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Relation of physical, chemical and sensory evaluation of cured ham to the backfat thickness of hog carcasses

Astrid Linnéa Molander
Iowa State University

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RELATION OF PHYSICAL, CHEMICAL AND SENSORY EVALUATION OF CURED HAM TO THE BACKFAT THICKNESS OF HOG CARCASSES

by

Astrid Linnéa Molander

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Approved:

Signature was redacted for privacy.

In Charge of Major Work

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Head of Major Department

Signature was redacted for privacy.

Dean of Graduate College

Iowa State University
Of Science and Technology
Ames, Iowa

1962

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INTRODUCTION

For some time investigators in swine breeding and swine nutrition have been concerned with reducing the amount of fat on the live hog and thickness of the backfat on hog carcasses. Their objectives were to determine the relationship between physical measurements of backfat thickness and yield of lean cuts or ratio of lean to fat in the total carcass. Relatively few investigations have been conducted to determine whether or not these characteristics were related to eating quality of pork cuts. In addition, many of the studies have been on pork loins and comparatively few on cured hams.

Since so few studies had been conducted on eating quality of different pork cuts in relation to carcass grade or to backfat thickness, an investigation was conducted in this laboratory on the relation of chemical and physical measurements to eating quality of pork roast and chops from carcasses varying in backfat thickness (Murphy 1959 and Oñate 1961).

In the recent decade, a recognition of greater prevalence of obesity has renewed interest in the function of fats and their component polyunsaturated fatty acids in human nutrition. Furthermore, the factors involved in coronary arterial diseases have made research in this area urgent. In addition, new knowledge in methods of analysis have made it possible to investigate the composition of foods in greater detail with respect to fatty acid content.

The research in the present study was conducted in two parts. The objectives of the first part were to determine the eating quality and physical and chemical composition of four muscles of cured, smoked and fully cooked hams from carcasses varying in backfat thickness. The muscles used for the investigation were the biceps femoris, rectus femoris, semimembranosus and semitendinosus. The hams were from the same carcasses as those used in the studies of Murphy (1959) and Oñate (1961). The specific objectives of this part of the study were:

1. to examine the dependence of marbling, yield of cured, smoked and fully cooked hams, chemical composition and flavor, tenderness and juiciness of hams on backfat thickness.
2. to compare tenderness as measured by the shear force apparatus and by sensory evaluation.

Also, this study was concerned with the fatty acid content of the internal fat of biceps femoris, rectus femoris and semitendinosus muscles of fresh raw, fresh cooked and cured, smoked and fully cooked hams from Duroc and Hampshire hogs.

The specific objectives of this part of the study were:

1. to determine the fat content in raw fresh ham, cooked fresh ham and cured, smoked and fully cooked ham.
2. to investigate the per cent weight of six fatty acids, namely: myristic, palmitic, palmitoleic, stearic, oleic and linoleic in _biceps femoris_, _rectus femoris_ and _semitendinosus_ muscles.
3. to examine possible differences in fatty acid components as affected by breed differences or by cooking treatment.

REVIEW OF LITERATURE

Earlier research reports on hams have dealt mostly with the effect of processing on the quality of cured, smoked and fully cooked hams (Hunt et al. 1939; Rice et al. 1947; Fields and Dunker 1952; Dunker et al. 1953; Wilson 1955; Mahon et al. 1956; Hougham 1960; Mills et al. 1960; Skelly 1960; and Kemp et al. 1961). The literature on pork quality in relation to marbling and eating quality of pork chops has been reviewed by Murphy (1959). Onate (1961) examined the literature on pork roasts in regard to the backfat thickness of the hog. Therefore, this review will be concerned mostly with investigations pertaining to the eating quality and the chemical and physical composition of hams as it relates to backfat thickness.

Consumer Studies on Pork

To determine consumer preferences for pork, Gaarder et al. (1960) conducted a household survey in Des Moines, Iowa during June 1955. In the 499 householders interviewed, income and family size were the principal determinants of pork consumption patterns. As the size of the family increased within a given income, the pork consumption increased; but as the income increased, the pork consumption gradually decreased. No influence of occupation was noted. Of the different kinds of pork cuts listed as the family's favorite, the pork chop was first (32 per cent) and ham second (28 per cent) choice.

Vrooman (1952) as well as Birmingham et al. (1954) found in their studies that consumers preferred leaner cuts of pork. Vrooman reported that only one person in 221 had a preference for the fattest cuts. According to Birmingham et al. (1954) the majority of the people in Columbia, Missouri, preferred Choice No. 1 grade hams. In this study, cured ham slices from Choice grade No. 1 were compared with Medium quality grade No. 2 from carcass weighing approximately 150 pounds (68 kg) and backfat thickness of 1.66 inches (42 mm) and 1.44 inches (35 mm) respectively. Although in this study of 627 households a preference was indicated for leaner cuts, Gaarder and Kline (1956) found that consumers were not concerned with the grade of the hog carcass as long as the cut was trimmed. This is of practical importance in pork loin roasts and pork chops as these cuts can be trimmed to order. However, with hams the trimming can not be carried out to the same extent. In both cases, the loss of fat through trimming plays an important economic role and should be considered.

Carcass Grades

The most recent specifications of objective grades for pork carcasses were issued by the United States Department of Agriculture in 1958. The specifications include backfat thickness and carcass length (Table 1).

Table 1. Weight and measurement guides to grades for barrow and gilt carcasses[a]

Carcass weight or length[c]	Average backfat thickness by grade[b]				
	U.S. No. 1	U.S. No. 2	U.S. No. 3	Medium	Cull
Under 120 lbs. or under 27 inches	1.2 to 1.5	1.5 to 1.8	1.8 or more	0.9 to 1.2	Less than 0.9
120 to 164 lbs. or 27 to 29.9 inches	1.3 to 1.6	1.6 to 1.9	1.9 or more	1.0 to 1.3	Less than 1.0
165 to 209 lbs. or 30 to 32.9 inches	1.4 to 1.7	1.7 to 2.0	2.0 or more	1.1 to 1.4	Less than 1.1
210 or more lbs. or 33 or more inches	1.5 to 1.8	1.8 to 2.1	2.1 or more	1.2 to 1.5	Less than 1.2

[a]Source: U. S. Department of Agriculture, Agr. Marketing Service (1958).

[b]Average of measurements made opposite the first and last ribs and last lumbar vertebra.

[c]Either carcass weight or length may be used with backfat thickness as a reliable guide to grade. The table shows the normal length range for given weights. In extreme cases where the use of length with backfat thickness indicates a different grade than by using weight, final grade is determined subjectively as provided in the standards. Carcass weight is based on a chilled, packer style carcass. Carcass length is measured from the aitch bone to the forward edge of the first rib.

Self *et al.* (1957) indicated that carcass grade can be used as a measure of quality in either loins or hams. Only No. 1 grade hams were considered acceptable in the retail trade. They stated that the grade of the hog does not necessarily indicate the degree of intramuscular fat in the ham, however, no evidence from research is given in this area.

Marbling

Marbling, one of the characteristics used to grade beef, is the distribution of fat along the connective tissue and between the muscle fibers giving the surface of the cut meat a streaked appearance. Marbling in pork has not been studied to the same extent as in beef and needs more attention.

Self *et al.* (1957) determined the association of carcass grade and weight with the quality and composition of certain pork cuts. They reported that the hams from U.S. No. 2 and U.S. No. 3 grade carcasses had more seam fat and excessive marbling than No. 1 and Medium grade carcasses.

In a study in which 622 pork carcasses were used, Kaufmann *et al.* (1958) found that there was a statistical relationship between feathering-overflow[a] and marbling of hams.

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[a]Feathering describes the fatty striated deposits between ribs; overflow is the fat over the rib cage.

Until a correlation between marbling scores and eating quality of ham muscles is established, the feathering-overflow is of little practical importance in the evaluation of consumer acceptance.

Batcher and Dawson (1960) reported that highly marbled muscles were higher in fat content and lower in moisture than were muscles that lacked marbling. Correlation coefficients for marbling score and intramuscular fat content were significant for the longissimus dorsi. However, the fat content of ham muscles was not related to the marbling score of the longissimus dorsi. Only marbling scores on longissimus dorsi were reported. No data on the correlation of marbling and fat content of ham muscles were found in the literature.

The use of photographs in scoring marbling in pork muscles has been reported by Batcher and Dawson (1960), Murphy and Carlin (1961) and Oñate (1961). In consumer preference studies of pork, Gaarder and Strand (1957) used photographs of pork cuts. They recommended colored pictures with a blue background, in order to give as real a picture as possible of the meat. Lewis (1958) used photomicrographs to determine the quantity and distribution of fat in muscle tissues of turkeys. The results obtained compared favorably with results from numerical scores assigned to the same muscles.

Batcher and Dawson (1960) reported that marbling scores correlated with the juiciness and tenderness in the case of rectus femoris and biceps femoris muscles of fresh ham. However, the marbling score was given to the longissimus dorsi muscle only. They stated that the marbling score is of minor importance since there appears to be other factors that influence tenderness and juiciness of the cooked muscles.

Yield

The proportions of lean, fat and bone in retail pork cuts are of great importance to the consumer both from the economical and the nutritional standpoint. Murphy and Carlin (1961) reported that backfat thickness of the hog carcass had a highly significant effect on the amount of lean, fat and bone in pork chops. Regression analysis revealed that separable fat in loins increased 9 per cent for raw and 7 per cent for cooked chops and lean decreased 6 per cent for raw and 3 per cent for cooked chops with each increase of 1 inch in backfat thickness. Oñate (1961) reported: "backfat thickness is a good indication of the yield of separable lean, fat and bone in both raw and cooked pork roasts. Per cent fat increases and percent lean decreases with increasing backfat thickness." No similar experiments have been reported on cured, smoked and fully cooked hams.

Cooking Losses

Total cooking losses which occur during cooking of meat include volatile loss and drippings. Volatile losses are mostly water and drippings include fat, water, salts, and non nitrogenous as well as nitrogenous extracts. Factors that affect cooking losses are the composition of the meat, temperature of cooking, surface area, method of cooking and cooking time. Lowe (1957) states that cooking losses of meat can vary from 5 to 50 per cent.

Little information on cooking losses on hams was found in the literature. Saffle and Bratzler (1959) reported that an analysis of variance revealed that the effect of the degree of finish on the total cooking losses of hams was not significant. Batcher and Dawson (1960) reported that cooking losses varied from 20 per cent in longissimus dorsi to 10 per cent in the adductor in fresh ham. The different muscles of the ham were all lower in cooking losses when compared with the longissimus dorsi.

Taste Panel Evaluation

One of the most important criteria in evaluation of quality of foods is the sensory measurements. Most of the research on flavor, tenderness and juiciness of meat has been conducted on beef, however, it is of equal importance that investigations be made on pork.

Only two studies were found in the literature which reported the relation of backfat thickness to eating quality of hams as evaluated by a taste panel. In the study by Saffle and Bratzler (1959) on cuts from carcasses with average backfat thickness of 1.0-1.3, 1.3-1.6 and 1.6-1.9 inches, a taste panel gave mean preference scores for loin chops of 6.40, 6.58 and 6.93 respectively, and their taste panel results on hams did not approach significance. It should be noted that the taste panel scores were on a preference scale and therefore, did not indicate definite evaluation of the eating characteristics, e.g., tenderness, juiciness of flavor, only an overall reaction of a dislike or like was obtained. Taste panel evaluations should clearly indicate the factors scored, e.g., juiciness, tenderness or flavor and the bias of preference should not be introduced. Batcher and Dawson (1960) reported on the correlation of backfat thickness with scores for flavor, tenderness and juiciness of pork loins and fresh ham muscles. However, the juiciness of the *semitendinosus* muscle of fresh ham was the only sensory evaluation characteristic that was related significantly to backfat thickness ($P = 0.05$).

Flavor

Flavor is a sensation where both odor and taste are involved. In tasting a food, one usually includes other sensations such as temperature and touch. Although flavor is one of the most important characteristics of meat, there is very little evidence as to what components are responsible for meat flavor. Hornstein _et al_. (1961) investigated the phospholipids in pork meat. They concluded that the phospholipids did not contribute to desirable meat flavor. However, the phospholipids might possibly contribute to the poor flavor in excessively lean meat.

Weir and Dunker (1953) investigated the flavor of different types of cured hams: Tendered, Ready-to-Eat, Long Brine and Smithfield. Samples of each type were compared organoleptically. The flavor of Tendered, Ready-to-Eat and Long Brine hams was similar with more pronounced brininess than the Smithfield ham. The latter had a sharper flavor with some indication of spiciness.

Batcher and Dawson (1960) reported that mean scores for flavor were similar for different muscles in loin and fresh hams. Also, the flavor and general acceptability seemed to be related.

Tenderness

Factors related to tenderness of meat are age of animal, degree of ripening, degree of marbling, amount of connective tissue, method of cooking, cooking time and cooking temperature (Paul _et al_., 1944; Ramsbottom _et al_., 1945; and Cover and

Hostetler, 1960). Consumer studies on meat revealed that tenderness is the most important palatability factor in acceptance of beef (Cover and Hostetler, 1960). Also, Judge et al. (1959, 1960) considered tenderness important since they placed greater confidence in the taste scores for tenderness than in juiciness and flavor scores. Tenderness of meat has been evaluated by means of organoleptic, mechanical, chemical and histological methods.

Cover and Hostetler (1960) found that carcass grade and marbling of beef were not as good bases for deciding between moist and dry heat methods of cooking as was formerly suggested. Furthermore, they stated that "...shear force values appeared to be less than perfect as a measure of total tenderness of meat from all cuts". From the investigations by Batcher and Dawson (1960) and Cover and Hostetler (1960), it seems that the amount of fat may not be the main factor in the tenderness of meat. In 1960, Batcher and Dawson reported that other factors than fat seem to influence tenderness of the cooked fresh ham muscles.

Shear force measurements have been used extensively in meat research to evaluate tenderness objectively. The most common device used is the Warner-Bratzler machine. However, other instruments have been developed. Batcher and Dawson (1960) used the Lee-Kramer shear press when judging fresh pork and ham. Both Murphy (1959) and Oñate (1961) reported no significant relation between backfat thickness and tenderness of the longissimus dorsi muscle of pork loin as evaluated by the shear force using the Warner-Bratzler machine.

It is generally accepted that muscles which contain a high amount of connective tissue are less tender than those that contain small amounts. Thus analysis of beef muscles for the amount of the constituents elastin and collagen have been reported by various investigators, e.g., Prudent (1947) and Hiner et al. (1955). No similar research on hams was found.

Hamm (1959) stated that tenderness is related to its water holding capacity. Factors that influence water holding capacity are pH, changes in protein structure, temperature, mechanical treatment such as grinding, addition of sodium chloride and some bivalent metallic cations. Judge et al. (1960) reported that in the longissimus dorsi muscle of pork, the firmness which is related to the water holding capacity of the meat and the pH were significantly related to tenderness. Also, Briskey et al. (1960) reported a significant correlation between expressible water (amount of relative "free H_2O") and pH in the rectus femoris and biceps femoris of fresh ham. The rectus femoris had a pH of 6.0 and 53 per cent expressible water. The biceps femoris had a pH of 5.83 and 57 per cent expressible water. Hamm and Deatherage (1960) stated that:

> The stepwise change of water holding capacity of meat and of its pH is determined by the stepwise decrease of the acidic group in muscle proteins. Heat denaturation does not cause a significant decrease in the amount of basic groups in muscle proteins.

Temperature of cooking is of considerable importance in its effect on the water holding capacity, which in turn affects the tenderness. At the isoelectric point of meat, pH 5, the waterholding capacity is at the lowest (Hamm 1959).

Histological studies to measure tenderness have not received as much attention as the previously discussed methods. Wang et al. (1956) studied the extensibility of single muscle fibers of beef and a relationship to tenderness was obtained but it was not large enough to be used as a single measure.

Juiciness

Weir (1960) described juiciness by separating it in two phases: a) the first is the impression of wetness during the first chews produced by the release of meat fluid and b) the second is one that probably is due to a slow release of serum and to the stimulation of fat on the salivary flow. Furthermore, the same author indicated that as the latter impression leaves a more lasting effect than the first, the juiciness has shown a closer relationship between the fat content than between the pressfluid from the meat.

Juiciness is tested in two different ways, subjectively by taste panel evaluation and objectively by means of a press-ometer, which measures the amount of press fluid in the meat. Murphy (1959) and Oñate (1961) who used sensory evaluation, found no significant relationship between juiciness of pork chops or pork roasts and backfat thickness. When the scores for tenderness and juiciness were examined, it was found that these two characteristics were closely related, thus if a high score for juiciness was given, a high score for tenderness was given and vice versa.

Chemical Composition

The objective of many of the investigations on the chemical composition of pork and ham have been to investigate the nutritive value. However, determinations of moisture and fat have been used to find correlation between chemical composition of the meat and other objective analyses such as shear force to establish norms for quality.

Moisture

Moisture content of different pork and ham muscles was reported by Batcher and Dawson (1960) to vary inversely with the fat content. Furthermore, the fat and the moisture content was lower in the ham muscles than in the *longissimus dorsi* muscle. Also, they found that the average moisture content of the raw muscles from carcasses with high and with low backfat thicknesses was very similar. Oñate (1961) reported that raw roasts and chops were similar in chemical composition and had approximately 71 per cent moisture. Cooked roasts and chops had less moisture than the raw cuts (62 per cent). Briskey et al. (1960) reported on raw fresh ham that biceps femoris contained 72 per cent and rectus femoris contained 75 per cent moisture. Watt and Merrill (1950) reported 42 per cent moisture for raw cured and smoked ham and 39 per cent for cooked cured and smoked ham. Leverton and Odell (1958) investigated cured and smoked ham and obtained 56 per cent moisture for the butt half of the ham (lean and marble) and 52 per cent for the shank end (lean and marble). The U. S. Department of Agriculture (1960) also reports a moisture content of 56 per cent for medium fat cured and smoked ham.

