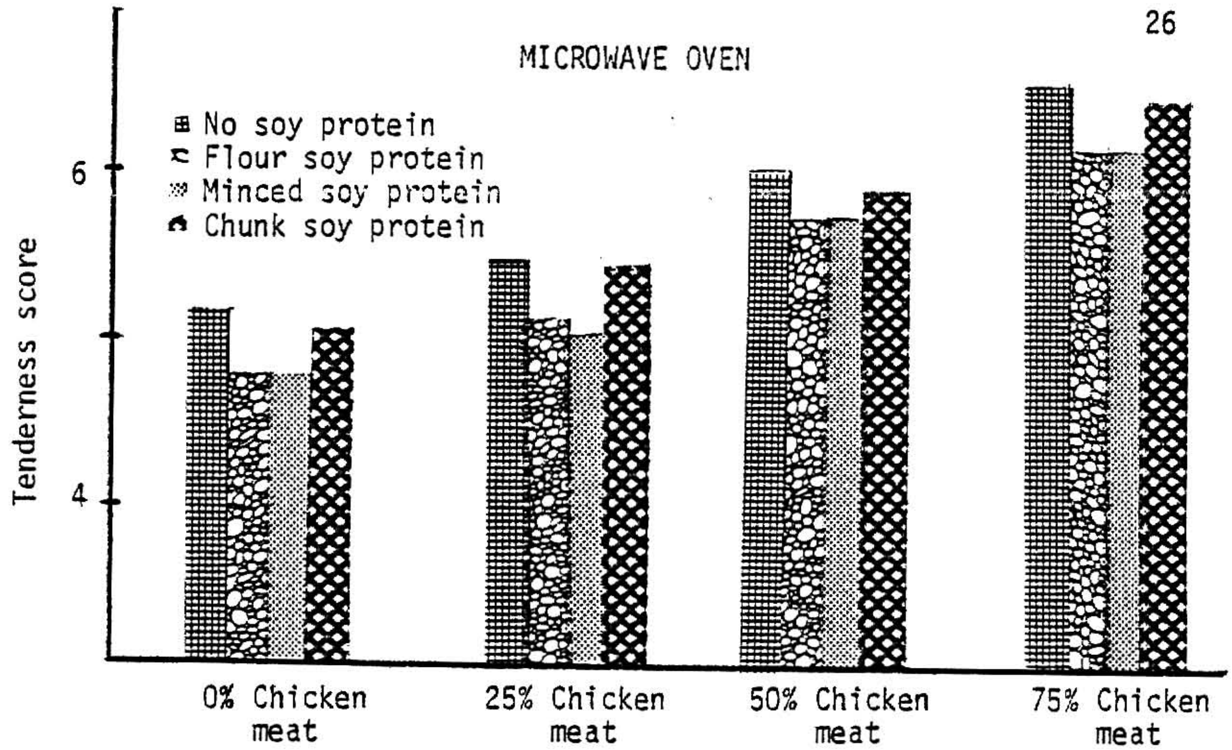

Fig. 7a - Tenderness score of sausages reheated in microwave oven (7-- very tender, 1-- extremely tough).