Fat

The fat content in pork has been analyzed both as crude fats and as fatty acids. Briskey et al. (1960) determined total fat in eight muscles from pork carcasses. Gluteus accessorius, gluteus medius, biceps femoris and rectus femoris of fresh ham were included in the investigation. Raw biceps femoris contained 4.8 per cent and rectus femoris 2.6 per cent fat as ether extract.

Batcher and Dawson (1960) reported on the intramuscular fat content of four muscles of fresh hams from eight pork carcasses varying in backfat thickness. Raw *biceps femoris* contained 3.6 per cent, *semimembranosus* 2.6 per cent, *rectus femoris* 2.5 per cent and *semitendinosus* 3.8 per cent fat. In the cooked muscles *biceps femoris* contained 7.0 per cent, *rectus femoris* 4.1 per cent, *semitendinosus* 7.6 per cent and *semimembranosus* 4.8 per cent fat. They stated: "No one muscle in the ham seemed to be a dependable guide to the whole fresh ham." Batcher and Dawson (1960) as well as Oñate (1961) reported that the fat content was higher in the cooked pork than in the raw meat when one compares the same muscles. Watt and Merrill (1950) reported on the fat content in cured and smoked hams. The raw ham contained 35 per cent fat and the cooked ham 33 per cent. Also, Leverton and Odell (1958) investigated the fat content in cured smoked butt halves and shank ends. The butt end which included both lean and marbling contained 10.8 per cent fat and the similar parts of the shank end contained 13.8 per cent. The U. S. Department of Agriculture (1960) reported 28 per cent fat in medium fat cured and smoked ham. Oñate (1961) reported on the fat content in pork roast and pork chops from raw and cooked meat. Raw roasts and chops contained about 6 per cent fat and cooked roasts and chops contained 10 per cent fat.

Investigations have been reported on the fatty acid content of lard but relatively few studies have been conducted on the fatty acids in lean meat. One of the earliest studies on the fatty acid composition of the fat of the pig was made by Ellis (1926) who studied fatty acid composition of pigs fed different diets. Differences between amounts of the acids were obtained and the differences were as great between animals as within animals. Research by Chang and Watts (1952) indicated that there were significant differences in the fatty acid distribution in meat from different locations of the same animal. Furthermore, they found that only a small amount of the polyunsaturated fatty acids of pork were lost during ordinary cooking methods. Therefore, the nutritional value in regard to the unsaturated fatty acids is not altered by cooking. Also, Willard et al. (1954) studied the fatty acid content of some foods which had undergone various types of processing. They found no significant increase in conjugated fat in the distilled compared with the non-distilled esters.

Fatty acid composition of meat tissue lipids were studied by Hornstein et al. (1961). Pork muscle contained approximately 5.0-7.0 per cent neutral fats. Furthermore, the unsaturated acids containing two or more double bonds made up 10 per cent of the triglyceride fraction.

Data from four investigations on the fatty acid composition of pork cuts are summarized in Table 2.

Protein

Dunker et al. (1953) determined nutritive properties of different types of commercially cured hams in regard to vitamin content, mainly niacin, thiamine and riboflavin by chemical analysis and the protein value was analyzed using a biological method. In cured hams, the biological value of the protein was about 90 per cent.

Table 2. Fatty acid composition of pork and ham

Fatty acid	Fresh ham[a] Raw	Fresh ham[a] Cooked	Cured ham[b]	Raw pork Diet[c] 1	Raw pork Diet[c] 2	Raw pork Fraction[d] 1	Raw pork Fraction[d] 2
	%	%	%	%	%	%	%
Lauric			0.47				0.4
Myristic			1.75			1.1	2.0
Palmitic			21.7			24.0	22.5
Palmitoleic			2.71			7.2	9.8
Stearic			13.7			12.1	7.0
Oleic	53.6	52.6	44.4	47.6	47.3	45.8	39.4
Linoleic	7.25	7.57	9.07	10.9	10.9	7.9	15.3
Linolenic	0.48	0.48	0.46	0.54	0.44	1.7	1.7
Arachidonic	0.37	0.39		0.56	0.52	-	1.2

[a]Chang and Watts (1952) spectrophotometric determination.

[b]Willard _et al_. (1954) spectrophotometric determination.

[c]Privett _et al_. (1955) alkaliisomerization; pigs fed two diets; 1 - corn, 2 - oats.

[d]Hornstein _et al_. (1961) gas chromatography; fraction 1 contained 85-90 per cent of the neutral lipid fraction. Fraction 2 contained both neutral fat and pigments that were separated in fractionation of the fat.

In investigations on protein content of ham, the following values were reported (Table 3).

Table 3. Protein content of ham

Pork cut	Protein	Reference
	%	
Ham cured, smoked		
raw	16.9	Watt and Merrill (1950)
cooked	23.0	Watt and Merrill (1950)
Butts, cured (lean plus marble)	25.1	Leverton and Odell (1958)
Shank end, cured (lean plus marble)	25.6	Leverton and Odell (1958)
Ham, medium fat	21.0	U. S. Dept. of Agr. (1960)

EXPERIMENTAL PROCEDURE

Part I

For the first part of this study, hams from the right and the left sides of 48 carcasses were used. These hams were purchased from the Rath Packing Company, Waterloo, Iowa. Hogs were selected on the basis of backfat thickness, which varied by 0.1 inch (0.25 cm) from 1.0 to 2.3 inches (2.5 to 5.75 cm).

The Rath Packing Company supplied information on the following characteristics: live weight, age, sex, length, backfat thickness, breed, grade, chilled weight of the carcass and weight of the ham before and after trimming (Table 26, Appendix).

As the Rath Packing Company is a member of the American Meat Institute, the company follows an agreement to trim the external fat to 1/4 inch (0.6 cm) at the packing plant. Data on the hams before reaching the laboratory and after arrival are given in the Table 27 of the Appendix.

The length of the carcasses ranged from 27.4 to 33.6 inches (69.6 to 85.3 cm). The weight range was 148 to 168 pounds (67 to 76 kg), with an average weight of 156 pounds (70 kg). The carcasses were graded according to the official United States pork standards (U. S. Agricultural Marketing Service 1958).

Hams were cured, smoked and fully cooked by the packer. The following information about the processing of the hams was obtained:

1. Hams chilled to about $40^{o}F$ ($4.4^{o}C$) prior to pumping.
2. Hams chilled 24 to 48 hours prior to pumping.
3. Pickle temperature at time of pump is 32 to $33^{o}F$ ($0-0.5^{o}C$).
4. The pump percentage is 10 per cent of the green weight[1] and 50 per cent of this goes into each artery branch.
5. Pump pickle is composed of

NaCl	11.0%
$NaNO_2$	0.1%
$NaNO_3$	0.1%
Sugar (sucrose)	2.5%
T.P.P.	3.0%
Water	balance

   All percentages are by weight.
6. Pumped hams are cured for 3 to 5 days at $40^{o}F$ in a cover pickle similar to the pump pickle. T.P.P. is eliminated with changes; other concentrations only slightly.
7. Cured hams are then washed in tap water spray, placed in stockinetts and cooked with smoke to an internal temperature minimum of $150^{o}F$ ($65.6^{o}C$). This is a gradual increasing temperature ending with a $190^{o}F$ ($87.8^{o}C$) house temperature. The total smoke house time varies from 20 to 24 hours depending on the other factors such as ham weight, house load, and slight variation in humidity.

The cured, fully cooked and smoked hams were delivered to Iowa State University usually 9 to 10 days after the hogs were slaughtered, depending upon the length of the curing and smoking process. The hams as delivered at the laboratory were wrapped with several layers of waxed paper and four hams in each cardboard box. The hams were stored in the boxes in a walk-in refrigerated room ($38^{o}F \pm 1.5^{o}$) for from one to six

[1]Weight right after slaughter, before aging takes place.

days. Thus, the total holding time from slaughter until time of testing the hams varied from 9 to 15 days. The following muscles were investigated: biceps femoris, rectus femoris, semimembranosus and semitendinosus (Figure 1).

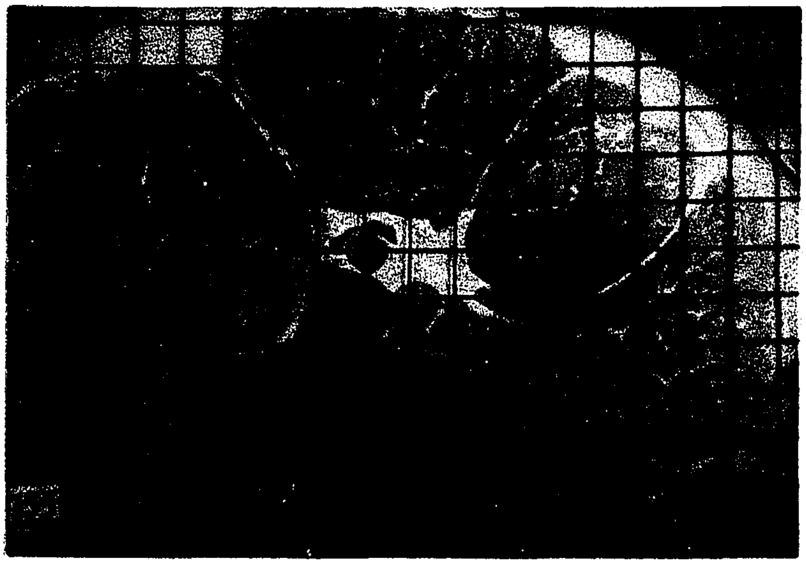
Statistical Design

Since the purpose of the first part of the study was to examine possible relationships of characteristics of cured hams such as flavor, shear force and chemical composition to the backfat thickness of the pork carcasses, an incomplete block design of paired comparisons was used (Kempthorne 1952). The design was planned so that at least 0.4 inches (1 cm) difference in backfat thickness was present in each comparison as presented in Table 4.

From the 91 possible paired comparisons, 24 pairs were chosen with a total of 14 groups. The pairs of the hogs were selected at random by the packing company following the comparisons given in Table 4. Each day of testing, the ham from the right or the left part of the carcass to be used for cooking was selected at random.

Analyses of the subjective evaluation scores were made on within day differences to eliminate between day differences caused by variability of and between judges, see Tables 23 and 24, Appendix, for normal equations used. The formula

Figure 1. Location of *biceps femoris*, *semimembranosus*, *semitendinosus* and *rectus femoris* in ham



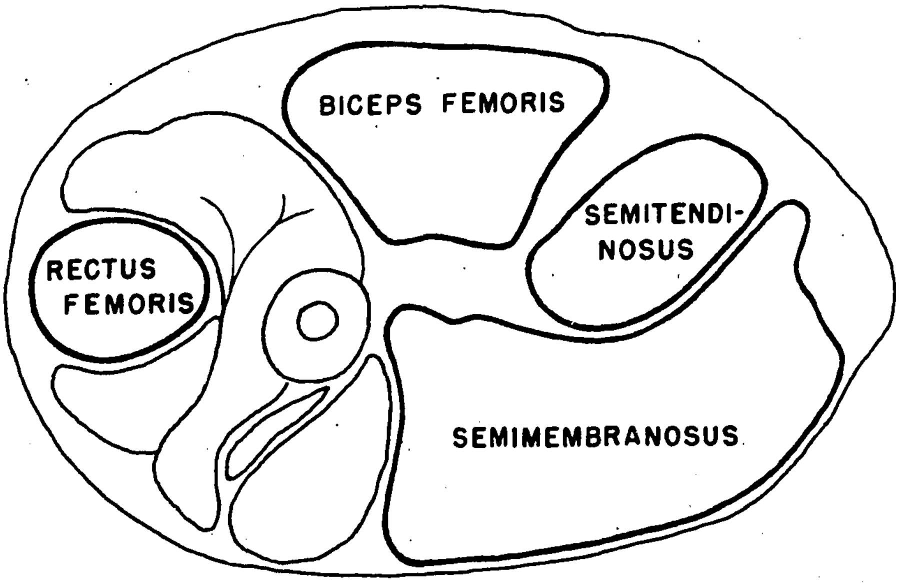

BICEPS FEMORIS
SEMITENDI-
NOSUS
RECTUS
FEMORIS
SEMIMEMBRANOSUS

Table 4. Statistical design and randomization[a] for paired comparisons

i	Backfat thickness in.	j: 0	1	2	3	4	5	6	7	8	9	10	11	12	13
		Backfat thickness													
		1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3
0	1.0					d_1 (21)		d_2 (20)			d_3 (11)		d_4 (19)		
1	1.1						d_5 (5)		d_6 (23)		d_7 (4)			d_8 (15)	
2	1.2							d_9 (1)		d_{10} (3)		d_{11} (24)		d_{12} (12)	
3	1.3								d_{13} (2)		d_{14} (8)		d_{15} (22)		
4	1.4									d_{16} (7)		d_{17} (9)			
5	1.5										d_{18} (6)				d_{19} (18)
6	1.6											d_{20} (10)			
7	1.7												d_{21} (16)		d_{22} (13)
8	1.8													d_{23} (14)	d_{24} (17)

[a]Randomization sequence is indicated in parenthesis.

used was:

$$d_k = t_i - t_j + e_k$$

where

d_k was the observed differences of the k^{th} pair

t_i was the effect of the i^{th} backfat thickness

t_j was the effect of the j^{th} backfat thickness

e_k was the error arising from the variability of judges between days.

Analyses of variance were used according to standard procedures (Snedecor, 1956).

$$\text{Total SS} = \sum_{k=1}^{24} d_k^{\,2}$$

The taste panel scores were tested by the formula:

$$F = \frac{\text{Treatment M.S.}}{\text{Error M.S.}}$$

Raw Cured Ham

Raw ham in the first part of the study refers to the cured, smoked and fully cooked ham, which did not receive any further heat treatment in the laboratory. On the day of testing, which started the day after delivery, the two randomly selected hams were weighed. The hams were cut into a butt section and a shank end with an electric meat saw. Each part was then weighed separately. A one inch slice was cut off from the shank end to be used for marbling evaluation and for shear force measurements.

Marbling

Two judges graded the marbling of biceps femoris, rectus femoris, semimembranosus and semitendinosus on the one inch slice, cut from the shank end of the ham. A 5-point scale based on pictures, selected as representative of marbling by this laboratory and the laboratories of the Human Nutrition Research Division, U. S. Department of Agriculture, were used (Figure 2). The marbling score represented the amount of internal fat in proportion to the lean of the muscle. The following values for marbling were used:

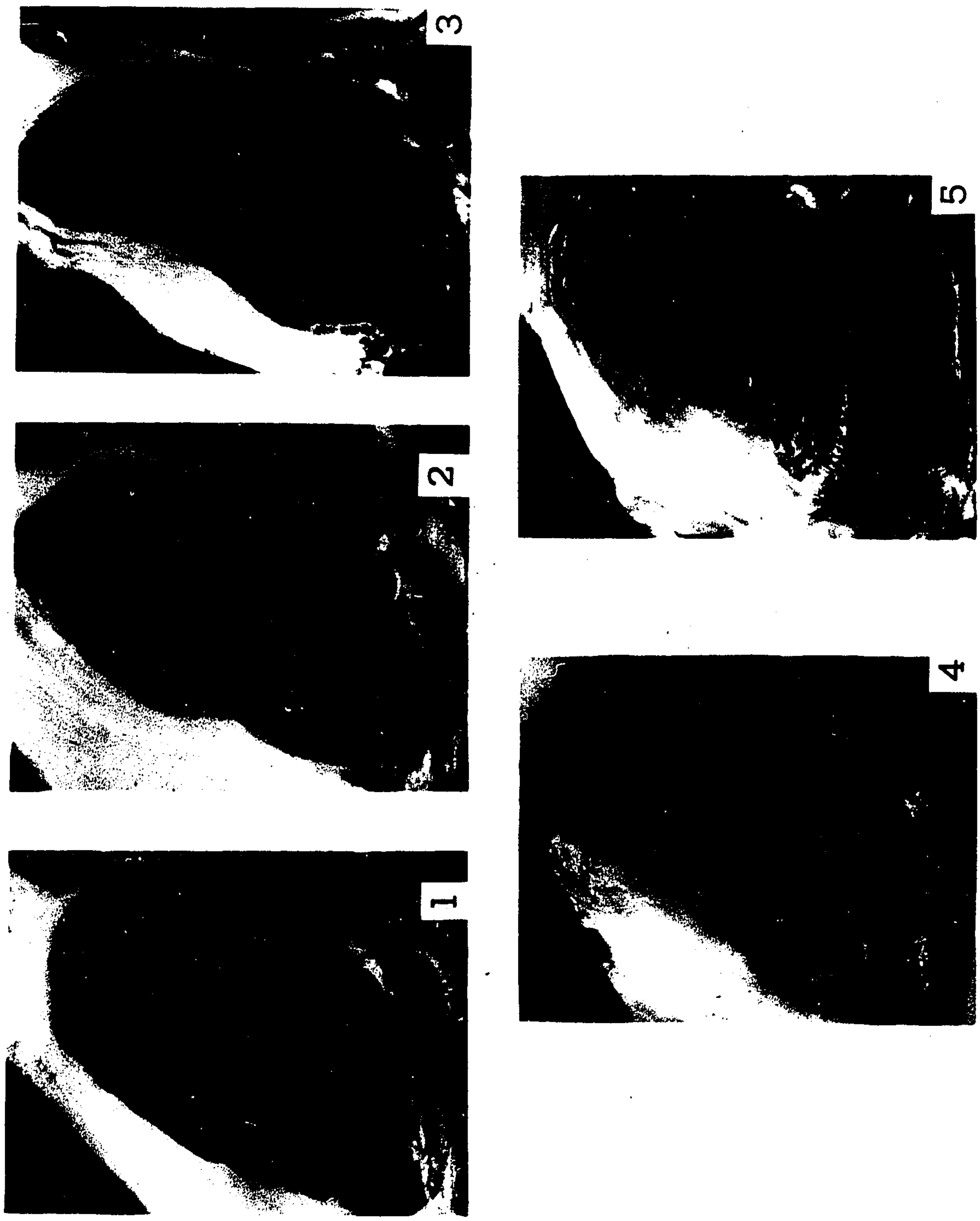
Description	Score
Abundant	5
Moderate plus	4
Moderate	3
Moderate minus	2
Slight	1

Yield of lean, fat and bone

After initial weights of the hams and marbling values were obtained a separation into lean, fat, bone and inedible waste was made on all hams in a laboratory that had temperature controlled. The weights of the lean, fat, bone and inedible waste were obtained and recorded.