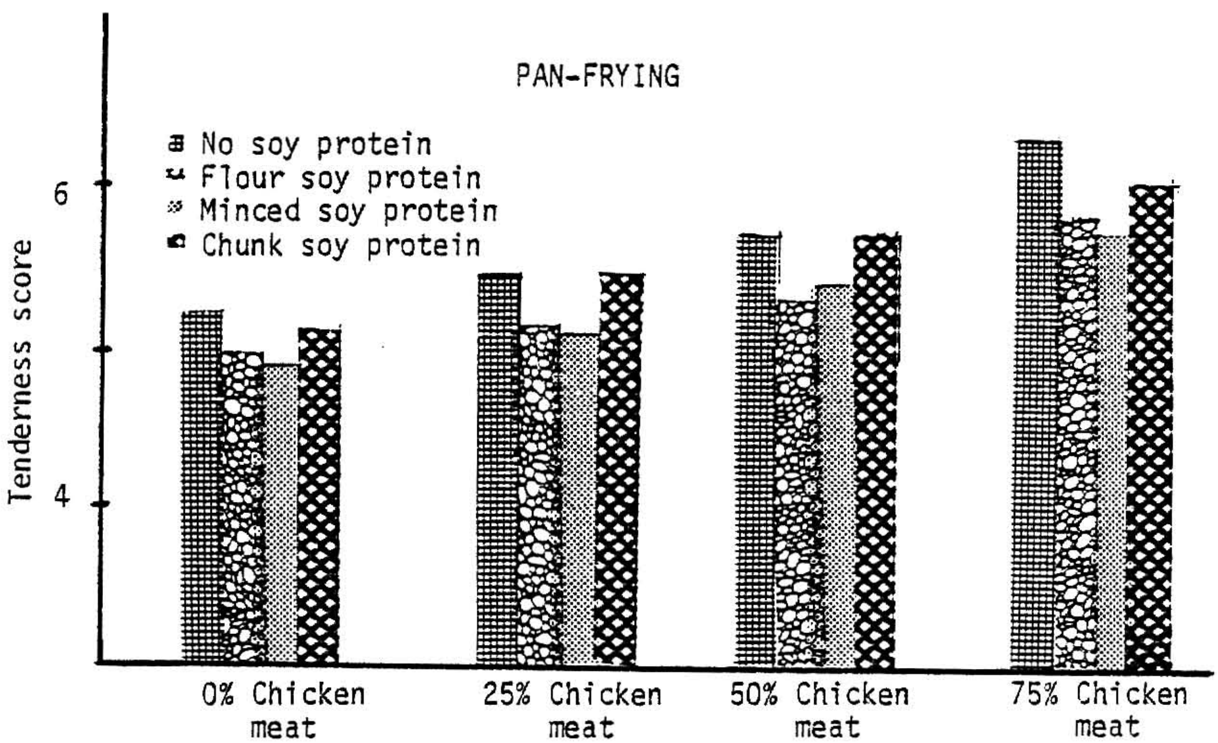

Fig. 7b - Tenderness score of sausages reheated by pan-frying (7-- very tender, 1-- extremely tough).

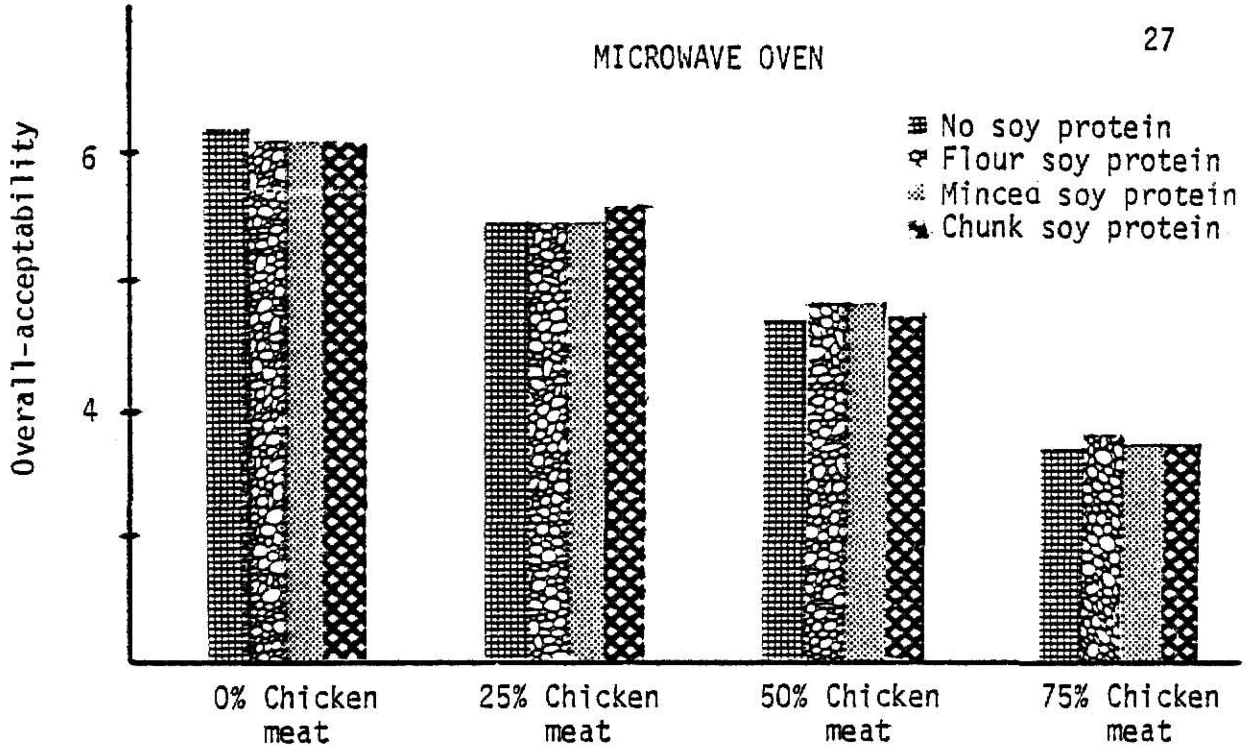

Fig. 8a - Overall-acceptability of sausages reheated in microwave oven (7-- very desirable, 1-- Very undesirable).