Figure 2. Marbling scores for pork muscles

Description	Score
Abundant	5
Moderate plus	4
Moderate	3
Moderate minus	2
Slight	1


1
2
3
4
5

Cooked Cured Ham

Preparation and cooking procedure

The hams used for the cooking experiment were randomly selected and brought from the refrigerated room each morning the day they were tested.

The ovens were preheated to 325°F (162.8°C) for about 30 minutes. Two thermocouple wires encased in hypodermic needles were inserted one inch apart in the *biceps femoris* muscle of the ham and temperature was recorded by a potentiometer.[1] The temperature was recorded in a data book every 20 minutes until the internal temperature reached 125°F (51.7°C). Thereafter, recording of the temperature was carried out every 5 minutes until 130°F (54.4°C) was reached. Hams were immediately taken out of the oven, weighed, covered with aluminum foil and set aside for 15 to 20 minutes. Then hams were sawed close to the aitch bone into a butt section and a shank end.

Four muscles, *biceps femoris*, *rectus femoris*, *semimembranosus* and *semitendinosus* were separated from the shank end and external fat was removed from the muscles. Then four inches (10 cm) of *biceps femoris*, *semimembranosus* and *semitendinosus* were cut from the proximal end and three inches (7.5 cm) of the *rectus femoris*. All the pieces of muscles were weighed. One inch of the muscles first mentioned was used for the taste panel.

[1]Honeywell Reg. Co., Minneapolis, Minnesota. (Model No. 153 X 60P8 - X - 31 Fl.).

The rest of the weighed parts of the muscles was cut into a one inch slice for shear force and the remaining two inch piece was used for chemical analysis. These samples were placed in polyethylene bags and kept at room temperature until tested or prepared for chemical analysis. The cooked ham to be separated into lean, fat, bone and inedible waste was covered with aluminum foil and set aside for about half an hour.

Cooking losses

The total cooking loss included volatile loss and loss of the fat and juice which collected in the pan during cooking. The volatile loss was obtained by subtracting drip loss from total cooking losses.

Taste panel

Six well trained judges were chosen from the staff and graduate college of the university for a taste panel. The score sheets used by the panel members and the nine-grade scale for the three characteristics, flavor, tenderness and juiciness that was used are shown in Table 25, Appendix. The time of the testing was 12 o'clock every day during the experiment.

The biceps femoris, semimembranosus and semitendinosus muscles were evaluated by the panel members. Slices of the three muscles were assigned to the judges so that one slice was served to judge number one the first day; on the next day the same judge was served the number two slice and so on. This pattern was followed throughout the experiment.

Yield of lean, fat and bone

Raw and cooked hams were separated into lean, fat, bone and inedible waste. In separation procedures small weight losses occurred. The difference between the total weight and the sum of the individual parts was therefore considered preparation loss. The separation was carried out in a controlled temperature room (27^{o}C).

Shear Force

Objective evaluation of tenderness was conducted with a modified Warner-Bratzler shear force apparatus. One inch cores were cut from the biceps femoris, semimembranosus, semitendinosus and rectus femoris of both raw and cooked hams. The cores were cut with a sharp-edged cylinder, one inch in diameter. Three cores were obtained from the biceps femoris and the semimembranosus muscles and two cores from the semitendinosus and rectus femoris muscles. Two shear force measurements were made on each core; thus a total of six measurements were obtained on the first two muscles and four on the latter two muscles.

Chemical Analysis

Sample preparation

Two-inch (5 cm) samples were cut from the shank end muscles; biceps femoris, semimembranosus, semitendinosus and rectus femoris. The samples were trimmed of as much exterior fat as possible and were kept in polyethylene bags to prevent any loss of moisture, until the raw and cooked yield were completed. Then the two-inch samples from the four muscles were rapidly ground three times and mixed thoroughly between each grinding. A Hobart electric meatgrinder[1], which was equipped with a plate that had 3/16 inch (0.5 cm) openings, was used. The ground meat was packed in the polyethylene bags and precaution was taken to exclude as much air as possible. The package was sealed with masking tape to keep it compact and was placed in no. 1 tin cans, which were sealed on an automatic can sealing machine. Samples were immediately stored in a walk-in freezer at -10^{o}F (-23.3^{o}C). Three months later, moisture and fat content in four muscles and protein content in two muscles were determined.

Moisture

For moisture determinations, a Brabender semi-automatic moisture tester oven[2] was used. This oven is equipped with a

[1]Hobart Manufacturing Company, Troy, Ohio.

[2]Brabender Corporation, Rochelle Park, New Jersey.

slowly rotating turntable that contains ten aluminum cups for samples. The oven has a balance for weighing the samples one at the time during the drying period without removing the sample from the drying cabinet. The per cent of moisture is read directly from a scale on the instrument. During drying, the temperature was kept at 102 $\pm$ 1^{o}C. Teflon coated (polytetrafluorethylene) aluminum cups were used for the raw ham and plain aluminum cups for the cooked ham. A five gram portion of each the raw and cooked ham was used.

Preliminary work was carried out to find thawing and drying time for the ham samples. Approximately one hour was found satisfactory to thaw the samples. Then, the sample was thoroughly mixed in the closed polyethylene bag and a five gram sample was rapidly and accurately weighed into the aluminum cup. Preliminary drying experiments indicated that the ham samples should be dried for 1.5 hours. Readings were taken at intervals of 30 minutes at the beginning and 15 minute intervals near the end of the drying period. The samples were considered dry when the change in moisture was not more than 0.1 per cent in 30 minutes. When the samples were dry, the cups with the ham samples were kept in a desiccator for approximately 30 minutes to cool.

Fat

After the dried ham was removed from the aluminum cups and wrapped in fat-free Whatman filter paper No. 43, the sample was pounded with a porcelain pestle to get smaller particles for a more efficient extraction. When the sample seemed to contain a large amount of fat a second filter paper was used to protect the sample from losing any of the fat.

A Goldfisch fat extraction apparatus[1] and petroleum ether (boiling range: 38.7°C-50.5°C) was used for the fat determinations. The sample in the filter paper was placed in a clay extraction thimble, which was put into the thimble holder and set in a clean dry weighed Goldfisch beaker. The aluminum cup used for drying the ham sample was rinsed with small amounts of petroleum ether. The rinsing procedure was carried out about six times to assure that all the sample and fat were transferred into the extraction thimble and about 35 to 40 ml of petroleum ether were used. The beaker with the thimble then was placed in the extraction apparatus.

Preliminary work indicated that six hours of extraction were sufficient to remove all the fat from the sample. When the extraction was completed the petroleum ether was evaporated on a steam bath. The Goldfisch beakers with the fat were dried at 100°C for 90 minutes in an air oven. Then the beakers were placed in a desiccator to be cooled and weighed. The weight of the fat was obtained by difference in weight of the beakers before and after the fat extraction.

[1]Laboratory Construction Corp., Kansas City, Missouri. (No. 950).

Protein

Protein was determined indirectly on the fat extracted samples by a modified Micro-Kjeldahl method (Perrin 1953). Prior to the protein analysis, the samples were ground in a Wiley mill, 20 mm mesh.

The amount of nitrogen in the samples was calculated by the formula:

$$\frac{\text{ml HCl} \times \text{N HCl} \times \text{wt of N}}{\text{wt of sample}} \times 100 = \text{per cent N} .$$

The weight of the sample was corrected for fat and moisture. In general, protein contains about 16 per cent nitrogen. The factor used to convert nitrogen to protein was 6.25. Therefore, N x 6.25 = per cent protein.

Part II. Fatty Acid Composition

One objective of the second part of this study was to examine the fatty acid content of one breed of hogs chosen to represent animals with low backfat thickness versus a breed of hogs with a high amount of backfat. The animal breeders suggested that Duroc and Hampshire hogs would have the desired contrast in amount of backfat. Thus 8 Duroc and 8 Hampshire hogs were selected on the basis of probe measurements made on the live hogs on the Iowa State University farm. However, measurements taken after slaughter revealed that the backfat on carcasses from Duroc hogs averaged 1.6 inches, with a range of 1.4 to 1.8 and from Hampshires averaged 1.3 inches with a range of 1.1 to 1.4 inches. Although there was very little similarity in backfat in the two groups, see Table 49, Appendix, there was not as much difference between the two groups as had been predicted from the probe measurements on the live animal.

The 16 hogs were 5 months old and weighed about 211 pounds (Table 49, Appendix). The ration given to the hogs is in Table 48, Appendix. The pigs were slaughtered by the Hormel Packing Company, Fort Dodge, Iowa. One day after slaughter, fresh hams from one side of each animal were delivered to the Meat Laboratory at Iowa State University. One week later, the cured, smoked and fully cooked hams from the same animals were received. After arrival, both fresh and cured hams were packaged in Cry-o-vac and stored in a walk-in freezer at a temperature of -10^{o}F (-23.3^{o}C). They were kept frozen during the test period which was approximately one month. Weight of hams before cure ranged for Duroc from 13.2 to 14.6 pounds (average 13.9 pounds) and for Hampshire 13.9 to 17.1 pounds (average 14.8 pounds). Weights of hams after cure ranged from 12.1 to 18.1 pounds (average 15.2 pounds) for Hampshire and from 13.4 to 15.3 pounds (average 14.2 pounds) for Duroc.

Raw fresh hams, cooked fresh hams and raw cured, smoked hams were tested in this part of the investigation. The raw ham was divided in two parts: the butt half was analyzed raw, the shank end was analyzed cooked. The other ham from the same animal was cured, smoked and fully cooked and did not receive any further heat treatment in this laboratory before analysis. The hams were frozen.

Biceps femoris, semitendinosus and rectus femoris muscles from each treatment were analyzed for their total fat content as extracted by chloroform-methanol, fatty acids of the lipid mixture obtained by the extraction were determined by gas chromatography.

Preparation of samples

The frozen ham was removed from the freezer the day before testing. The frozen ham was sawed into a shank end and a butt half with an electric meat saw. Both parts of the ham were thawed over night in a refrigerator at a temperature of 34°F (1.5°C). Thermocouple wires encased in hypodermic needles were inserted in the three muscles of the shank end of the fresh ham that was baked at 325°F (163°C) until the internal temperature of the muscles reached 185°F (85°C). A one inch piece of biceps femoris, rectus femoris and semitendinosus from the raw, the cooked fresh ham and the cured, smoked and fully cooked ham was ground three times in an ice cold Hobart meat grinder, packed in polyethylene bags and stored in a walk-in refrigerator at a temperature of 34°F (1.5°C) during the analyses.

Fat extraction

The method used for the determination of the total lipids in the ham muscles was that reported by Folch _et al_. (1957). The chloroform-methanol and petroleum ether used during the extraction were evaporated with reduced pressure under nitrogen. The weight of total fat was obtained by subtracting the weight of the flask from the weight of the flask plus the fat.

Fatty acid determination

The methyl esters were prepared from the total lipid by the method of Stoffel _et al_. (1959) with modifications suggested by Hammond.[1] Approximately 50 mg of the lipid mixture were transferred to the interesterification tube and 2 ml of anhydrous sodium hydroxide in methyl alcohol (0.25 per cent) were added. The mixture was refluxed in a bath of 550 silicone oil (Dow Corning) at 85-90^{o}C for about 1½ hours with frequent shaking at the start to dissolve the lipid mixture. After cooling to room temperature, 1 ml Skelly B, 1 drop concentrated hydrochloric acid and 5 ml distilled water were added. The mixture was centrifuged for 5 minutes and the upper phase containing the methyl esters were transferred to storage tubes and dried over a 1:1 mixture of sodium sulfate-sodium bicarbonate. The methyl esters were stored under nitrogen in a refrigerator at 34^{o}F (1.5^{o}C) until they were analyzed. The analysis was performed on a gas chromatograph[2] using polyester succinate

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[1]Hammond, E. G. Modification of interesterification procedure. Personal communication. Iowa State University of Science and Technology, Ames, Iowa.

[2]This instrument was locally constructed and used a thermal conductivity cell.

as a stationary phase at 210°C (Craigh and Murty 1959). The column was a coiled tube of $\frac{1}{4}$ inch copper $7\frac{1}{2}$ feet long. The carrier gas was dried helium at a flow rate of approximately 60 ml per minute. The peaks were identified by comparison to known methyl esters. The calculation for the percentage weight of the different fatty acid esters of the ham muscles was made by measuring the area under the peaks by triangulation.

RESULTS AND DISCUSSION

Part I

Hams from 48 carcasses were obtained from Rath Packing Company, Waterloo, Iowa. Animals were randomly selected and the backfat thickness ranged from 1.0 to 2.3, with increments of 0.1 inch. Information on the live hogs as well as on the carcasses given by the packing company was as follows:

1. Age: 5.5-8.0 months
2. Breed: Hampshire (3)
   Tamworth (1)
   Yorkshire (4)
   Chester White (2)
   Duroc (3)
   Crossbreeds (9)
3. Sex: 22 females, 22 males and 4 unknown
4. Live weight: 215-230 pounds (average 223 pounds)
5. Carcass weight: 148-168 pounds (average 156 pounds)
6. Carcass length: 27-34 inches (average 30 inches)
7. U. S. grades: U.S. No. 1 - 22 carcasses
   U.S. No. 2 - 12 carcasses
   U.S. No. 3 - 13 carcasses

It should be mentioned that as the backfat increased the age decreased. More detailed information is given in Table 26, Appendix.

Weight of hams before cure ranged from 11.2 to 18.2 pounds. Cured hams ranged in weight from 11.7 to 18.5 pounds and averaged 14.5 pounds. Based on weight before pumped, some hams gained while others lost. The gain in weight ranged from 0.1 to 1.2 pounds. Weight losses ranged from 0.1 to 1.7 pounds (Table 27, Appendix).

Marbling

Marbling is the term used to describe the streaks of fat deposited in the muscle. Scores for marbling were obtained for biceps femoris, rectus femoris, semimembranosus and semitendinosus muscles of the cured, smoked and fully cooked hams. Judgments were based on pictures (Figure 3) selected as representative of 5 degrees of marbling and used by judges in this laboratory and in the laboratories of the Human Nutrition Research Division in assigning scores for marbling (Batcher and Dawson 1960).

Average marbling scores for muscles in the hams were 2.5 for biceps femoris, 2.4 for semimembranosus, 2.2 for semitendinosus and 1.1 for rectus femoris. The marbling score was 1 for all rectus femoris muscles with the exception of those in 4 hams (Table 28, Appendix). A slice of ham from a carcass with 1.9 backfat thickness and with a low marbling score in rectus femoris and with a high score for biceps femoris, semimembranosus and semitendinosus is shown in Figure 3a. Also, a slice of ham from a carcass with 1.2 backfat thickness and with a low marbling score for all muscles is shown in Figure 3b.

Figure 3. Slices of ham illustrating degrees of marbling

Animal 37: Backfat thickness 1.9 inches

Muscle	Score
rectus femoris	1
biceps femoris	3
semimembranosus	4
semitendinosus	3

Animal 165: Backfat thickness 1.2 inches

Muscle	Score
rectus femoris	1
biceps femoris	2
semimembranosus	2
semitudinosus	2

The data on marbling scores revealed that most of the hams were in the moderate groups of marbling. Although 5 was the highest possible marbling score, no muscle was given that score. In only 5 cases, the marbling score was 4 for one of the muscles; that is the <u>semimembranosus</u> muscle.

Statistical analysis of the regression of marbling scores for the four muscles indicated that there was no trend for marbling to increase as the backfat increased (Table 31, Appendix). This is in agreement with the findings of Oñate (1961), who reported on marbling in the <u>longissimus dorsi</u> muscle between the 10th and the 11th rib of pork roasts. Murphy (1959) reported that marbling in the posterior part of the <u>longissimus dorsi</u> from the same loins as those used in the investigation by Oñate (1961) were positively related to the backfat thickness. Also, findings by Saffle and Bratzler (1959) showed positive relation between marbling and backfat thickness; however, marbling was measured by specific gravity and ether extract.

Yield of Raw Cured Ham

Yield of cured, smoked and fully cooked hams was based on lean, fat, bone and inedible waste which was separated by hand with knives. Distribution of the weights of 96 raw hams are summarized in Table 5 and ranged from 11.7 pounds to 18.5 pounds (5.31 kg - 8.40 kg).

Table 5. Distribution of weights of raw[a] and cooked hams

Weight intervals lbs	Number of hams	
	Raw	Cooked
9 - 10		2
10.1 - 11		8
11.1 - 12	1	13
12.1 - 13	11	10
13.1 - 14	29	11
14.1 - 15	22	2
15.1 - 16	20	2
16.1 - 17	8	
17.1 - 18	4	
18.1 - 19	1	
Total	96	48

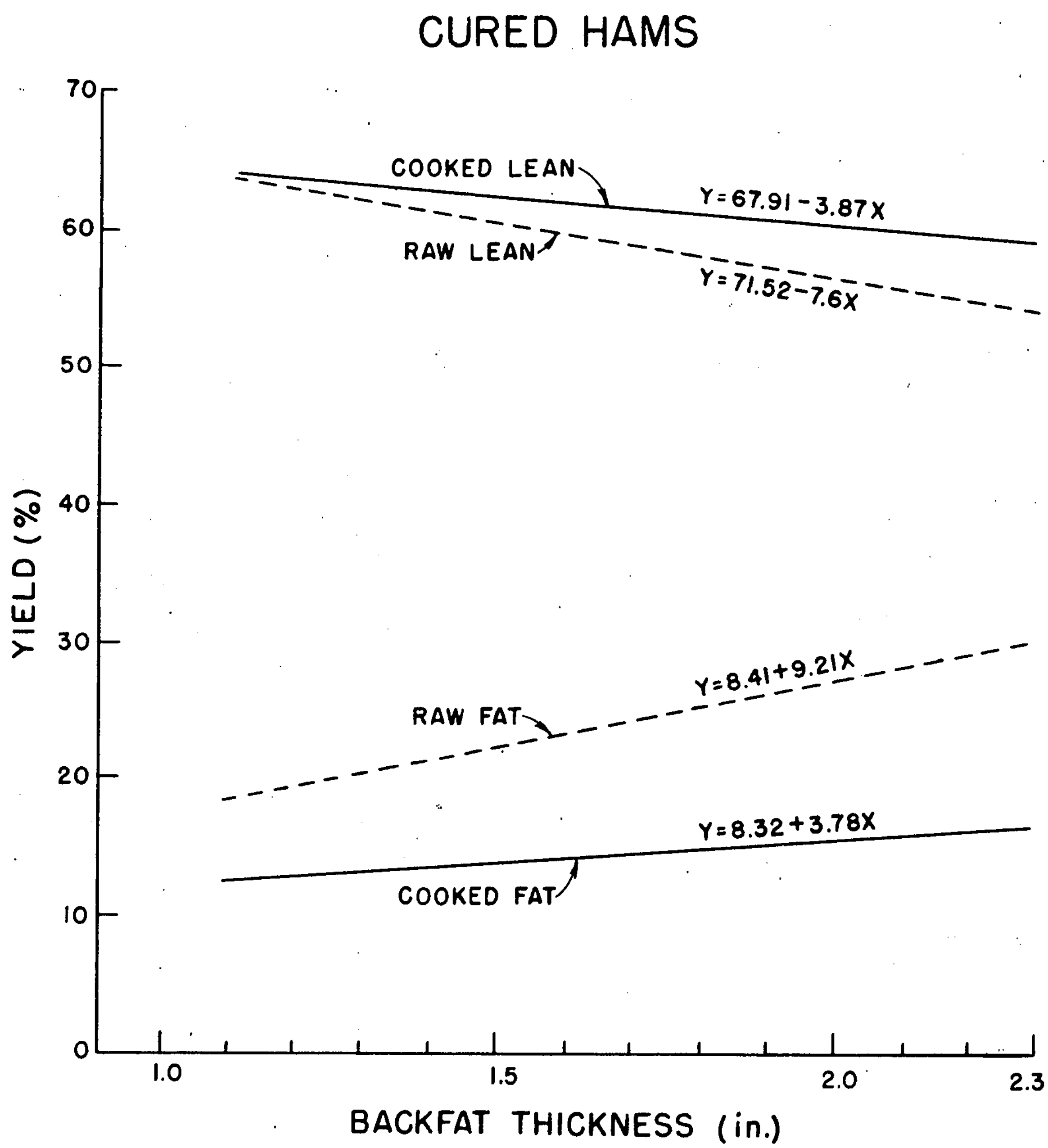
[a]Data on raw hams were provided by Rath Packing Company.

Data for the yield of 48 raw hams indicated that there was an average of 59 per cent lean, 23 percent fat and 10 per cent bone (Table 29, Appendix). These values correspond to an average weight of 8.6 pounds of lean, 3.4 pounds of fat and 1.4 pounds of bone for hams with an average weight of 14.5 pounds

(6.5 kg). The range for lean of raw hams was from 51 to 68 per cent, the fat ranged from 12 to 32 per cent and the bone ranged from 8 to 12 per cent. As the amount of backfat increased, the amount of separable fat increased (Figure 4). Contrary to the yield of fat, the yield of lean and bone decreased as the backfat increased.

Analysis of regression of the data for raw yield on backfat thickness revealed that the increase of fat and decrease of lean and bone was highly significant (Table 31, Appendix). It should be noted that the decrease in bone of raw ham was statistically significant; however, this is of little practical importance, as the decrease in yield was only 1.56 per cent for each one inch increase in backfat thickness. Data reported by Oñate (1961) and Murphy (1959) on pork roasts and chops, from the same animals as used in the present study, indicated that the regression of per cent yield of raw lean and fat on backfat thickness was significant. Although the bone from raw loin chops was not significantly related to backfat thickness, the bone from raw rib chops and roasts was related to backfat thickness at the 1 per cent level. Results from these three studies gave strong evidence that backfat thickness can be used to predict per cent yield of separable lean, fat and bone in raw pork loins and hams with a high degree of precision.

Figure 4. Regression of yield of lean and fat of raw and cooked hams on backfat thickness


CURED HAMS
COOKED LEAN
Y=67.91-3.87X
RAW LEAN
Y=71.52-7.6X
Y=8.41+9.21X
RAW FAT
Y=8.32+3.78X
COOKED FAT
YIELD (%)
70
60
50
40
30
20
10
0
1.0
1.5
2.0
2.3
BACKFAT THICKNESS (in.)

Yield of Cooked Cured Ham

Distribution of weights of hams after cooking is presented in Table 2. The total yield of cooked hams expressed in per cent of the weight of raw hams ranged from 78 to 88 per cent for individual hams which in weight corresponds to 10.3 pounds and 12.5 pounds, respectively (Table 30, Appendix). Cooked yield of loins from the same animals as those used in this investigation ranged from 73 to 87 per cent (Oñate 1961). Average per cent yield of cooked hams was 84 per cent, which is 4 percentage points higher than the average per cent yield for the pork roasts.

The averages for yield of separable lean fat and bone in 48 raw and cooked hams (Table 6) indicated that regardless of backfat thickness, the yield of fat was about 9 percentage points higher in cooked than in räw hams. However, the yield of bone was the same for both raw and cooked hams, i.e. 10 per cent. Also, the yield of lean and fat in raw and cooked hams can be compared in Figure 4.

Table 6. Yield of lean, fat and bone from cured, smoked and fully cooked hams from 48 hog carcasses

	Raw ham		Cooked ham[a]	
	Range	Average	Range	Average
	%	%	%	%
Lean	51-68	59	56-70	62
Fat	12-32	23	10-20	14
Bone	8-12	10	4-13	10

[a]Per cent yield based on weight of cooked meat.

A comparison of the data reported by Oñate (1961) in which loins had an average value of 53 per cent for lean, 19 per cent for fat and 22 per cent for bone, with the data on hams investigated in this study (Table 6), revealed that cooked hams had a higher proportion of lean than the rib roasts. Furthermore, the amount of fat and bone are lower in the hams than in the loins and the pork chops (Murphy 1959) from the same animals.

Although there were some fluctuations in the yield of separable fat from cooked hams (Table 31, Appendix), an analysis of regression of the data revealed the b value was 3.78 per cent or an increase of approximately 4 per cent of fat for each one inch increase in backfat thickness, which is significant at the 0.1 per cent level. The b value of -3.87 for lean revealed that the decrease in the amount of lean in cooked hams on backfat thickness was highly significant (Table 31, Appendix). Backfat thickness can be used as an indicator for the yield of lean and fat of raw and cooked hams, since the statistical analysis indicated that an increase in backfat thickness significantly affects the yield of separable fat and lean in both raw and cooked hams.

Shear Force

Shear force, a measurement of tenderness as estimated by physical means, was obtained from three one-inch cores of *biceps femoris* and *semimembranosus* and two one-inch cores of semitendinosus and rectus femoris from raw and cooked hams. The Warner-Bratzler apparatus was used, measurements were made in pounds and readings were averaged for all cores from each muscle. Averages and ranges of shear force values indicated that shear force for all four muscles of both raw and cooked hams fluctuated somewhat as backfat thickness increased (Tables 32 and 33, Appendix and Table 7). However, analysis of vari-

Table 7. Ranges of shear force values from four muscles of raw and cooked cured ham

	Range			
	BF[a]	SM[a]	ST[a]	RF[a]
	lbs.	lbs.	lbs.	lbs.
Raw	5.1-20.0	3.5-14.6	1.4-10.4	1.8-8.0
Cooked	4.9-13.3	3.4-17.2	2.0-11.7	1.1-15.8

[a]BF = biceps femoris; SM = semimembranosus; ST = semitendinosus; RF = rectus femoris.

ance of the differences in shear force between muscles of both raw and cooked hams was significant at the 1 per cent level between biceps femoris and rectus femoris; biceps femoris and semitendinosus; and at the 5 per cent level between biceps femoris and semimembranosus (Table 8). The magnitude of the actual shear force values of raw muscles were for biceps femoris 9.5 pounds, semimembranosus 8.5 pounds, semitendinosus 6.4 pounds and rectus femoris 5.2 pounds. For cooked ham muscles

Table 8. Analyses of variance of differences of shear force for *biceps femoris*, *semimembranosus*, *semitendinosus* and *rectus femoris* in raw and cooked cured hams

Source of variation	d.f.	M.S.	F value
Raw ham			
BF vs SM			
Mean	1	53.55	5.08*
Regression	1	10.36	
Residual	46	10.54	
Total	47		
BF vs ST			
Mean	1	481.96	52.82**
Regression	1	18.11	
Residual	46	9.12	
Total	47		
BF vs RF			
Mean	1	885.21	102.51**
Regression	1	7.57	
Residual	46	8.64	
Total	47		
Cooked ham			
BF vs SM			
Mean	1	47.60	5.46*
Regression	1	0.04	
Residual	46	8.71	
Total	47		
BF vs ST			
Mean	1	284.43	53.46**
Regression	1	0.0008	
Residual	46	4.65	
Total	47		
BF vs RF			
Mean	1	288.60	41.39**
Regression	1	9.61	
Residual	46	6.97	
Total	47		

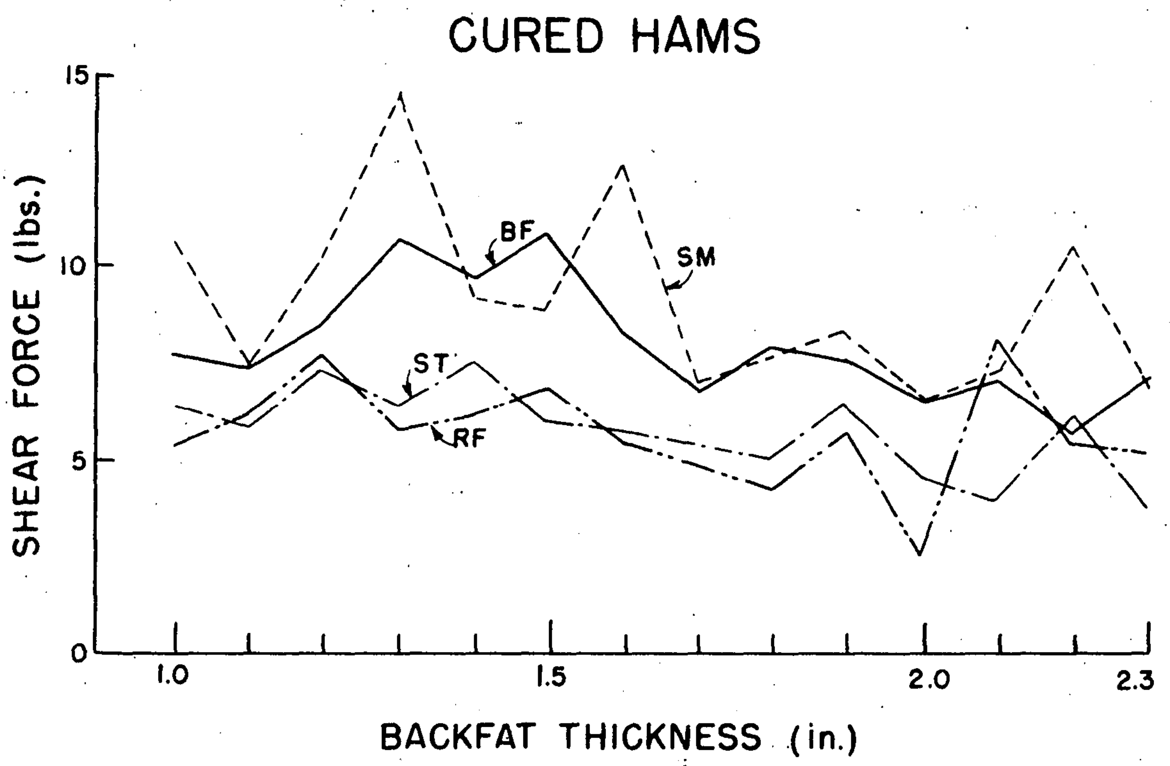
*5% level of significance.

**1% level of significance.

the shear force values were for biceps femoris 8.0 pounds, semimembranosus 9.0 pounds, semitendinosus 5.8 pounds and rectus femoris 5.7 pounds. Batcher and Dawson (1960) conducted their investigation on raw and cooked fresh ham and measured the shear force with the Lee-Kramer shear press. The biceps femoris was the least tender in comparison with the adductor, semitendinosus and semimembranosus, which is consistent with the results obtained in this study. Examination of Figure 5 reveals that the degree of differences in tenderness between the muscles biceps femoris and semimembranosus and between rectus femoris and semitendinosus were slight. These observations are in agreement with the statistical analysis of differences between muscles.

The regression of the shear force values of raw ham muscles on backfat thickness indicated that as the backfat thickness increased the tenderness as measured by the shear force increased in the biceps femoris and rectus femoris muscles at the 5.0 per cent level and 0.5 per cent level respectively (Table 34, Appendix). Furthermore, the regression of shear force values for cooked ham muscles on backfat thickness revealed a significant relation between the shear force values of biceps femoris and semitendinosus and backfat thickness at the 5 per cent and 1 per cent levels, respectively. However, considering the wide range for each individual muscle, the practi-

Figure 5. Relation between shear force measurements on four ham muscles and backfat thickness of the hog carcass


CURED HAMS
15
10
5
0
SHEAR FORCE (lbs.)
BF
SM
ST
RF
1.0
1.5
2.0
2.3
BACKFAT THICKNESS (in.)

cal significance of the increase in shear force, i.e., 1.77 pounds for biceps femoris with each increase in backfat thickness, is of minor importance (Table 34, Appendix).

Cooking Losses

Cooking time ranged from 13.5-17 minutes per pound for hams cooked at 325°F to an internal temperature of 130°F. Data on per cent drip loss, volatile loss and total cooking loss for individual hams were computed from the weight of the raw hams (Table 35, Appendix). Drip losses ranged from 5 to 15 per cent, volatile losses from 5 to 10 per cent and total cooking losses from 12 to 22 per cent.

The average losses for all hams were 9 per cent for drip loss, 7 per cent for volatile loss and 16 per cent for total cooking loss. Average cooking losses for pork roasts reported by Oñate (1961) were 6 per cent for drip loss, 15 per cent for volatile loss and 21 per cent for total cooking losses. Thus, total cooking losses were 5 percentage points lower in hams than in loins. Furthermore, volatile losses for hams were about 8 percentage points lower than for pork roasts. Murphy (1959) reported total cooking losses for pork chops of about 30 per cent of the raw weight, drip loss was 5 per cent and volatile loss 26 per cent regardless of the backfat thickness.

Regression statistics on cooking losses of cured, smoked and fully cooked hams on backfat thickness are presented in Figure 6 and in Table 31, Appendix. The relation between backfat thickness and drip loss and total cooking loss was highly significant. Contrary, the volatile loss was not related to backfat thickness. Similar results were reported by Oñate (1961) on pork roasts. Data by Murphy (1959) on pork chops indicated significant relation of drip, volatile loss and total loss on backfat thickness. However, Saffle and Bratzler (1959) reported no significant relation between total cooking losses of hams and backfat thickness. In summary, under the conditions used in this study, backfat thickness affected drip loss and total cooking loss, but not volatile loss.

Chemical Composition

Moisture and fat content were determined for biceps femoris, rectus femoris, semimembranosus and semitendinosus muscles from raw and cooked cured, smoked and fully cooked hams. However, protein content was determined for biceps femoris and rectus femoris only. Duplicate samples were analyzed for each muscle and average values for the chemical composition are presented in Tables 36, 37, 38, 39, 40, 41, 42 and 43, Appendix.

Moisture

For all muscles, the moisture content ranged from 65 to 77 per cent in raw ham and 61 to 75 per cent in cooked ham regardless of backfat thickness (Table 9).

Figure 6. Regression of cooking losses on backfat thickness of cured smoked and fully cooked hams

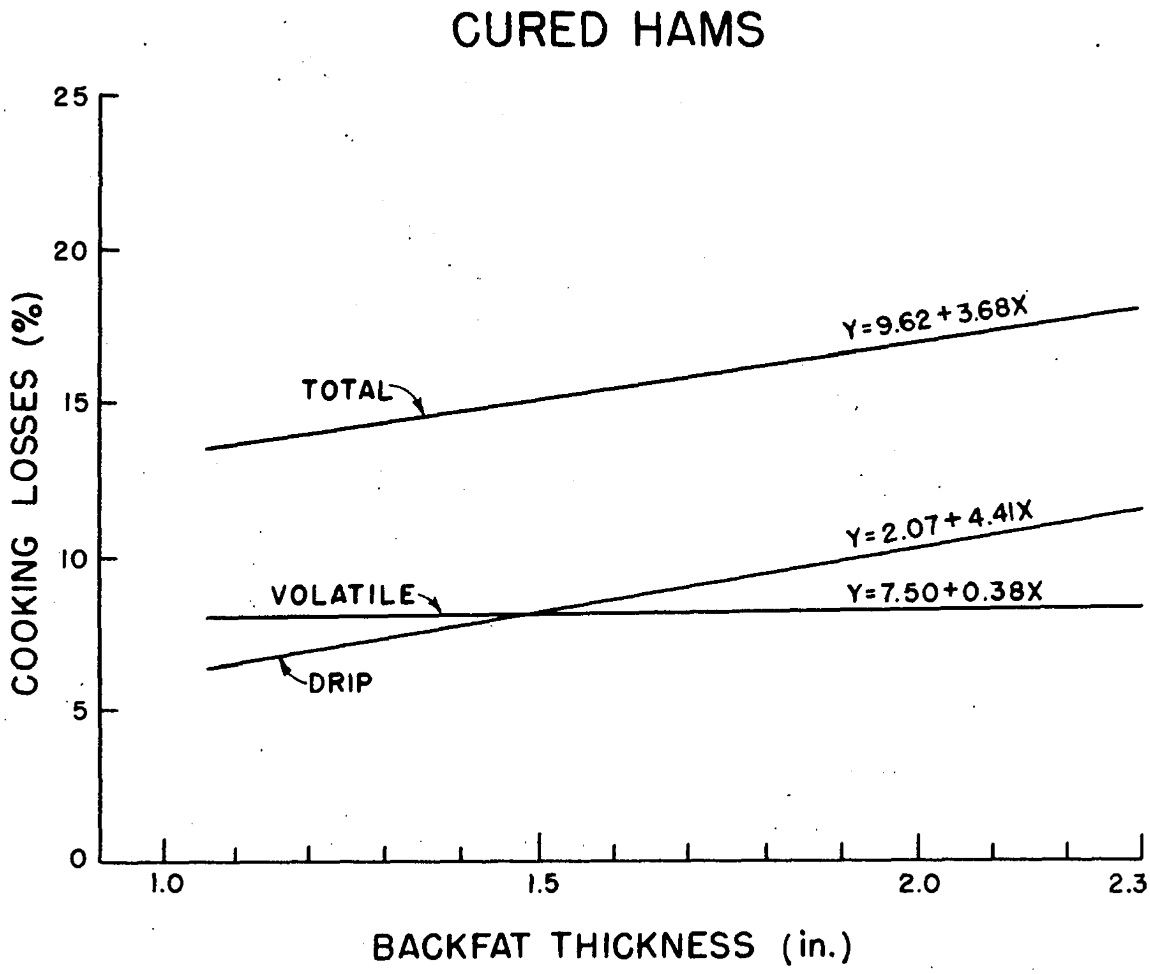

CURED HAMS
COOKING LOSSES (%)
25
20
15
10
5
0
TOTAL
Y=9.62+3.68X
Y=2.07+4.41X
VOLATILE
Y=7.50+0.38X
DRIP
1.0
1.5
2.0
2.3
BACKFAT THICKNESS (in.)