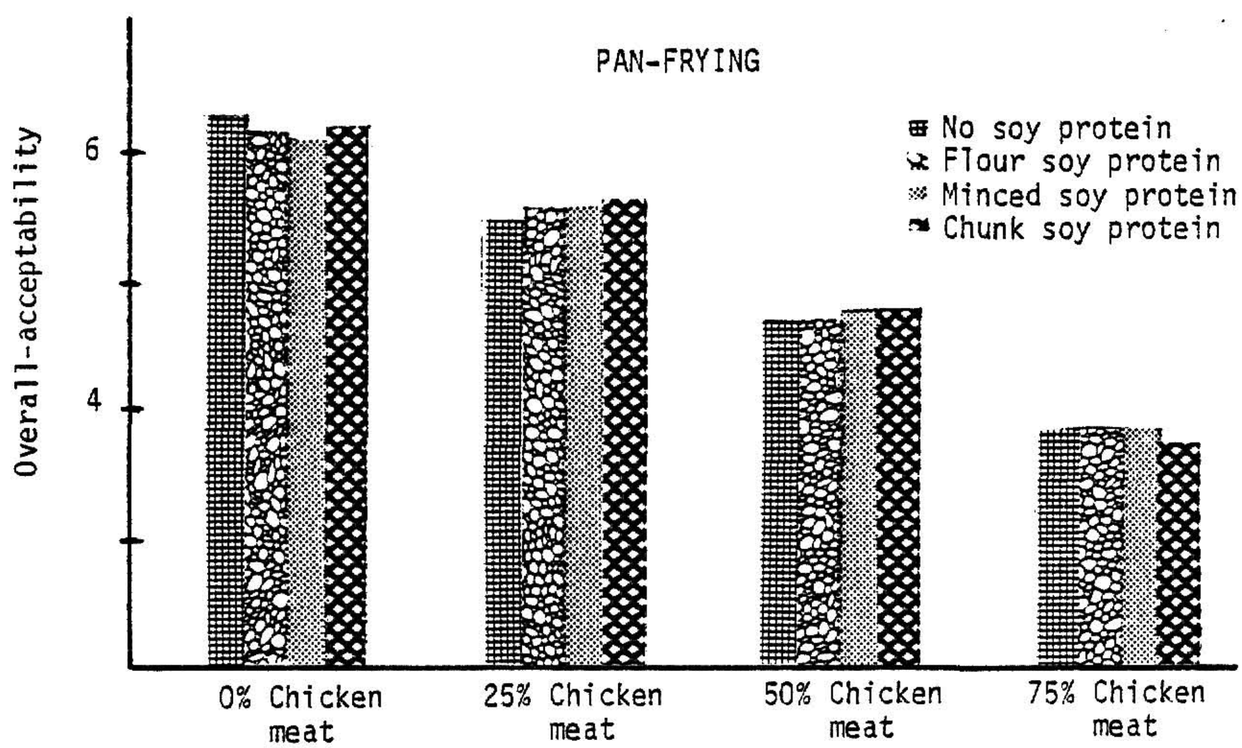

Fig. 8b - Overall-acceptability of sausages reheated by pan-frying (7-- very desirable, 1-- very undesirable).

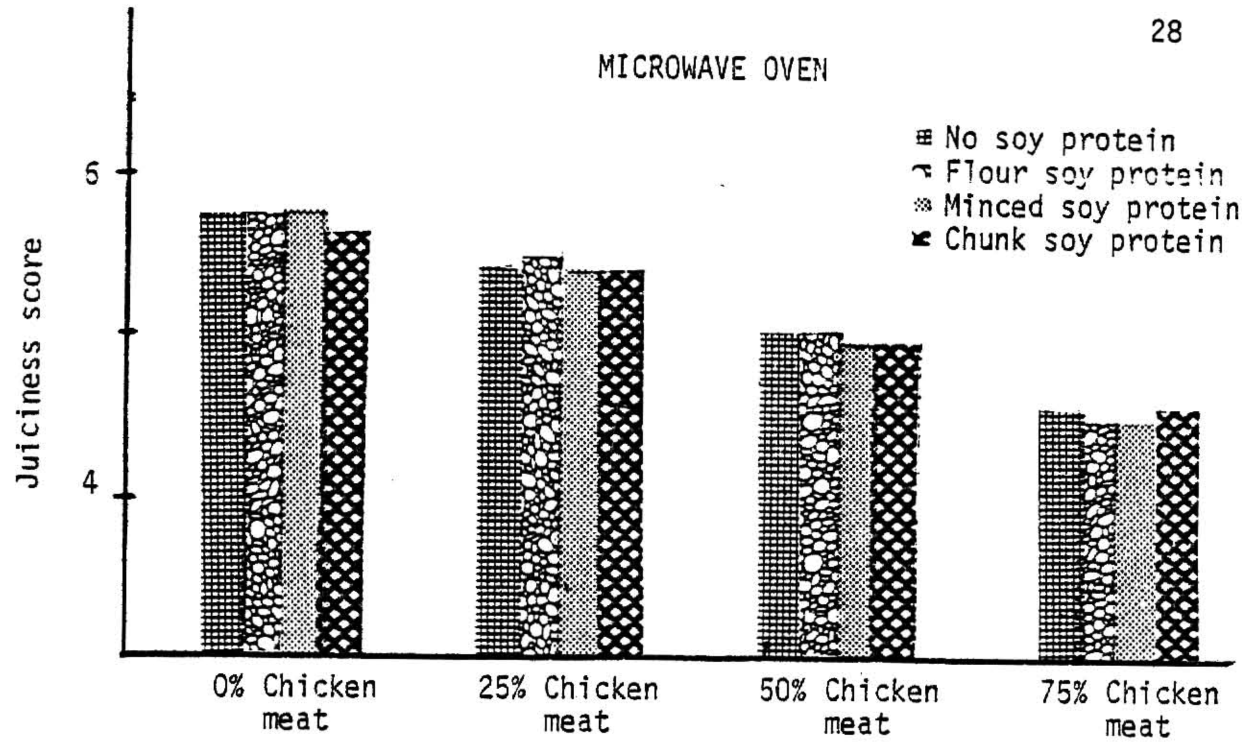

Fig. 9a - Juiciness score of sausages reheated in microwave oven (7-- very juicy, 1-- very dry).