Table 9. Per cent moisture of four ham muscles

Treatment and muscle	Range	Average
	%	%
Raw cured ham		
biceps femoris	68.1-74.3	71.8
semimembranosus	68.9-73.9	71.7
semitendinosus	65.4-74.7	71.2
rectus femoris	67.4-76.8	72.4
Cooked cured ham		
biceps femoris	61.8-71.0	67.5
semimembranosus	65.8-73.2	69.9
semitendinosus	61.1-75.1	70.8
rectus femoris	63.1-74.0	69.7

Moisture in raw ham averaged about 72 per cent for *biceps femoris*, *semimembranosus* and *rectus femoris* and 71 per cent for *semitendinosus*; cooked ham averaged about 71 per cent for *semitendinosus*, 70 per cent for *semimembranosus* and *rectus femoris* and 68 per cent for *biceps femoris*. Thus, the moisture content was slightly higher in raw than cooked meat, which is in agreement with findings by Oñate (1961) and Batcher and Dawson (1960). However, differences in moisture between raw and cooked cured hams were of a smaller magnitude than that reported for fresh hams in the study by Batcher and Dawson (1960).

Statistical regression analysis of the data on moisture content in four muscles of raw and cooked hams on backfat thickness revealed that there was no relation of moisture content to backfat thickness in either raw or cooked ham (Table 10).

Table 10. Regression of per cent moisture of biceps femoris, semimembranosus, semitendinosus and rectus femoris on backfat thickness

	Regression statistics		
	a	b	t
Raw			
biceps femoris	72.2	0.26	0.56
semimembranosus	70.8	0.50	1.19
semitendinosus	70.3	0.56	0.89
rectus femoris	72.6	0.14	0.24
Cooked			
biceps femoris	67.9	0.27	0.37
semimembranosus	70.0	0.04	0.07
semitendinosus	71.2	0.29	0.31
rectus femoris	69.8	0.03	0.04

Fat

The intramuscular fat content of raw and cooked ham muscles was determined by ether extraction. Average values for duplicate samples of biceps femoris, rectus femoris, semimembranosus and semitendinosus of raw and cooked cured ham are presented in Tables 36, 37, 38, 39, 40, 41, 42 and 43, Appendix. Examination of Table 11 indicates that in raw ham, semitendinosus muscle had the highest fat content, rectus femoris the least fat. The fat content was higher in cooked cured ham than in raw ham, with the exception of the semitendinosus and semimembranosus muscles. Batcher and Dawson (1960) reported that the intramuscular fat content was higher in all muscles of the cooked fresh ham as compared with those in raw fresh ham. The range in fat content was greatest in the semitendinosus muscle regardless of backfat thickness. In the two leaner muscles, the ranges were smaller (Table 11).

Table 11. Per cent fat content[a] of four ham muscles

Treatment and muscle	Range	Average
Raw cured ham	%	%
biceps femoris	2.0-12.0	4.6
semimembranosus	1.7- 7.3	3.6
semitendinosus	2.7-16.4	6.4
rectus femoris	1.2- 6.1	2.6
Cooked cured ham		
biceps femoris	3.1-15.9	6.3
semimembranosus	2.0- 8.8	3.3
semitendinosus	2.6-17.0	5.8
rectus femoris	1.7- 6.0	3.1

[a]Based on wet weight.

The results reported by Briskey (1960) who obtained per cent fat of raw fresh ham muscles (biceps femoris with 4.8 per cent and rectus femoris with 2.6 per cent), compared well with those in this study, although the results in this study were from cured hams. Similar results were obtained on fresh hams by Batcher and Dawson (1960). They also reported on cooked fresh ham muscles which contained a slightly higher amount of fat than those in this study. It might be expected, since their hams were fresh and cooked to a higher temperature, which influenced the cooking loss and in turn the chemical composition with a lower moisture content and a higher fat content. Variation in the fat content of biceps femoris for hams from carcasses within a backfat thickness group was as great as variation between backfat thickness groups. Similar results were obtained for all muscles (Tables 36, 37, 38, 39, 40, 41, 42 and 43, Appendix).

Examination of Table 12 indicates that there were very slight differences in the fat content of both raw and cooked muscles between the four backfat thickness groups.

Table 12. Average per cent fat content of four muscles of raw and cooked cured ham

Backfat thickness	BF[a]	RF[a]	SM[a]	ST[a]
Raw cured ham	%	%	%	%
1.0-1.2	4.1	2.4	3.4	6.2
1.3-1.6	4.9	2.9	4.0	7.3
1.7-1.9	4.8	2.4	3.8	6.8
2.0-2.3	4.7	2.6	3.4	5.5
Cooked cured ham				
1.0-1.2	5.6	2.9	3.0	5.1
1.3-1.6	6.8	3.0	3.6	6.3
1.7-1.9	6.3	2.8	3.3	5.9
2.0-2.3	6.6	3.4	3.4	5.7

[a]BF = *biceps femoris*; RF = *rectus femoris*; SM = *semimembranosus*; ST = *semitendinosus*.

Analysis of regression of the relation of fat content from raw and cooked ham to backfat thickness revealed no significant relation of fat from any of the four muscles analyzed to backfat thickness (Table 13). The findings by Oñate (1961) indicated that the intramuscular fat content of raw and cooked rib roasts was not related to backfat thickness. However, fat content of the raw pork chops was related to backfat thickness at the 5 per cent level. Thus it was found that ether extracted intramuscular fat can not be used as a reliable criterion for evaluating quality of cured smoked and fully cooked hams. Similar results on fresh hams were obtained by Batcher and Dawson (1960).

Table 13. Regression analysis of per cent fat from four muscles of raw and cooked cured hams on backfat thickness

Treatment and muscle	Regression statistics		
	a	b	t
Raw			
<u>biceps femoris</u>	3.62	0.61	0.98
<u>semimembranosus</u>	3.74	0.07	0.16
<u>semitendinosus</u>	7.65	0.74	0.93
<u>rectus femoris</u>	2.40	0.11	0.39
Cooked			
<u>biceps femoris</u>	5.15	0.71	0.85
<u>semimembranosus</u>	3.00	0.20	0.49
<u>semitendinosus</u>	5.41	0.21	0.23
<u>rectus femoris</u>	2.63	0.29	0.96

A multiple regression was computed in which the relation of both marbling and backfat thickness to fat content in the four muscles of cured hams was considered. The results indicated that in all cases marbling and backfat thickness were significantly related to fat content (Table 14). Therefore, marbling and backfat thickness combined is a better indication of fat content than backfat thickness alone.

Similar results were obtained by Oñate (1961) on pork roasts and pork chops. Also findings by Judge *et al.* (1960) agree with these results. Therefore, it is evident that marbling, as judged subjectively, is shown by this research to be a reliable measure of the actual amount of intramuscular fat of muscles from hams.

Protein

Data obtained from Micro-Kjeldahl analyses of nitrogen for *biceps femoris*, and *rectus femoris* were used to compute average values of per cent protein for each muscle of the raw and cooked hams (Tables 36, 39, 40 and 43, Appendix). A comparison of the data from raw and cooked cured hams revealed that cooked ham muscles contained about 2 to 3 percentage points more protein than the raw muscles (Table 15). A further examination of the table indicates that the *rectus femoris* which was found to contain less fat than the *biceps femoris* muscle contained more protein. Also, the range in protein content was

Table 14. Multiple regression of per cent fat (Y) of four muscles of raw and cooked cured ham on degree of marbling (X_2) and on backfat thickness (X_1)

	a	b_1	t_1	b_2	t_2
Raw ham					
biceps femoris	0.79	0.58	1.02	1.13	3.33**
semimembranosus	1.95	0.11	0.27	0.77	3.67**
semitendinosus	3.55	1.28	2.26	2.26	6.89**
rectus femoris	0.95	0.03	0.12	1.43	5.94**
Cooked ham					
biceps femoris	1.74	0.67	0.87	1.36	2.94**
semimembranosus	1.78	0.18	0.46	0.52	2.65**
semitendinosus	1.67	0.28	0.35	2.06	4.52**
rectus femoris	1.49	0.22	0.83	1.13	3.87**

**Significant at the 1 per cent level.

Table 15. Per cent protein content[a] of two ham muscles

Treatment and muscle	Range	Average
Raw cured ham	%	%
biceps femoris	15.4-21.5	18.6
rectus femoris	16.5-25.6	20.7
Cooked cured ham		
biceps femoris	16.4-24.6	21.7
rectus femoris	18.2-28.9	22.8

[a]Based on wet weight.

greater for rectus femoris than for biceps femoris.

Regression analysis revealed that protein content and backfat thickness were not related (Table 16). Oñate (1961), who investigated the relation of protein to backfat thickness in pork roasts and pork chops, found a significant relation of protein and backfat thickness. However, she stated that the increase was of such small magnitude that the practical significance was relatively minor.

A comparison of the chemical composition of cooked pork roasts and rib and loin chops with cooked cured hams, all obtained from the same carcasses, revealed that cooked ham had less fat, less protein but higher moisture and residual content than either pork roasts or pork chops (Table 17).

Table 16. Regression analyses of protein from two muscles from raw and cooked cured ham on backfat thickness

Treatment and muscle	Regression statistics		
	a	b	t
Raw cured ham			
biceps femoris	20.02	0.87	1.98
rectus femoris	21.03	0.18	0.26
Cooked cured ham			
biceps femoris	21.74	0.01	0.02
rectus femoris	23.32	0.29	0.33

Table 17. Chemical composition of cooked pork roasts and pork chops and cooked cured hams

Cut	Moisture	Fat	Protein	Residual
	%	%	%	%
Rib roast[a]	62.5	10.2	26.5	0.8
Rib chops[a]	53.5	10.0	35.3	1.2
Center chops[a]	53.4	11.1	34.4	1.1
Ham	69.5	4.6	22.2	4.4

[a]Oñate (1961).

The higher moisture content in hams might be explained by the cooking method used. Hams were heated to an internal temperature of 130°F, whereas the loins were heated to an internal temperature of 185°F. The difference in temperature depended on the previous treatment the hams had received; they were smoked and fully cooked. Therefore the cooking time per pound was less than for roasts. The higher residual in hams could be explained by the fact that they were cured and smoked and therefore, contained added salts.

Subjective Evaluation

Six taste panel members, selected from graduate students and staff members of the College of Home Economics, Iowa State University, judged slices of biceps femoris, semimembranosus and semitendinosus from each of 48 cooked hams. Flavor, tenderness and juiciness were scored from 1 to 9. The score card used and the scale employed in judging the three characteristics of the ham muscles are presented in Table 25 in the Appendix. Data on flavor, tenderness and juiciness of the three muscles of the cured, smoked and fully cooked hams are given in Tables 44, 45, and 46, Appendix. An examination of the average scores in these tables indicated that in any one muscle in all the hams very slight differences in flavor, tenderness and juiciness were found between the backfat thickness groups of cured hams.

Analysis of variance of flavor, tenderness and juiciness of _biceps femoris_, _semimembranosus_ and _semitendinosus_ indicated that these characteristics were not related to backfat thickness of the pig (Table 47, Appendix). Similar results on roasts and pork chops were reported by Oñate (1961) and Murphy (1959). However, Batcher and Dawson (1960) found correlation of backfat thickness with juiciness of fresh ham (5 per cent level). Multiple regression of flavor, tenderness and juiciness on marbling and backfat thickness indicated no significant relationship (Table 18).

Examination of the average scores for tenderness and juiciness of the three muscles regardless of backfat thickness revealed that _biceps femoris_ had an average score of 7.0 for tenderness and 7.0 for juiciness; semitendinosus had an average score of 8.4 for tenderness and 7.7 for juiciness; semimembranosus had an average score of 7.4 for tenderness and 7.0 for juiciness. Thus as the tenderness increased, the juiciness increased.

Table 18. Regression of taste panel scores (Y) of 3 muscles of cured ham on degree of marbling (X_2) and backfat thickness (X_1)

	a	b_1	t_1	b_2	t_2
Juiciness					
biceps femoris	5.82	0.52	2.17	0.11	0.77
semimembranosus	6.26	0.37	1.54	0.06	0.48
semitendinosus	6.93	0.11	0.54	0.18	1.54
Tenderness					
biceps femoris	6.97	0.24	1.13	0.15	1.19
semimembranosus	7.20	0.22	1.34	0.06	0.79
semitendinosus	8.02	0.13	1.16	0.09	1.39
Flavor					
biceps femoris	7.17	0.20	0.72	0.10	0.58
semimembranosus	7.31	0.04	0.14	0.0024	0.02
semitendinosus	6.50	0.13	0.47	0.10	0.62

Although for each muscle there was no significant relation between taste panel scores for tenderness and backfat thickness, there was a difference in tenderness among the muscles. The magnitude of this difference is illustrated in

Figure 7. Relation between tenderness scores for three ham muscles and backfat thickness of the hog carcass

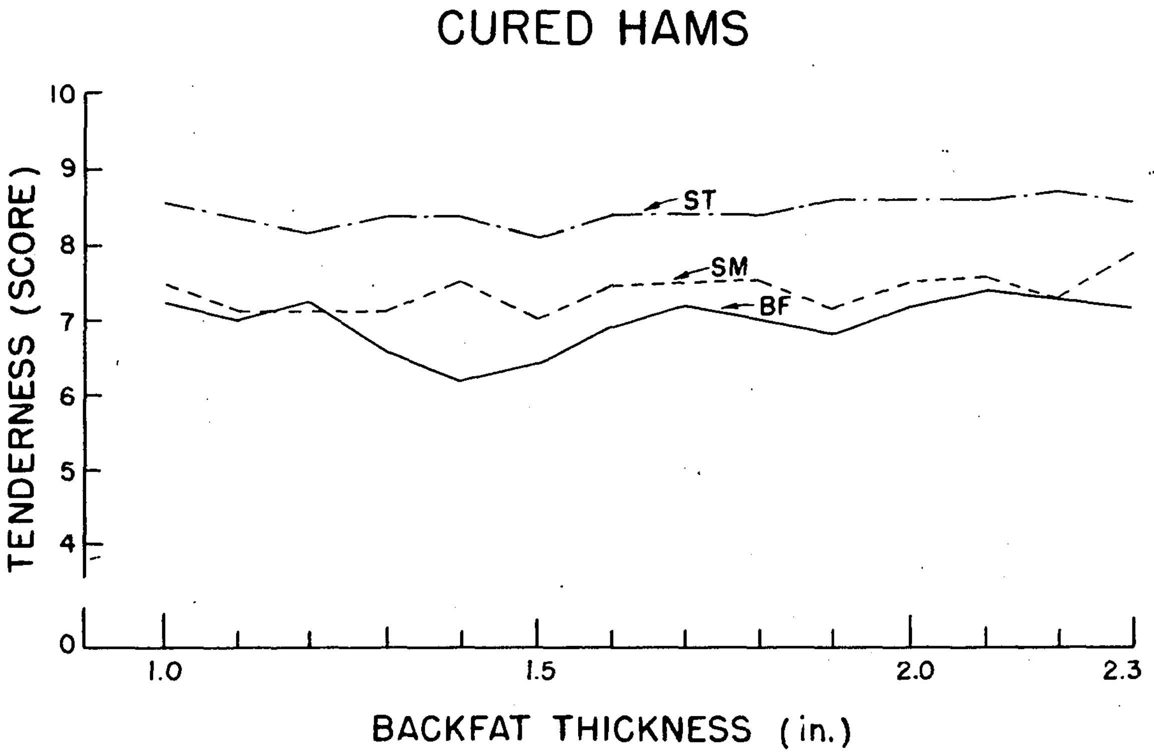

CURED HAMS
TENDERNESS (SCORE)
10
9
8
7
6
5
4
0
ST
SM
BF
1.0
1.5
2.0
2.3
BACKFAT THICKNESS (in.)

Figure 7. Thus taste panel scores indicated that the semitendinosus was the most tender and in general, biceps femoris was the least tender. A comparison of Figures 5 and 7 indicated that shear force measurements and taste panel scores were in agreement. Similar results were reported by Batcher and Dawson (1960) who stated that the semitendinosus muscle was the most tender, whereas semimembranosus was the least tender of the cooked cuts as evaluated by a taste panel.

Part II

In the second part of the study, 8 animals from each of the Duroc and Hampshire breeds were used. Data on the pigs as well as on the hams were given by the Animal Husbandry Department, Iowa State University of Science and Technology, Ames, Iowa, and the Hormel Packing Company, Fort Dodge, Iowa (Table 49, Appendix). Raw fresh hams, and cured, smoked and fully cooked hams were frozen upon arrival at the laboratory. Biceps femoris, rectus femoris and semitendinosus from the raw fresh, the cooked fresh and cured smoked and fully cooked hams were investigated for total fat and fatty acid composition.

Total fat

The data for average fat content for the biceps femoris, rectus femoris and semitendinosus muscles for each breed are summarized in Table 19. The data for the total fat content in each muscle for each animal is presented in Table 50, Appendix.

Table 19. Average per cent fat in three muscles of raw fresh, cooked fresh and cured smoked hams[a]

Muscle and treatment	Breed Duroc	Hampshire
	%	%
Biceps femoris		
Raw fresh ham	5.4	4.9
Cooked fresh ham	8.6	7.2
Cured smoked ham	5.5	3.8
Rectus femoris		
Raw fresh ham	4.1	3.9
Cooked fresh ham	5.3	5.0
Cured smoked ham	4.3	3.1
Semitendinosus		
Raw fresh ham	11.5	10.7
Cooked fresh ham	11.9	12.7
Cured smoked ham	8.6	8.5

[a]Hams were frozen prior to analysis.

Analysis of variance revealed no significant difference between Duroc and Hampshire breeds in fat content of frozen raw fresh and cooked fresh and cured, smoked and fully cooked and frozen hams. However, the fat content differed significantly at the 1 per cent level among muscles within the same animal (Table 51, Appendix).

The treatment effect on the fat content was significant at the 1 per cent level. The overall treatment differences were partitioned into differences between individual treatments and these differences were examined for statistical significance. There was a definite difference in total fat content between frozen raw fresh and cooked fresh ham as well as between raw fresh and cured, smoked ham. The differences were significant at the 1 per cent level, when examined independently (Table 51, Appendix).

When the total fat content of biceps femoris, rectus femoris and semitendinosus from the 28 pigs of various breeds with backfat thickness varying from 1.1 to 1.8 inches (Part I) was compared to total fat content in the same muscles from 16 pigs of Duroc and Hampshire breeds with similar backfat thickness (Part II), the fat content in biceps femoris appears to be similar but the fat content in rectus femoris and semitendinosus seems to be somewhat higher in Duroc and Hampshire pigs (Table 20).

Table 20. Average fat content in three muscles of cured smoked ham investigated in Part I and Part II of this study

Muscle	Fat content[a]	Fat content[b]
	%	%
Biceps femoris	4.6	4.6
Rectus femoris	2.6	3.7
Semitendinosus	6.8	8.5

[a]28 pigs.

[b]16 pigs. The hams were frozen prior to analysis.

Fatty acids

The data on fatty acid composition of *biceps femoris*, *rectus femoris*, and *semitendinosus* muscles of frozen fresh hams and cured, smoked, fully cooked and frozen hams from Duroc and Hampshire hog carcasses are given in Tables 52, 53, 54, 55, 56 and 57, Appendix. Data on average values for the six fatty acids in three muscles of raw fresh, cooked fresh and cured, smoked hams are summarized in Table 21. Since the three muscles analyzed comprise approximately one half of the total area of a whole slice of ham, an overall average of the fatty acid content in *biceps femoris*, *rectus femoris* and *semitendinosus* provides an estimate of the fatty acids supplied to the diet by this part of a slice of ham (Table 22).

Analysis of variance of the data on fatty acids revealed that the effects of breed on the content of fatty acid are highly significant (P = 0.01) for four of the fatty acids. Thus the content of myristic, palmitic, palmitoleic and linoleic acid differed between the two breeds (Tables 58, 59, 60, 63, Appendix). The amount of palmitic, palmitoleic, stearic, oleic and linoleic acids differed significantly (P = 0.01) among muscles (Tables 59, 60, 61, 62 and 63, Appendix). For three of the six fatty acids studied, the differences among muscles were not the same for the two breeds; that is, for palmitoleic acid and stearic acid there was a highly significant interaction

Table 21. Average per cent fatty acids in three muscles of raw fresh, cooked fresh and cured smoked ham[a] from two breeds of pigs

Treatment and breed	Myristic acid	Palmitic acid	Palmitoleic acid	Stearic acid	Oleic acid	Linoleic acid
	%	%	%	%	%	%
Biceps femoris						
Raw fresh ham						
Duroc	1.70	25.8	5.27	11.9	45.6	9.29
Hampshire	1.32	23.8	4.27	11.6	47.3	11.7
Cooked fresh ham						
Duroc	1.53	26.0	5.01	11.7	46.2	9.50
Hampshire	1.24	23.9	3.99	11.5	47.2	12.2
Cured smoked ham						
Duroc	1.52	25.6	5.79	11.2	46.4	9.27
Hampshire	1.19	23.9	3.83	11.8	47.8	11.2
Rectus femoris						
Raw fresh ham						
Duroc	1.73	26.7	5.00	12.2	42.1	12.3
Hampshire	1.28	24.6	4.06	12.3	42.1	15.6
Cooked fresh ham						
Duroc	1.56	26.1	5.43	12.3	42.4	12.4
Hampshire	1.19	24.8	3.86	12.5	42.4	15.3
Cured smoked ham						
Duroc	1.50	26.3	5.54	12.4	42.3	11.9
Hampshire	1.23	24.4	3.60	12.8	42.0	16.0
Semitendinosus						
Raw fresh ham						
Duroc	1.63	27.7	4.57	12.4	45.6	8.05
Hampshire	1.38	25.2	3.58	11.4	48.4	9.29
Cooked fresh ham						
Duroc	1.63	27.2	4.23	12.3	46.8	7.91
Hampshire	1.30	24.7	3.86	11.3	48.8	9.98
Cured smoked ham						
Duroc	1.52	26.9	4.66	12.3	46.9	7.68
Hampshire	1.40	24.4	3.75	11.7	49.3	9.48

[a]Hams were frozen prior to analysis.

(P = 0.01) and for linoleic acid a significant interaction (P = 0.05), (Tables 60, 61 and 63, Appendix).

Only myristic acid content exhibited a significant difference between treatments (P = 0.01) (Table 58, Appendix). When differences of pairs of treatments were examined independently, the only case of statistical significance was for myristic acid content of raw fresh ham versus that of cooked fresh ham (P = 0.01). The difference was, however, small, being between 0 and 0.2 per cent for Durocs and about 0.1 per cent for Hampshires. The variability between animals within breeds for this fatty acid was very low, so that a very small average difference was found to be significant. The statistical analysis indicated interactions of treatments and breed only with regard to palmitoleic acid. The small differences were significant at the 1 per cent level, again because of low variability.

In comparison of the present results with those reported by other investigators it should be emphasized that the methods used to determine the fatty acid content were different from that used in this study with one exception. Willard _et al._ (1954) determined spectrophotometrically the fatty acids in cured hams and the results were slightly lower in oleic, palmitic and palmitoleic acid but higher in the amount of stearic acid. Chang and Watts (1952) also reported lower amounts of oleic acid but higher amounts of linoleic acid as determined spectrophotometrically than those obtained in the present study. The results reported by Hornstein *et al.* (1961) who used gas chromatography are similar to the present study, when the range is considered.

Gas chromatography seemed to lend itself well for fatty acid determinations of intramuscular fat of ham muscles when both saturated and unsaturated acids of meat are determined at the same time. The method is useful when one considers the small amount of fat that some of the muscles contain, e.g., the *rectus femoris* containing about 2.2 per cent fat (Table 50, Appendix).

Table 22. Average per cent fatty acid content for three muscles of hams[a] from two breeds of pigs

Treatment Breed	Myristic acid	Palmitic acid	Palmitoleic acid	Stearic acid	Oleic acid	Linoleic acid
	%	%	%	%	%	%
Raw fresh						
Duroc	1.69	26.7	4.95	12.2	44.4	9.88
Hampshire	1.33	24.5	3.97	11.8	45.9	11.8
Cooked fresh						
Duroc	1.57	26.4	4.89	12.1	45.1	9.99
Hampshire	1.24	24.5	3.90	11.8	46.1	12.5
Cured smoked						
Duroc	1.52	26.3	5.33	12.0	45.2	9.61
Hampshire	1.27	24.2	3.73	12.1	46.4	12.2

[a]Hams were frozen prior to analysis.

SUMMARY

In the first part of this study, cured, smoked and fully cooked hams from 48 pork carcasses that varied in backfat thickness from 1.0 to 2.3 inches in increments of 0.1 inch were purchased from the Rath Packing Company. For each day of testing, the paired hams were selected from carcasses with a difference in backfat thickness of at least 0.4 inch. Results on yield and cooking losses of the whole hams and marbling, shear force, chemical analysis and sensory evaluation of *biceps femoris*, *semimembranosus*, *semitendinosus* and *rectus femoris* muscles are reported in this study.

Data on raw hams, i.e. no further heat treatment of cured, smoked and fully cooked hams were obtained to determine marbling, shear force and chemical composition, which included moisture, fat and protein content. Yield of separable lean, fat and bone, per cent total cooking loss, drip and volatile loss were obtained for the reheated hams. The cooked ham muscles were evaluated by a taste panel for flavor, tenderness and juiciness. Chemical analysis and shear force measurements of the cooked muscles also were obtained.

Marbling scores were obtained for *biceps femoris*, *rectus femoris*, *semimembranosus* and *semitendinosus* of the cured, smoked and fully cooked hams. Average score for *biceps femoris* was 2.5, for *rectus femoris* 1.1, for *semimembranosus* 2.4 and for

semitendinosus 2.2. Analysis of regression revealed no relation of marbling scores of these muscles on backfat thickness.

The weights of the raw hams ranged from 11.7 pounds to 18.5 pounds and averaged 14.5 pounds. Data on yield for the 48 raw hams indicated that there was an average of 59 per cent lean, 23 per cent fat and 10 per cent bone. These values correspond to an average weight of 8.6 pounds of lean, 3.4 pounds of fat and 1.4 pounds of bone for hams with an average weight of 14.5 pounds. Analysis of regression of the data for yield of lean, fat and bone of cured, smoked and fully cooked hams on backfat thickness revealed that the increase of 9.2 per cent in fat, a decrease of 7.6 per cent in lean and a decrease of 1.6 per cent in bone for each 1 inch increase in backfat thickness, was significant at the 1 per cent level.

The cured, smoked and fully cooked ham was reheated at 325°F to an internal temperature of 130°F. The cured and smoked hams that weighed 14.5 pounds before baking weighed 12.2 pounds after reheating. The yield of the cooked ham averaged 62 per cent lean (8.9 pounds), 14 per cent fat (2 pounds) and 10 per cent bone (1.4 pounds). Analysis of regression indicated a highly significant (0.1 per cent) relation between cooked yield and backfat thickness; for each inch increase in backfat thickness lean decreased 3.9 per cent and separable fat increased 3.8 per cent. However, the bone from the cooked ham was not significantly related to backfat thickness. From the findings in this study, it is evident that backfat thickness can be used as an indicator for the yield of both raw and cooked cured, smoked and fully cooked hams.

Averages and ranges of shear force values indicated that tenderness fluctuated somewhat as backfat thickness increased. The regression of shear force values of raw muscles on backfat thickness indicated that as the backfat thickness increased the tenderness increased for two of the four muscles studied; i.e. 2.5 pounds for *biceps femoris*, and 1.6 pounds for *rectus femoris* significant at the 5 per cent and 0.5 per cent level respectively. No relation was found between shear force values of *semimembranosus* or *rectus femoris* and backfat thickness. Considering the wide range in shear force obtained for each muscle, the practical significance of using backfat thickness as an estimate for tenderness is of minor importance. When differences in shear force measurements between muscles were analyzed without regard to backfat thickness, *biceps femoris* was significantly different in tenderness from *semimembranosus*, *semitendinosus* and *rectus femoris* in both raw and cooked cured hams.

Under the conditions in this study, results obtained from data on cooking losses for reheated, cured, smoked and fully cooked hams revealed that per cent total cooking loss and per cent drip loss were significantly related to backfat thickness at the 0.1 per cent level. However, per cent volatile loss was not significantly related to backfat thickness.

Average losses for all hams were 9 per cent for drip loss, 7 per cent for volatile loss and 16 per cent for total cooking loss.

Data on chemical composition were obtained for moisture and fat in *biceps femoris*, *semimembranosus*, *semitendinosus* and *rectus femoris*. Protein content was obtained for *biceps femoris* and *rectus femoris* only. Moisture content for *biceps femoris*, *semitendinosus*, *semimembranosus* and *rectus femoris* muscles ranged from 65 to 77 per cent in raw hams and 61 to 75 per cent in cooked hams. The average per cent moisture was 72 per cent for raw hams and 70 per cent for cooked hams. Moisture content of either raw or reheated cured hams was not related to backfat thickness.

The intramuscular fat content was extracted by ether, from *biceps femoris*, *rectus femoris*, *semimembranosus* and *semitendinosus* muscle. The average fat content in *biceps femoris* of raw cured ham was 4.6 per cent; of cooked cured ham, 6.3 per cent; *rectus femoris* of raw cured ham, 2.6 per cent; of cooked cured ham, 3.1 per cent. *Semimembranosus* of raw cured ham contained 3.6 per cent fat and cooked cured ham, 3.3 per cent; *semitendinosus* of raw cured ham, 6.4 per cent fat and cooked cured ham 5.8 per cent. Thus *semitendinosus* muscle had the highest fat content and *rectus femoris* the least fat.

Analysis of regression revealed no significant relation of the fat content to backfat thickness. However, multiple regression on the relation of both marbling and backfat thickness to fat content in the four muscles of cured ham indicated that in all cases marbling and backfat thickness were significantly related to fat content. Therefore, marbling and backfat thickness combined is a better indication of fat content than backfat thickness alone.

Protein content was determined by analysis for nitrogen in the muscles *biceps femoris* and *rectus femoris*. The factor to convert nitrogen to protein was 6.25. *Biceps femoris* of raw cured ham contained an average amount of 18.6 per cent protein and of cooked cured ham 21.7 per cent protein. *Rectus femoris* of raw cured ham contained 20.7 per cent and of cooked cured ham 22.8 per cent protein. A comparison of the data revealed that cooked ham muscles contained approximately 2 percentage points more protein than the raw ham. Protein content of the two muscles was not related to backfat thickness.

Under the conditions in this study, taste panel evaluations revealed that backfat thickness on the hog carcasses did not affect the flavor, tenderness and juiciness of *biceps femoris*, *semimembranosus* and *semitendinosus* from reheated cured, smoked and fully cooked hams.

In the second part of this study, fresh hams and cured, smoked and fully cooked hams from 16 carcasses were obtained from the Animal Husbandry Department, Iowa State University of Science and Technology, Ames, Iowa. The backfat thickness of the carcasses from the Duroc breed varied from 1.4 to 1.8 and from the Hampshire breed from 1.1 to 1.4 inches. Average weights of the hamswere 13.9 pounds for fresh hams and 14.2 for cured, smoked hams from the Duroc pigs and 14.8 pounds for fresh hams and 15.2 for cured, smoked hams from the Hampshire pigs. All hams were frozen immediately upon arrival from the packing plant. The length of time the frozen hams were held extended from 1 to 30 days.

Fat content as extracted by chloroform-methanol, in biceps femoris, rectus femoris and semitendinosus muscles of the ham was determined. The average fat content in biceps femoris muscle of raw, fresh ham from 16 pigs of Duroc and Hampshire breeds was 5.1 per cent; of cooked fresh, ham, 7.9 per cent; of cured, smoked ham, 4.6 per cent. The rectus femoris muscle from the same hams had an average fat content for raw, fresh ham of 4.0 per cent; cooked, fresh ham, 5.2 per cent; cured, smoked ham, 3.7 per cent. The semitendinosus muscle of raw fresh ham had an average fat content of 11.1 per cent; cooked, fresh ham, 12.3 per cent; cured, smoked ham, 8.5 per cent.

Statistical analysis of the data on fat content in ham muscles revealed no significant difference between Duroc and Hampshire breeds. However, fat content differed significantly at the 1 per cent level among muscles within the same animal.

There was a significant difference in fat content between raw, and cooked, fresh ham and also between raw fresh, ham and cured, smoked ham.

Fatty acid content in the three ham muscles was analyzed by gas chromatography. One ham of the animal was analyzed raw, fresh and cooked, fresh. The other ham was analyzed after it was cured, smoked and fully cooked. Although statistical analyses indicated that the content of myristic, palmitic, palmitoleic and linoleic acids was affected significantly ($P = 0.01$) by the breed of the pig, these differences were small, only 1 to 3 percentage points. The range in percentage fatty acid content in the three muscles regardless of breed and treatment were: myristic acid, 1.2 to 1.7; palmitic acid, 23.8 to 27.7; palmitoleic acid, 3.6 to 5.8; stearic acid, 11.2 to 12.8; oleic acid, 42.0 to 49.3; linoleic acid, 8.0 to 16.0. However, the amount of palmitic, palmitoleic, stearic, oleic and linoleic acids differed significantly among muscles but not among the three treatments, cooked, raw and smoked. In the case of palmitoleic, stearic and linoleic acid content the breed affected the differences among muscles in the amount of these fatty acids.

CONCLUSIONS

The conclusions from the first part of the study are related to 48 hog carcasses that varied in backfat thickness from 1.0 to 2.3 inches with increments of 0.1 of an inch, and with carcass weights that ranged from 148 pounds to 168 pounds. From the results obtained in this investigation of 96 cured, smoked and fully cooked hams and from muscles thereof, it is concluded that:

1. Marbling of *biceps femoris*, *rectus femoris*, *semimembranosus*, and *semitendinosus* from cured, smoked and fully cooked hams is not related to backfat thickness of pork carcasses.

2. Backfat thickness can be used as an indicator for the yield of lean and fat in both raw and cooked cured hams.

3. Cured, smoked and fully cooked hams lose about 16 per cent weight in cooking. Per cent total loss and per cent drip loss are significantly related to backfat thickness. Volatile loss is not affected by backfat thickness.

4. Although shear force values were significantly related to backfat thickness, the range of shear force values for each individual muscle fluctuated to such an extent that the practical significance of using backfat thickness as an indicator of tenderness is questionable.