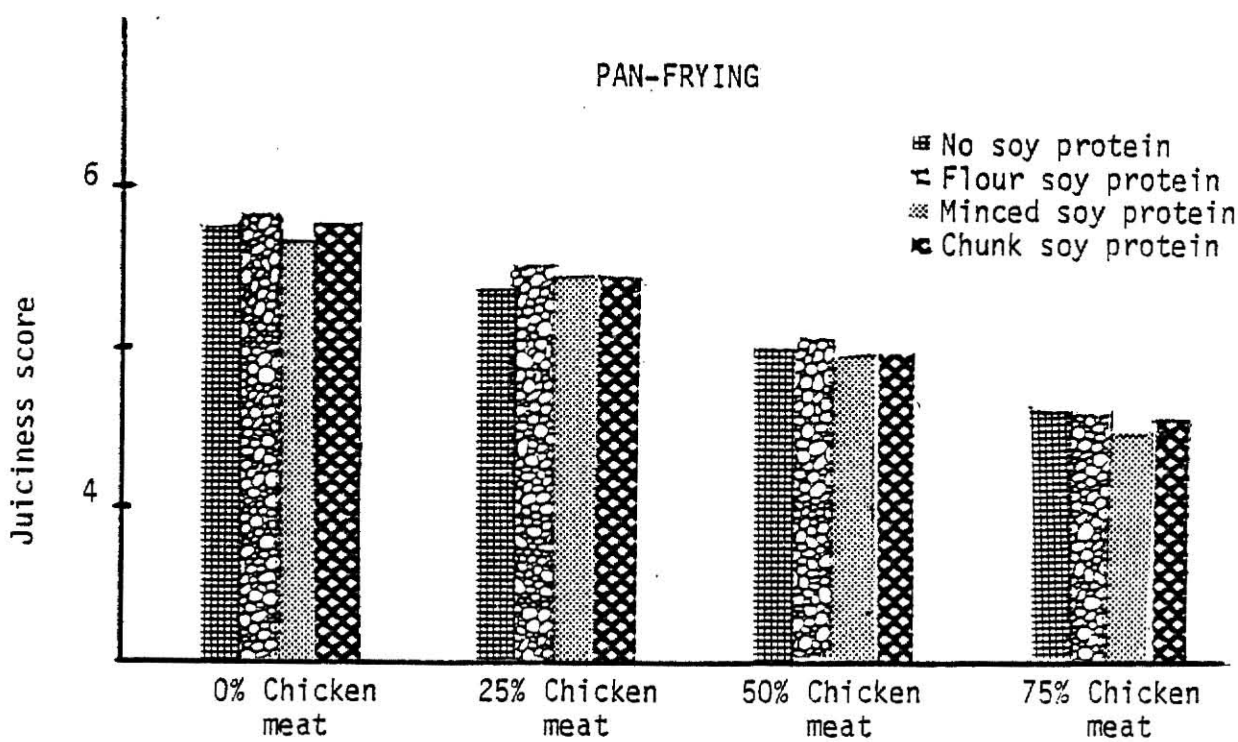

Fig. 9b - Juiciness score of sausages reheated by pan-frying (7-- very juicy, 1-- very dry).

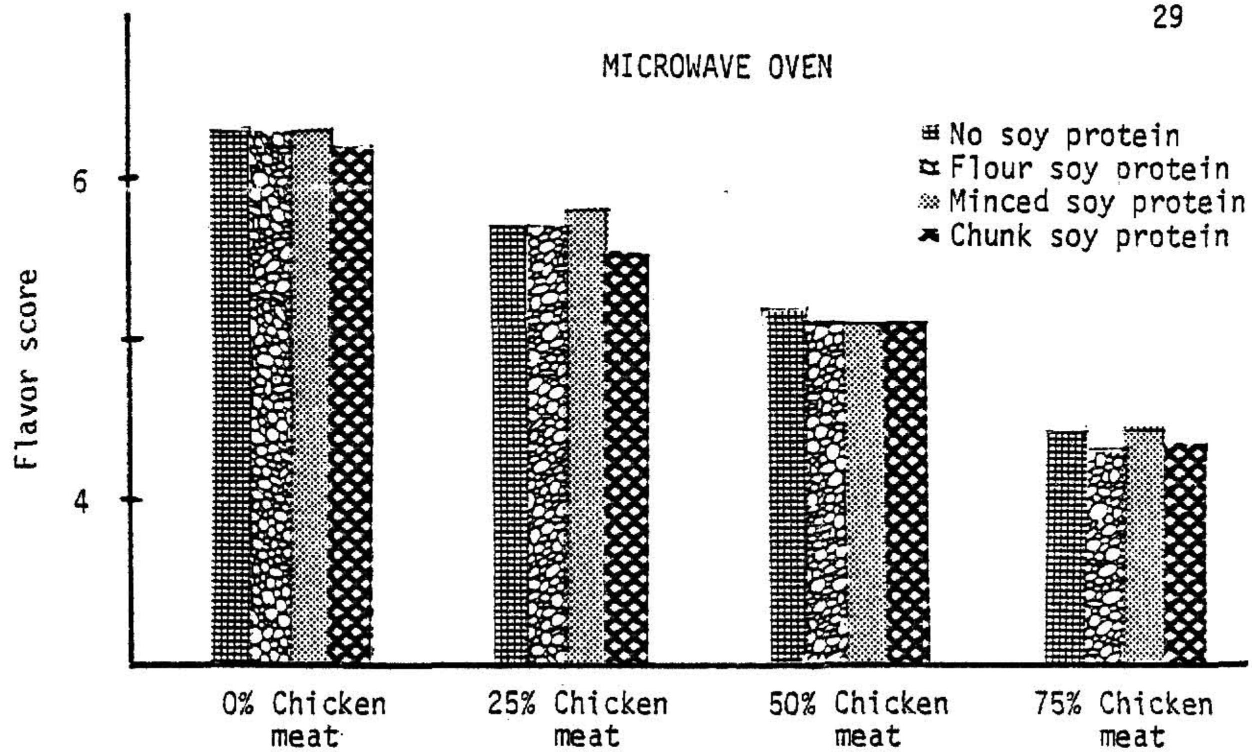

Fig. 10a - Flavor score of sausages reheated in microwave oven (7-- very desirable, 1-- very undesirable).

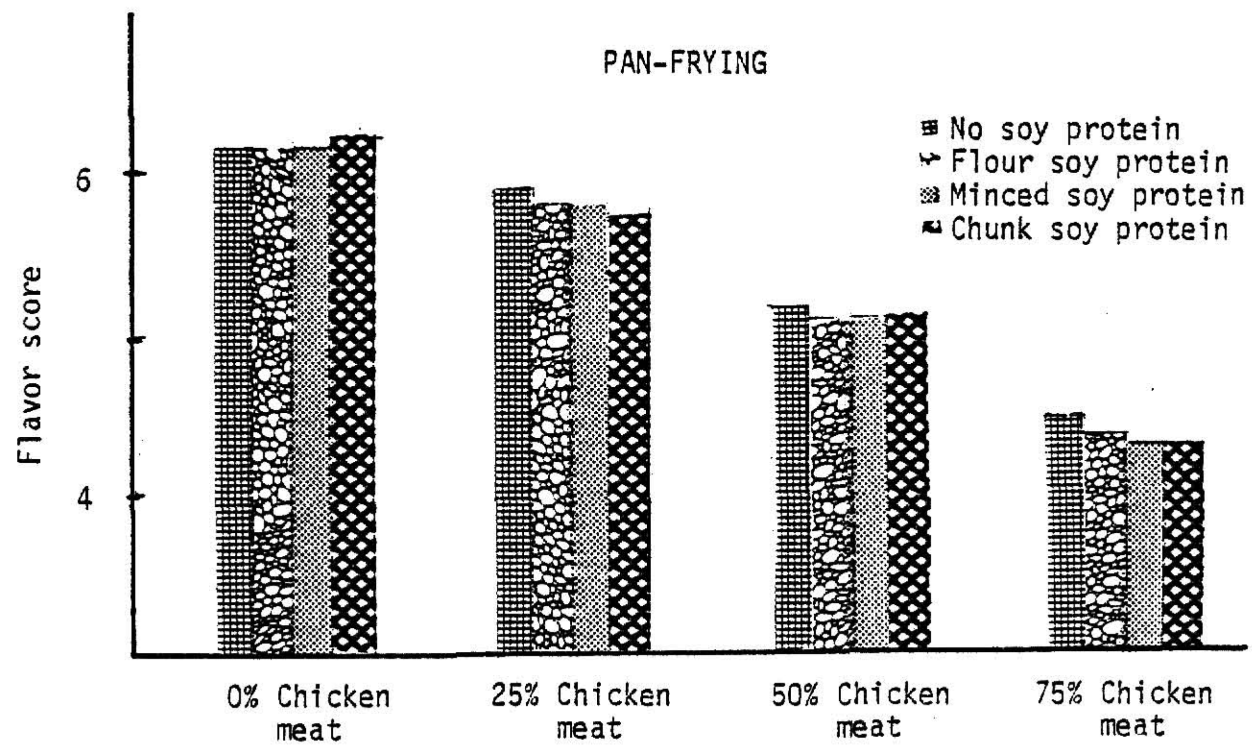

Fig. 10b - Flavor score of sausages reheated by pan-frying (7-- very desirable, 1-- very undesirable).