5. Moisture, fat and protein content of cooked and raw

ham is not significantly affected by the backfat thickness. The chemical composition, averaged for four muscles from raw cured fully cooked hams, is 72 per cent moisture, 4 per cent fat and for two muscles, 20 per cent protein. The chemical composition, averaged for four muscles from reheated cured fully cooked hams, is 70 per cent moisture, 5 per cent fat and for two muscles, 22 per cent protein.

6. Backfat thickness does not affect the flavor, tenderness and juiciness of three muscles from cured ham as evaluated by a taste panel.

Under conditions used in the second part of the study in which 16 frozen fresh and 16 frozen cured, smoked and fully cooked hams from Duroc and Hampshire pigs were studied in regard to total fat and fatty acid content, the following conclusions are drawn:

1. Fat content differs among the muscles biceps femoris, rectus femoris and semitendinosus.

2. Fat content differs between raw fresh ham and cooked fresh ham. Also the fat content in raw fresh ham differs from cured, smoked ham.

3. Duroc and Hampshire breeds did not differ in the per cent of total fat in the three muscles.

4. The average fat content in per cent for the three muscles from the two breeds is for raw fresh ham, 7; for cooked fresh ham, 8; and for cured ham, 6.

5. The amount of myristic, palmitic, palmitoleic and linoleic acid in the three ham muscles of Duroc pigs is different from that in the muscles of Hampshire pigs.

6. The amount of palmitic, palmitoleic, stearic, oleic and linoleic acid differs among the three muscles within the same animal.

7. Cooking and smoking treatments of the hams have no effect on the amount of the fatty acids in the three muscles.

8. The average fatty acid content in per cent for the three muscles regardless of breed and treatment is: myristic acid, 1; palmitic acid, 25; palmitoleic acid, 4; stearic acid, 12; oleic acid, 46; and linoleic acid, 11.

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APPENDIX

Table 23. Right hand side of normal equations used in analyses of taste panel scores

y_1	$d_5 + d_6 + d_7 + d_8$
y_2	$d_9 + d_{10} + d_{11} + d_{12}$
y_3	$d_{13} + d_{14} + d_{15}$
y_4	$-d_1 + d_{16} + d_{17}$
y_5	$-d_5 + d_{18} + d_{19}$
y_6	$-d_2 + d_9 + d_{20}$
y_7	$-d_6 - d_{13} + d_{21} + d_{22}$
y_8	$-d_{10} - d_{16} + d_{23} + d_{24}$
y_9	$-d_3 - d_7 - d_{14} - d_{18}$
y_{10}	$-d_{11} - d_{17} - d_{20}$
y_{11}	$-d_4 - d_{15} - d_{21}$
y_{12}	$-d_8 - d_{12} - d_{23}$
y_{13}	$-d_{19} - d_{22} - d_{24}$

Table 24. Solution of reduced normal equation used in analysis of variance of taste panel scores

t_1		.690	.285	.363	.180	.500	.165	.435	.331	.388	.210	.266	.435	.422	y_1
t_2		.285	.688	.183	.300	.259	.381	.229	.442	.182	.456	.137	.472	.310	y_2
t_3		.363	.183	.746	.122	.361	.107	.466	.229	.368	.137	.404	.258	.352	y_3
t_4		.180	.300	.122	.568	.174	.221	.154	.341	.119	.363	.092	.274	.223	y_4
t_5		.500	.259	.361	.174	.811	.151	.408	.328	.418	.195	.256	.362	.516	y_5
t_6		.165	.381	.107	.221	.151	.593	.134	.264	.106	.399	.080	.270	.183	y_6
t_7	=	.435	.229	.466	.154	.408	.134	.687	.291	.327	.172	.384	.318	.462	y_7
t_8		.331	.442	.229	.341	.328	.264	.291	.674	.222	.349	.173	.482	.431	y_8
t_9		.388	.182	.368	.119	.418	.106	.327	.222	.543	.136	.232	.264	.322	y_9
t_{10}		.210	.456	.137	.363	.195	.399	.172	.349	.136	.739	.103	.338	.239	y_{10}
t_{11}		.266	.137	.404	.092	.256	.080	.384	.173	.232	.103	.596	.192	.271	y_{11}
t_{12}		.435	.472	.258	.274	.362	.270	.318	.482	.264	.338	.192	.797	.388	y_{12}
t_{13}		.422	.310	.352	.223	.516	.183	.462	.431	.322	.239	.271	.388	.803	y_{13}

Table 25. Score card and judging scale for hams

Cut of pork__________ Judge__________

Date__________

Time__________

Sample No. __________

Flavor of lean __________

Tenderness __________

Juiciness__________

No. of chews __________

Remarks

Sample No. __________

Sample No. __________

Sample No. __________

Sample No. __________

Tenderness

9 very tender
7 slightly less tender
5 moderately tender
3 slightly tough
1 very tough

Juiciness

9 very juicy
7 slightly less juicy
5 moderately juicy
3 slightly dry
1 very dry

Flavor

9 very full, rich characteristic
7 full, characteristic
5 moderately full
3 slightly weak
1 lacking or masked*

*If natural flavor is masked by off-flavor, name off-flavor and indicate intensity as slight, moderate or pronounced

Table 26. Backfat thickness, grade, age and total carcass weight of 48 pigs[a]

Code no.	Backfat thickness	Grade	Age	Total carcass weight
	in.		mo.	lbs.
1	1.0	1	6.5	162
2	1.0	1	[b]	164
3	1.0	1	[b]	157
4	1.0	medium		148
Average				158
5	1.1	1	8.0	157
6	1.1	1	7.5	157
7	1.1	1	6.5	148
8	1.1	1	[b]	150
Average				153
9	1.2	1	6.0	148
10	1.2	1	7.0	157
11	1.2	1	6.5	159
12	1.2	1	[b]	152
Average				154
13	1.3	1	7.0	164
14	1.3	1	6.0	162
15	1.3	1	[b]	152
Average				159
16	1.4	1	6.0	152
17	1.4	1	6.0	150
18	1.4	1	[b]	152
Average				151
19	1.5	1	7.0	149
20	1.5	1	7.0	160
21	1.5	1	[b]	161
Average				157
22	1.6	1	[b]	161
23	1.6	1	6.0	159
24	1.6	2	6.5	152
Average				157

[a]Data supplied by Rath Packing Co., Waterloo, Iowa.

[b]Unknown.

Table 26. (Continued)

Code no.	Backfat thickness	Grade	Age	Total carcass weight
	in.		mo.	lbs.
25	1.7	2	b	149
26	1.7	2	b	148
27	1.7	2	6.0	168
28	1.7	2	b	154
Average				155
29	1.8	2	6.0	152
30	1.8	2	b	161
31	1.8	2	b	160
32	1.8	2	7.0	153
Average				156
33	1.9	2	6.0	152
34	1.9	2	6.5	158
35	1.9	3	6.0	153
36	1.9	2	6.5	162
Average				153
37	2.0	3	5.5	153
38	2.0	3	b	153
39	2.0	3	b	152
Average				153
40	2.1	3	b	153
41	2.1	3	b	152
42	2.1	3	b	152
Average				152
43	2.2	3	5.5	161
44	2.2	3	5.5	164
45	2.2	3	6.0	164
Average				163
46	2.3	3	b	149
47	2.3	3	5.5	164
48	2.3	3	b	162
Average				158

Table 27. Weight of hams and weight changes during curing processing[a]

No.	Back-fat thick-ness	Weight: Before cure left	Weight: After cure left	Weight: Diff. in weight	Weight: Before cure right	Weight: After cure right	Weight: Diff. in weight
		lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
1	1.0	18.1	17.4	-0.7	18.2	17.6	-0.6
2		16.8	17.0	0.2	16.4	16.0	-0.4
3		16.2	15.8	-0.4	15.1	15.0	-0.1
4		14.8	14.9	0.1	14.8	14.7	-0.1
5	1.1	15.9	16.1	0.2	15.5	15.6	0.1
6		15.8	15.8	0.0	16.0	16.1	0.1
7		15.2	15.5	0.3	15.3	16.2	0.9
8		16.6	16.1	0.5	16.6	15.6	1.0
9	1.2	14.2	13.9	-0.3	13.9	13.8	-0.1
10		16.6	16.0	-0.6	15.8	15.6	-0.2
11		17.4	16.0	-1.4	17.4	16.6	-0.8
12		14.9	13.9	-1.0	14.9	14.4	-0.5
13	1.3	16.6	16.2	-0.4	16.0	15.9	-0.1
14		14.5	14.1	-0.4	15.9	16.1	0.2
15		14.9	14.7	-0.2	15.2	14.7	-0.5
16	1.4	15.0	15.4	0.4	15.1	15.9	0.8
17		13.4	13.2	-0.2	13.6	13.5	-0.1
18		14.3	14.4	0.1	14.2	14.4	0.2
19	1.5	14.2	14.1	-0.1	14.0	13.6	-0.4
20		15.5	15.6	0.1	16.0	16.9	0.9
21		17.2	17.9	0.7	17.6	18.5	0.9
22	1.6	14.4	14.5	0.1	14.6	14.2	-0.4
23		14.2	14.1	-0.1	15.0	14.9	-0.1
24		13.6	13.4	-0.2	13.2	12.9	-0.3
25	1.7	13.7	14.0	0.3	13.1	13.3	0.2
26		14.9	15.0	0.1	14.2	14.1	-0.4

[a]Data supplied by Rath Packing Co., Waterloo, Iowa.

Table 27. (Continued)

No.	Backfat thickness	Weight: Before cure left	Weight: After cure left	Diff. in weight	Weight: Before cure right	Weight: After cure right	Diff. in weight
		lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
29	1.8	13.4	13.5	0.1	14.0	14.2	0.2
30		16.9	17.4	0.5	15.8	16.0	0.2
31		15.0	15.2	0.2	13.2	13.8	0.6
32		15.2	15.6	0.4	15.0	14.9	-0.1
33	1.9	13.7	13.9	0.2	13.0	12.9	-0.1
34		14.2	13.1	-1.1	14.5	13.8	-0.7
35		14.4	14.4	0.0	14.0	14.1	0.1
36		15.5	15.8	0.3	15.4	15.5	0.1
37	2.0	12.6	12.5	-0.1	13.5	13.2	-0.3
38		13.9	13.4	-0.5	14.0	14.0	0.0
39		14.2	14.1	-0.1	13.8	13.8	0.0
40	2.1	13.1	13.4	0.3	13.6	14.1	0.5
41		13.8	12.1	-1.7	13.6	13.1	-0.5
42		14.0	13.8	-0.2	13.8	13.4	-0.4
43	2.2	13.2	12.4	-0.8	13.8	13.1	-0.7
44		14.2	14.5	0.3	13.8	13.8	0.0
45		13.8	14.0	0.2	13.5	13.8	0.3
46	2.3	12.2	12.5	0.3	11.2	11.7	0.5
47		14.9	15.2	0.3	14.9	15.3	0.4
48		12.6	13.1	0.5	12.8	13.2	0.4

Table 28. Marbling scores for _biceps femoris_, _semimembranosus_, _rectus femoris_ and _semitendinosus_ muscles of ham

Code no.	Backfat thickness	BF	SM	RF	ST
1	1.0	2	2	1	2
2	1.0	2	1	1	2
3	1.0	3	2.5	1	2.5
4	1.0	2.5	2	1	1.5
Average	1.0	2.4	1.9	1.0	2.0

Table 28. (Continued)

Code no.	Backfat thickness	BF	SM	RF	ST
5	1.1	3.5	4	1	3
6	1.1	3	2	1	2
7	1.1	3	2	1	3
8	1.1	2	2	1	1
Average	1.1	2.9	2.5	1.0	2.2
9	1.2	2	2	1	2
10	1.2	2	2	1	2
11	1.2	2	2	1	2
12	1.2	1.5	2	1	1.5
Average	1.2	1.9	2.0	1.0	1.9
13	1.3	2	2	1	1
14	1.3	3	4	1	3
15	1.3	2	2	1	2
Average	1.3	2.3	2.7	1.0	2.0
16	1.4	4	3	3	4
17	1.4	2	1	1	2
18	1.4	3	3	1	2.5
Average	1.4	3.0	2.3	1.7	2.8
19	1.5	2	2	1	1
20	1.5	3	2	1	2
21	1.5	3	3	2	3
Average	1.5	2.7	2.3	1.3	2.0
22	1.6	2.5	2.5	1	1
23	1.6	3	3	1	2
24	1.6	3	4	1	2
Average	1.6	2.8	3.2	1.0	1.7
25	1.7	2	2	1	3
26	1.7	3	2	1	2
27	1.7	3	3	1	3
28	1.7	1	1.5	1	1
Average	1.7	2.2	2.1	1.0	2.2
29	1.8	4	4	1	3
30	1.8	3	3	1	2
31	1.8	3	3	1	2
32	1.8	3	2	1	1.5
Average	1.8	3.2	3.0	1.0	2.1

Table 28. (Continued)

Code no.	Backfat thickness	BF	SM	RF	ST
33	1.9	3	4	1	3
34	1.9	2	3	1	3
35	1.9	3	3	1	3
36	1.9	2	3	1	2
Average	1.9	2.5	3.2	1.0	2.8
37	2.0	4	3	1	2
38	2.0	2	3	1	2
39	2.0	3	2	1	3
Average	2.0	3.0	2.7	1.0	2.3
40	2.1	3	3	2	3
41	2.1	2	1	1	2
42	2.1	1.5	2	1	1
Average	2.1	2.2	2.0	1.3	2.0
43	2.2	2	2	2	2
44	2.2	3	2	1	2
45	2.2	2	2	1	2
Average	2.2	2.3	2.0	1.3	2.0
46	2.3	3	2	1	3
47	2.3	2	2	1	3
48	2.3	2	1	1	2
Average	2.3	2.3	1.7	1.0	2.7
Overall average	2.5	2.5	2.4	1.1	2.2

Table 29. Yield of raw ham

Code no.	Backfat thickness	Lean	Fat	Bone	Trim waste[a]	Preparation loss[b]
		%	%	%	%	%
1	1.0	62.8	19.1	9.6	6.1	2.3
2	1.0	60.6	19.2	11.4	5.7	3.1
3	1.0	67.5	16.4	9.4	4.2	2.5
4	1.0	63.0	17.9	11.3	5.4	2.5
Average		63.5	18.2	10.4	5.4	2.6

[a]Inedible waste.

[b]Obtained by difference.

Table 29. (Continued)

Code no.	Backfat thickness	Lean	Fat	Bone	Trim waste[a]	Preparation loss[b]
	in.	%	%	%	%	%
5	1.1	61.7	18.7	12.0	4.5	3.0
6	1.1	61.3	20.1	11.5	5.0	2.1
7	1.1	62.8	18.3	10.0	5.1	3.8
8	1.1	61.2	19.9	10.7	4.0	4.2
Average		61.8	19.2	11.0	4.6	3.3
9	1.2	63.0	18.1	10.4	5.4	2.9
10	1.2	62.4	19.6	10.8	5.2	2.0
11	1.2	61.9	20.9	9.3	5.4	2.5
12	1.2	60.4	21.3	11.1	4.1	3.0
Average		61.9	20.0	10.4	5.0	2.6
13	1.3	64.1	16.8	11.4	6.2	1.5
14	1.3	58.6	24.0	9.3	5.3	2.7
15	1.3	63.1	21.4	9.0	3.7	2.8
Average		61.9	20.7	9.9	5.1	2.3
16	1.4	55.1	26.7	9.1	5.6	3.4
17	1.4	64.8	17.0	10.2	5.4	2.6
18	1.4	59.4	24.9	8.7	4.7	2.3
Average		59.8	22.9	9.3	5.2	2.8
19	1.5	65.1	11.9	10.8	6.1	6.1
20	1.5	64.0	18.6	9.2	6.0	2.2
21	1.5	65.0	17.5	8.3	7.4	1.8
Average		64.7	16.0	9.4	6.5	3.4
22	1.6	62.0	21.2	9.1	5.0	2.6
23	1.6	59.0	21.5	9.9	5.6	4.0
24	1.6	66.4	18.8	8.5	5.8	0.6
Average		62.5	20.5	9.2	5.5	2.4

[a]Inedible waste.

[b]Obtained by difference.