Table 6

Analysis of variance for composition of smoked sausages.

Source of variance		DF	Mean square and significance[1] Moisture	Fat	Protein
Percentage of chicken	(P)	3	85.273**	28.463**	21.995**
Type of soy protein	(T)	3	4.021*	0.105ns	0.114ns
P X T		9	3.001*	0.043ns	0.015ns
Error		80	0.996	0.041	0.046
Total		95			

[1]ns non-significance.
* significance at 5% level.
** significance at 1% level.

Table 7

Analysis of variance for smokehouse loss of smoked sausages.

Source of variance		DF	Mean square and significance
Percentage of chicken	(P)	3	15.648**
Type of soy protein	(T)	3	0.842*
P X T		9	0.713*
Error		32	0.266
Total		47	

** significance at 1% level.
* significance at 5% level.

Table 8

Analysis of variance for physical and sensory properties of sausages reheated by microwave or pan-frying.

Source of variance	DF	Mean square and significance[1]					
		Shear press	WHC	Flavor	Juiciness	Tenderness	Overall-accept.
Percentage of chicken (P)	3	8.6432**	0.1318**	13.9013**	14.2384**	10.1065**	11.1864**
Type of soy protein (T)	3	0.6843*	0.0020*	0.0052ns	0.0041ns	0.0187*	0.0073ns
Reheating method (R)	1	0.7352*	0.0006ns	0.0038ns	0.0053ns	0.0217*	0.0069ns
P X T	9	0.2341ns	0.0016*	0.0026ns	0.0031ns	0.0014ns	0.0028ns
P X R	3	0.1659ns	0.0002ns	0.0013ns	0.0018ns	0.0009ns	0.0023ns
T X R	3	0.1441ns	0.0005ns	0.0009ns	0.0036ns	0.0006ns	0.0042ns
P X T X R	9	0.0013ns	0.0000ns	0.0006ns	0.0004ns	0.0002ns	0.0004ns
Error	64	0.2181	0.0005	0.0034	0.0027	0.0062	0.0039
Total	95						

[1]ns non-significance.
* significance at 5% level.
** significance at 1% level.

decreased (Table 9, Fig. 1). That result agreed with the report of Dhillon and Maurer (1975c) that chicken meat had poorer emulsifying capacity than red meat. It was also probably due to the greater percentage of chicken skin in the sausages made from more chicken meat. Hudspeth and May (1969) reported that skin was the least desirable tissue in emulsification properties.

The initial greater moisture and protein content in chicken meat (Table 3) caused the increase moisture and protein content in the smoked sausages (Table 9 and Fig. 2, 3). Increased moisture was not directly proportional to the increased use of chicken (Fig. 2). That might relate to the lower water holding capacity of the chicken meat as shown by the Carver lab press (Table 10 and Fig. 5a, 5b). As the amount of chicken increased in the sausage, smokehouse loss increased (Table 9 and Fig. 4). Those results agreed with Rust (1977) that poultry meat had the poorest capacity to retain water compared to pork and beef.

As the concentration of chicken meat increased, tenderness increased ($P<.05$). That was evidenced by both taste-panel scores for tenderness and the shear values (Table 10, and Fig. 6a, 6b, 7a, and 7b). Sausages containing 75% chicken were often described as loose and mushy. Those results agreed with earlier comments from consumers that frankfurters made from chicken generally have a somewhat softer texture than ones made from red meat, and lacked "snap" (Baker et al., 1969). The overall acceptability of the reheated sausages were scored significantly ($P<.05$) less as the amount of chicken increased (Table 10, and Fig. 8a, 8b). The sausages with 75% chicken meat were scored less than the average acceptable value (4.0) in the Hedonic scale of 1 through 7. Those results might be due to the poor binding ability of the poultry meat as reported by Vedehra and Baker (1969). They found that comminuted poultry meat was difficult to bind following heating.

Table 9

Average of moisture, protein, fat, and smokehouse loss of finished sausages in various chicken levels.

Percentage of chicken	Moisture %	Protein %	Fat %	Smokehouse loss %
0	52.21a	19.70a	26.19a	9.01a
25	54.01b	20.51b	24.40b	10.29b
50	55.67c	21.32c	22.34c	12.08c
75	56.48d	22.12d	19.52d	14.46d

Values not having the same superscripts within each column are significantly different at the 5% level of probability using Duncan's multiple range test.

Table 10

Average of physical and sensory properties of sausages in various chicken levels.

Percentage of chicken	Shear press (Kg/g)	WHC	Flavor	Juiciness	Tenderness	Overall-accept.
0	4.28a	0.75a	6.3a	5.8a	4.9a	6.2a
25	3.63b	0.68b	5.9b	5.5b	5.3b	5.6b
50	3.18c	0.57c	5.2c	5.1c	5.8c	4.9c
75	2.45d	0.46d	4.6d	4.7d	6.4d	3.9d

Values not having the same superscripts within each column are significantly different at the 5% level of probability using Duncan's multiple range test.

Sausages containing greater amounts of chicken were less juicy significantly (P<.05) (Table 10, and Fig. 9a, 9b). The flavor of sausages were significantly (P<.05) less when greater concentrations of chicken meat were included (Table 10, and Fig. 10a, 10b).

Effect of soy protein

There were significant differences (P<.05) in chemical and physical properties among types of sausages with added soy proteins. Chemical and physical properties of the sausages, irrespective of chicken level, with different types of soy protein (flour, minced, or chunk) added are shown in Table 11 and 12. Kiseph (1974) reported that soy protein helped reduce cooking loss. We found that sausages with flour or minced soy protein added had significantly (P<.05) greater water holding capacity (WHC) and moisture content, consequently less smokehouse loss than sausage without soy protein (Table 11 and 12). There were significant interactions (P<.05) between types of soy protein and chicken concentrations (Table 6, 7, and 8) in moisture content, smokehouse loss, and WHC of finished sausages. As shown in Fig. 2, 4, and 6a, 6b; moisture, smokehouse loss, and WHC of the sausages with added soy protein did not significantly differ from sausages without soy protein when the amount of chicken was increased to 75%. Perhaps there was too much moisture in the sausage with 75% chicken meat so the effect of the soy proteins could not be detected. Sausages containing chunk soy protein had greater WHC but not significantly greater than those without added soy protein. This might be due to the surface area in chunk soy protein not being adequate to retain available moisture and as a result the difference would not be detected.

Protein increased, but not significantly, while fat decreased when soy protein (flour, minced, or chunk) was added in sausage (Table 11). Those results agreed with Huffman and Powell (1970) that beef patties with 2%

Table 11

Average of moisture, protein, fat, and smokehouse loss of finished sausages in various types of soy protein.

Type of soy protein	Moisture %	Protein %	Fat %	Smokehouse loss %
No soy protein	54.25a	20.84a	23.20a	11.74a
Chunk soy protein	54.37a	20.90a	23.10a	11.60a
Minced soy protein	54.79b	20.93a	23.04a	11.29b
Flour soy protein	54.94b	20.98a	23.01a	11.22b

Values not having the same superscripts within each column are significantly different at the 5% level of probability using Duncan's multiple range test.

Table 12

Average of physical and sensory properties of sausages in various types of soy protein.

Type of soy protein	Shear press (Kg/g)	WHC	Flavor	Juiciness	Tenderness	Overall-accept.
No soy protein	3.25a	0.59a	5.5a	5.3a	5.8a	5.1a
Chunk soy prot.	3.29a	0.60a	5.4a	5.3a	5.7a	5.1a
Minced soy prot.	3.48b	0.63b	5.5a	5.3a	5.4b	5.1a
Flour soy prot.	3.53b	0.63b	5.5a	5.3a	5.4b	5.1a

Values not having the same superscripts within each column are significantly different at the 5% level of probability using Duncan's multiple range test.

soy had more protein but less fat than those containing no soy. There were no significant interactions between types of soy protein and amount of chicken for protein and fat.

The sausages with soy protein (flour or minced type) were firmer ($P<.05$) than those without soy protein as shown by shear press and taste panel data (Table 12). That agreed with Kiseph (1974) that soy protein increased binding ability of meat. There were no significant differences in shear press or tenderness scores for sausages containing chunk type soy and those without added soy protein (Table 8). That might be due to uneven distribution of the particles of chunk soy protein and the sample containing no chunk soy protein selected for shearing or taste. There were no significant interactions between types of soy protein and amount of chicken for shear press values or tenderness scores (Table 8).

Sensory evaluations (flavor, juiciness, and overall acceptability) did not differ for sausages containing soy protein (flour, minced, or chunk) and those without soy protein added (Table 12). Thus soy protein might be used to improve certain properties without changing sensory properties. There was no significant interaction between types of soy protein and amount of chicken (Table 8).

<u>Effect of particle size of soy protein</u>

For sausages with soy protein added, smokehouse loss did not differ between sausages containing flour and minced soy protein, but was significantly less ($P<.05$) than those sausages containing chunk particles (Table 11). Moisture and WHC were also greater for sausages with flour or minced soy protein particles added (Table 11 and 12). Perhaps larger surface area enabled minced or flour soy protein to bind more water than chunk particles. The protein and fat content were not affected by different particle size of soy protein (Table 11).

There was no significant difference in shear press value or tenderness score between sausages with flour soy protein added and those with minced soy protein added, but the shear press values were less and tenderness scores were greater for sausages containing chunk soy protein particles ($P<.05$) than for those containing flour or minced soy protein particles (Table 12). That might be due to uneven distribution of the chunk particle which prevented binding ability of soy protein in sausages.

For sensory evaluation (flavor, juiciness, and overall acceptability), there was no difference among the three different particle size of soy protein (Table 12).

Effect of reheating method

Sausages reheated by pan-frying were firmer ($P<.05$) as shown by the shear press and tenderness score than those reheated in the microwave oven (Table 13). That agreed with the study of Cunningham (1977) that shear press values of patties cooked by pan-frying were significantly greater than for those cooked by microwave. There were no significant differences in flavor, juiciness, overall acceptability, or WHC between those two cooking methods (Table 13). There was no significant interaction between physical properties of sausages, chicken concentrations, reheating methods, types of soy protein (Table 8).

Table 13

Average of physical and sensory properties of sausages reheated by microwave or pan-frying.

Reheating method	Shear press (Kg/g)	WHC	Flavor	Juiciness	Tenderness	Overall-accept.
Microwave oven	3.34a	0.64a	6.22a	5.28a	5.68a	5.07a
Pan-frying	3.60b	0.62a	6.29a	5.25a	5.47b	5.11a

Values not having the same superscripts within each column are significantly different at the 5% level of probability using Duncan's multiple range test.

CONCLUSIONS

Fat and water retention in summer sausages were decreased as the concentration of chicken was increased. Addition of chicken did not improve summer sausages. However, it was shown that up to 50% chicken could be added and still have an acceptable product.

Addition of 3% soy protein in minced and flour forms improved water retention ability of the sausages, but addition of chunk style soy protein did not improve water retention. Properties of sausages containing chunk style soy protein were similar to those of sausages without soy.

There was no difference in the sensory properties of sausages reheated by microwave or by pan-frying, but pan-fryed sausages were firmer in tenderness score and shear press value.

ACKNOWLEDGEMENTS

The author is grateful and indebted to her major professor, Dr. Franklin E. Cunningham, Department of Animal Sciences and Industry, for providing the initial idea for this work, for his help during the study, and for his assistance and suggestions in preparation of this thesis.

Sincere appreciation is extended to Dr. Don H. Kropf and Mr. Don A. Sapienza, Department of Animal Sciences and Industry, for their kind assistance and advice and for use of laboratory facilities.

Gratitude also is expressed to the members of the taste panel for their faithful participation.

The author wishes to thank Dr. Richard Bassette and Dr. Jim T. Marshall, Department of Animal Sciences and Industry, for serving on her committee and for their helpful comments on this manuscript.

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APPENDIX

SCORE SHEET FOR SUMMER SAUSAGE

Name: ______________________ Date: ______________________

Please score these three samples individually.

Sample No.	Desirability of Flavor	Juiciness	Tenderness Score	Overall Acceptability

Descriptive terms for scoring:

Flavor	Juiciness	Tenderness
7. Very desirable	7. Very juicy	7. Very tender
6. Desirable	6. Juicy	6. Tender
5. Moderately desirable	5. Moderately juicy	5. Moderately tender
4. Slightly desirable	4. Slightly juicy	4. Slightly tender
3. Slightly undesirable	3. Moderately dry	3. Moderately tough
2. Moderately undesirable	2. Dry	2. Tough
1. Very undesirable	1. Very dry	1. Extremely tough

Overall Acceptability

7. Very desirable
6. Desirable
5. Moderately desirable
4. Slightly desirable
3. Moderately undesirable
2. Undesirable
1. Very undesirable

PROPERTIES OF BLENDS OF CHICKEN-PORK IN SUMMER SAUSAGES

by

SHEI FANG TSAI

B.S., Fu Jen University, 1977

AN ABSTRACT OF A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

in

Food Science

Department of Animal Sciences and Industry

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1980

ABSTRACT

Pork (shoulder) and hand deboned chicken meat were ground through 3/8 in.-plate and 1/8 in.-plate twice with a Hobart meat grinder. Chicken and pork were blended in 0/100, 25/75, 50/50, or 75/25 ratios to make fermented (pH 4.9) sausages. Three types of soy protein (powdered, minced or chunk) were used with the four different combinations of meat. Pork fat was added to make all fat levels equal 25%. All samples were analyzed for moisture, fat, and protein after smoking and cooking. Also objective and subjective measurements; shear press, Carver lab press, and sensory evaluation (flavor, juiciness, tenderness and overall acceptability) were made on the cooked sausages reheated in a microwave oven or by pan-frying.

As the amount of chicken was increased, smokehouse loss, moisture, and protein content of the sausages increased significantly ($P<.05$); while fat and water holding capacity (WHC) decreased. Shear press values were lower and tenderness scores of sausages were significantly higher ($P<.05$) when the chicken concentration was greater. Flavor and juiciness scores decreased with more chicken in the blend. Overall acceptability for sausage containing 75% chicken meat was rated below acceptable.

The addition of soy protein (powdered, or minced) increased moisture retention, WHC significantly ($P<.05$); and resulted in less smokehouse loss. There was however no soy protein effect on those properties when concentration of chicken reached 75%. The protein and fat content of finished sausages were not significantly effected by the addition of soy protein. Sausages with chunk soy protein were significantly poorer in moisture retention and WHC, but greater in smokehouse loss than those with minced or powdered soy protein.

No significant differences were found in sensory evaluations among types of sausages with soy protein, except firmer texture and higher shear

press values among those with powdered or minced particle size soy.

Sausages reheated by pan-frying were firmer (P<.05) than those reheated in a microwave oven. No significant differences for other physical properties existed because of the reheating method.