Table 29. (Continued)

Code no.	Backfat thickness	Lean	Fat	Bone	Trim waste[a]	Preparation loss[b]
	in.	%	%	%	%	%
25	1.7	55.2	26.0	9.9	4.4	4.5
26	1.7	59.1	22.3	9.8	6.3	2.5
27	1.7	59.2	25.2	9.7	4.1	1.8
28	1.7	59.4	24.0	9.2	4.5	2.9
Average		58.2	24.4	9.6	4.8	2.9
29	1.8	52.8	30.1	9.2	6.2	1.6
30	1.8	64.4	19.1	9.4	4.7	2.4
31	1.8	55.6	27.4	8.6	5.7	2.7
32	1.8	57.5	25.9	8.9	4.6	3.0
Average		57.6	25.6	9.0	5.3	2.4
33	1.9	53.4	28.4	9.8	4.5	3.9
34	1.9	55.9	28.0	9.3	4.0	2.8
35	1.9	58.5	26.3	9.2	3.9	2.1
36	1.9	54.7	30.4	8.3	3.6	3.0
Average		55.6	28.3	9.2	4.0	3.0
37	2.0	53.8	29.6	9.1	4.7	2.8
38	2.0	58.5	25.8	7.9	4.6	3.2
39	2.0	58.5	26.6	8.1	3.8	3.0
Average		56.9	27.3	8.4	4.4	3.0
40	2.1	52.1	31.8	8.3	5.2	2.6
41	2.1	57.8	24.7	9.4	5.0	3.1
42	2.1	52.6	32.3	8.4	3.5	2.9
Average		54.2	29.6	8.7	4.6	2.9
43	2.2	53.0	24.9	8.5	5.6	8.0
44	2.2	57.2	26.9	8.7	3.5	3.7
45	2.2	54.1	28.9	9.1	4.5	3.4
Average		54.8	26.9	8.8	4.5	5.0
46	2.3	55.1	27.6	9.2	4.5	3.6
47	2.3	56.1	27.9	9.0	3.5	3.4
48	2.3	50.7	32.2	9.5	4.9	2.6
Average		54.0	29.2	9.2	4.3	3.2
Overall average		59.2	23.4	9.5		

Table 30. Yield of cooked ham

Code no.	Back-fat thick-ness	Lean	Fat	Bone	Trim waste[a]	Prepa-ration loss[b]	Cooked total yield
	in.	%	%	%	%	%	%
1	1.0	66.4	11.0	10.1	7.3	5.1	85.4
2	1.0	69.5	13.3	4.2	6.8	6.2	85.6
3	1.0	59.9	16.0	9.0	8.0	7.0	84.8
4	1.0	62.4	13.5	12.5	5.6	6.0	86.2
Average		64.6	13.4	9.0	6.9	6.1	85.5
5	1.1	62.9	12.0	12.1	6.8	6.1	87.6
6	1.1	63.4	11.7	12.0	6.3	6.6	88.5
7	1.1	62.6	11.6	12.0	8.4	5.4	85.5
8	1.1	62.6	9.6	11.5	10.2	6.0	82.4
Average		62.9	11.2	11.9	7.9	6.0	86.0
9	1.2	62.4	11.4	9.5	8.2	8.5	87.7
10	1.2	60.8	14.5	10.7	8.2	5.8	87.7
11	1.2	65.9	10.1	10.3	8.9	4.8	82.5
12	1.2	61.5	12.4	11.3	9.4	5.4	83.4
Average		62.6	12.1	10.4	8.7	6.1	85.3
13	1.3	65.7	11.9	12.7	7.4	2.3	87.7
14	1.3	60.4	13.1	10.7	9.2	6.6	87.8
15	1.3	67.6	10.2	9.7	7.0	5.5	86.5
Average		64.6	11.7	11.0	7.9	4.8	87.3
16	1.4	57.0	18.2	10.4	7.6	6.7	85.6
17	1.4	62.0	13.3	10.4	6.9	7.4	84.8
18	1.4	63.9	13.8	10.0	5.9	6.3	82.2
Average		61.0	15.1	10.3	6.8	6.8	84.2
19	1.5	62.5	13.4	10.2	7.0	6.8	88.4
20	1.5	63.5	13.3	8.7	7.5	7.0	85.2
21	1.5	65.4	10.7	9.6	7.6	6.7	84.5
Average		63.8	12.5	9.5	7.4	6.8	86.0

[a]Inedible waste.

[b]Obtained by difference.

Table 30. (Continued)

Code no.	Back-fat thick-ness	Lean	Fat	Bone	Trim waste[a]	Prepa-ration loss[b]	Cooked total yield
	in.	%	%	%	%	%	%
22	1.6	63.1	14.2	10.4	6.8	5.5	86.1
23	1.6	59.7	16.6	9.7	8.1	5.9	83.1
24	1.6	66.3	11.2	9.3	7.4	5.8	86.8
Average		63.0	14.0	9.8	7.4	5.7	85.3
25	1.7	55.5	20.5	10.6	8.0	5.3	84.7
26	1.7	62.7	12.8	10.9	8.0	5.5	85.1
27	1.7	60.5	17.6	10.2	8.4	3.3	85.0
28	1.7	62.3	13.8	10.5	7.7	5.6	83.5
Average		60.2	16.2	10.6	8.0	4.9	84.6
29	1.8	58.8	19.1	9.9	7.3	4.9	84.6
30	1.8	63.7	13.6	9.5	7.8	5.4	83.6
31	1.8	61.3	14.6	10.7	7.0	6.4	85.3
32	1.8	62.2	16.0	9.1	6.4	6.3	85.2
Average		61.5	15.8	9.8	7.1	5.8	84.7
33	1.9	59.5	14.9	11.4	8.4	5.8	86.4
34	1.9	58.8	17.1	10.6	9.4	4.1	83.9
35	1.9	60.5	16.5	9.6	7.3	6.1	86.5
36	1.9	59.3	16.6	9.9	6.7	7.5	83.1
Average		59.5	16.3	10.4	7.9	5.9	85.0
37	2.0	61.0	14.3	10.7	8.2	5.7	79.9
38	2.0	59.9	15.8	9.0	8.1	7.2	82.5
39	2.0	62.9	15.3	8.4	6.9	6.5	82.0
Average		61.3	15.1	9.4	7.7	6.5	81.5
40	2.1	56.0	20.1	9.5	9.0	5.3	80.7
41	2.1	57.2	17.0	11.7	7.3	6.8	79.8
42	2.1	57.8	19.2	9.8	7.5	5.8	83.6
Average		57.0	18.8	10.3	7.9	6.0	81.4

Table 30. (Continued)

Code no.	Back-fat thick-ness	Lean	Fat	Bone	Trim waste[a]	Prepa-ration loss[b]	Cooked total yield
	in.	%	%	%	%	%	%
43	2.2	56.3	17.0	9.2	9.4	8.1	81.5
44	2.2	61.0	18.6	9.0	5.8	5.6	82.7
45	2.2	58.1	16.9	9.7	9.3	6.0	82.0
Average		58.5	17.5	9.3	8.1	6.6	82.1
46	2.3	66.7	6.5	10.5	9.4	6.9	81.4
47	2.3	62.2	15.8	9.5	6.1	6.4	82.9
48	2.3	56.0	17.5	11.8	8.0	6.7	78.4
Average		61.6	13.3	10.6	7.8	6.7	80.9
Overall average		61.7	14.5	10.2	7.5	6.0	84.4

Table 31. Regression of marbling of four muscles of ham, yield of lean, fat and bone, and cooking losses on backfat thickness

	Regression statistics		
	a	b	t
Marbling			
<u>biceps femoris</u>	2.50	0.03	0.12
<u>semimembranosus</u>	2.33	0.05	0.16
<u>semitendinosus</u>	1.81	0.24	0.94
<u>rectus femoris</u>	1.00	0.06	0.45
Yield of lean[a]			
Raw	71.52	-7.60	-7.15***
Cooked	67.91	-3.87	-3.84***
Yield of fat[a]			
Raw	8.41	9.21	8.09***
Cooked	8.32	3.78	4.04***

***Significant at the 0.1 per cent level.

[a]Lean and fat of whole ham.

Table 31. (Continued)

	Regression statistics		
	a	b	t
Yield of bone[a]			
Raw	12.07	-1.56	-5.67***
Cooked	10.79	-0.37	-0.77
Cooking losses			
Drip	2.07	4.10	8.09***
Volatile	7.50	0.38	1.07
Total	9.62	3.68	5.52***

[a]Lean, fat and bone of whole ham.

Table 32. Average[a] shear force values and differences between shear force values from four muscles of raw ham

Code no.	Backfat thickness	Muscles				Differences		
		BF	SM	ST	RF	BF-SM	BF-ST	BF-RF
	in.	lb.	lb.	lb.	lb.	lb.	lb.	lb.
1	1.0	8.0	9.8	5.8	7.2	-1.8	2.2	0.8
2	1.0	15.7	9.5	9.6	5.3	6.2	6.1	10.4
3	1.0	10.9	8.6	7.8	3.1	2.3	3.1	7.8
4	1.0	10.1	7.8	5.6	4.8	2.3	4.5	5.3
Average		11.2	8.9	7.2	5.1			
5	1.1	6.1	5.5	6.0	6.3	0.6	0.1	-0.2
6	1.1	9.4	6.2	4.5	6.8	3.2	4.9	2.6
7	1.1	12.8	12.0	8.6	6.8	0.8	4.2	6.0
8	1.1	9.4	4.0	6.6	-	5.4	2.8	-
Average		9.4	6.9	6.4	6.6			
9	1.2	13.7	8.7	10.2	6.7	5.0	3.5	7.0
10	1.2	9.1	12.6	7.5	5.2	-3.5	1.6	3.9
11	1.2	9.3	10.4	7.0	8.0	-1.1	2.3	1.3
12	1.2	7.2	6.9	4.4	-	0.3	2.8	-
Average		9.8	9.6	7.3	6.6			

[a]Average represents at least 4 measurements of each muscle.

Table 32. (Continued)

Code no.	Backfat thickness	Muscles				Differences		
		BF	SM	ST	RF	BF-SM	BF-ST	BF-RF
	in.	lb.	lb.	lb.	lb.	lb.	lb.	lb.
13	1.3	9.2	14.6	7.6	5.0	-5.4	1.6	4.2
14	1.3	12.6	9.6	5.5	5.8	3.0	7.1	6.8
15	1.3	9.2	8.8	7.0	6.8	0.4	2.2	2.4
Average		10.3	11.0	6.7	5.9			
16	1.4	7.4	5.3	3.2	4.6	2.1	4.2	2.8
17	1.4	20.0	14.4	5.0	7.1	5.6	15.0	12.9
18	1.4	11.2	10.5	10.4	6.6	0.7	0.8	4.6
Average		12.9	10.1	6.2	6.1			
19	1.5	10.8	11.6	8.0	5.4	-0.8	2.8	5.4
20	1.5	14.3	12.7	8.2	6.5	1.6	6.1	7.8
21	1.5	12.8	9.4	6.6	5.7	3.4	6.2	7.1
Average		12.6	11.2	7.6	5.9			
22	1.6	7.5	13.4	4.5	5.2	-5.9	3.0	2.3
23	1.6	9.3	6.2	5.2	5.0	3.1	4.1	4.3
24	1.6	9.7	8.6	8.5	5.4	1.1	1.2	4.3
Average		8.8	9.4	6.1	5.2			
25	1.7	12.6	7.2	5.4	3.8	5.4	7.2	8.8
26	1.7	8.6	9.8	7.6	4.1	-1.2	1.0	4.5
27	1.7	6.6	6.4	6.2	5.2	0.2	0.4	1.4
28	1.7	7.2	3.5	2.7	-	3.7	4.5	-
Average		8.8	6.7	5.5	4.4			
29	1.8	6.6	7.5	6.7	4.7	-0.9	-0.1	1.9
30	1.8	7.2	8.6	4.6	3.8	-1.4	2.6	3.4
31	1.8	6.9	6.7	5.0	4.8	0.2	1.9	2.1
32	1.8	13.6	5.9	5.9	4.2	7.7	7.7	9.4
Average		8.6	7.2	5.6	4.4			
33	1.9	15.6	8.7	8.0	7.6	6.9	7.6	8.0
34	1.9	5.4	6.4	6.6	3.6	-1.0	-1.2	1.8
35	1.9	5.5	3.8	0.9	5.8	1.7	4.6	-0.3
36	1.9	11.3	7.4	8.7	-	3.9	2.6	-
Average		9.4	6.6	6.0	5.7			

Table 32. (Continued)

Code no.	Backfat thickness	Muscles				Differences		
		BF	SM	ST	RF	BF-SM	BF-ST	BF-RF
	in.	lb.	lb.	lb.	lb.	lb.	lb.	lb.
37	2.0	10.3	10.7	9.4	5.2	-0.4	0.9	5.1
38	2.0	8.5	6.7	9.2	4.0	1.8	-0.7	4.5
39	2.0	5.1	6.8	1.4	-	-1.7	3.7	-
Average		8.0	8.1	6.7	4.6			
40	2.1	7.3	6.1	4.0	1.8	1.2	3.3	5.5
41	2.1	7.9	9.8	7.6	2.2	-1.9	0.3	5.7
42	2.1	7.9	7.1	4.9	4.7	0.8	3.0	3.2
Average		7.7	7.7	5.5	2.9			
43	2.2	6.8	11.6	6.8	3.4	-4.8	0	3.4
44	2.2	6.3	8.2	8.2	6.4	-1.9	-1.9	-0.1
45	2.2	7.0	12.0	8.7	4.2	-5.0	-1.7	2.8
Average		6.7	10.6	7.9	4.7			
46	2.3	10.5	4.6	3.1	3.0	5.9	7.4	7.5
47	2.3	7.2	7.6	6.2	4.3	-0.4	1.0	2.9
48	2.3	10.4	7.1	4.8	6.6	3.3	5.6	3.8
Average		9.4	6.4	4.7	4.6			
Overall average		9.5	8.5	6.4	5.2			

Table 33. Average shear force values and differences between shear force values of four muscles of cooked ham

Code no.	Backfat thickness	Muscles				Differences		
		BF	SM	ST	RF	BF-SM	BF-ST	BF-RF
	in.	lb.	lb.	lb.	lb.	lb.	lb.	lb.
1	1.0	5.8	10.5	5.0	2.5	-4.7	0.8	3.3
2	1.0	8.2	13.3	6.2	8.9	-5.1	2.0	-0.7
3	1.0	8.9	8.6	8.8	6.7	0.3	0.1	2.2
4	1.0	8.3	10.5	5.8	3.1	-2.2	2.5	5.2
Average	1.0	7.8	10.7	6.4	5.3			

Table 33. (Continued)

Code no.	Backfat thickness	Muscles				Differences		
		BF	SM	ST	RF	BF-SM	BF-ST	BF-RF
	in.	lb.	lb.	lb.	lb.	lb.	lb.	lb.
5	1.1	7.7	5.8	4.9	6.1	1.9	2.8	1.6
6	1.1	7.2	7.9	7.5	5.3	-0.7	-0.3	1.9
7	1.1	8.2	11.5	5.6	8.1	-3.3	2.6	0.1
8	1.1	6.6	4.5	5.6	5.1	2.1	1.0	1.5
Average	1.1	7.4	7.4	5.9	6.2			
9	1.2	9.8	9.9	7.2	11.2	-0.1	2.6	-1.4
10	1.2	10.8	13.8	5.8	3.0	-3.0	5.0	7.8
11	1.2	7.4	9.8	9.9	7.8	-2.4	-2.5	-0.4
12	1.2	5.9	7.2	6.3	9.3	-1.3	-0.4	-3.4
Average	1.2	8.5	10.2	7.3	7.8			
13	1.3	10.6	8.8	5.9	5.1	1.8	4.7	5.5
14	1.3	12.5	12.2	8.6	4.6	0.3	3.9	7.9
15	1.3	10.9	17.2	4.3	7.9	-6.3	6.6	3.0
Average	1.3	11.3	12.7	6.3	5.9			
16	1.4	10.6	5.4	4.0	5.2	5.2	6.6	5.4
17	1.4	8.6	10.4	7.0	6.2	-1.8	1.6	2.4
18	1.4	10.5	12.2	11.7	7.0	-1.7	-1.2	3.5
Average	1.4	9.9	9.3	7.6	6.1			
19	1.5	10.5	7.5	7.0	5.3	3.0	3.5	5.2
20	1.5	13.3	11.3	6.8	8.7	2.0	6.5	4.6
21	1.5	9.2	8.6	4.3	6.6	0.6	4.9	2.6
Average	1.5	11.0	9.1	6.0	6.9			
22	1.6	8.2	14.5	7.6	5.3	-6.3	0.6	2.9
23	1.6	5.9	11.1	3.5	4.8	-5.2	2.4	1.1
24	1.6	10.8	12.9	6.2	6.3	-2.1	4.6	4.5
Average	1.6	8.3	12.8	5.8	5.5			
25	1.7	7.2	7.3	3.7	5.4	-0.1	3.5	1.8
26	1.7	7.2	8.0	8.0	4.9	-0.8	-0.8	2.3
27	1.7	6.8	7.7	6.1	5.0	-0.9	0.7	1.8
28	1.7	6.5	5.0	3.8	4.3	1.5	2.7	2.2
Average	1.7	6.9	7.0	5.4	4.9			

Table 33. (Continued)

Code no.	Backfat thickness	Muscles				Differences		
		BF	SM	ST	RF	BF-SM	BF-ST	BF-RF
	in.	lb.	lb.	lb.	lb.	lb.	lb.	lb.
29	1.8	7.4	9.8	5.4	3.8	-2.4	2.0	3.6
30	1.8	7.8	7.8	3.6	2.4	0	4.2	5.4
31	1.8	5.8	6.4	3.7	3.0	-0.6	2.1	2.8
32	1.8	11.0	6.7	7.3	7.4	4.3	3.7	3.6
Average	1.8	8.0	7.7	5.0	4.2			
33	1.9	7.6	8.8	8.3	8.0	-1.2	-0.7	-0.4
34	1.9	6.8	6.3	6.7	5.5	0.5	0.1	1.3
35	1.9	5.1	7.2	3.7	2.5	-2.1	1.4	2.6
36	1.9	11.2	11.4	6.9	7.1	-0.2	4.3	4.1
Average	1.9	7.7	8.4	6.4	5.8			
37	2.0	6.9	7.0	5.5	1.1	-0.1	1.4	5.8
38	2.0	8.0	7.0	5.1	3.0	1.0	2.9	5.0
39	2.0	5.0	5.9	3.0	3.7	-0.9	2.0	1.3
Average	2.0	6.6	6.6	4.5	2.6			
40	2.1	6.3	3.8	2.0	2.3	2.5	4.3	4.0
41	2.1	8.0	9.7	5.6	15.8	-1.7	2.4	-7.8
42	2.1	7.1	8.0	4.5	6.1	-0.9	2.6	1.0
Average	2.1	7.1	7.2	4.0	8.1			
43	2.2	5.4	15.7	6.5	5.1	-10.3	-1.1	0.3
44	2.2	4.9	9.5	4.8	6.0	-4.6	0.1	-1.1
45	2.2	7.2	9.3	6.9	5.2	-2.1	0.3	2.0
Average	2.2	5.8	11.5	6.1	5.4			
46	2.3	7.0	3.4	4.1	4.8	3.6	2.9	2.2
47	2.3	6.4	9.2	2.5	4.6	-2.8	3.9	1.8
48	2.3	7.8	8.3	4.4	6.2	-0.5	3.4	1.6
Average	2.3	7.1	7.0	3.7	5.2			
Overall average		8.0	9.0	5.8	5.7			

Table 34. Regression of shear force values of four muscles of raw and cooked hams (Y) on backfat thickness (X)

Muscle	Regression statistics		
	a	b	t
Raw			
Biceps femoris	13.52	2.45	2.30*
Semimembranosus	10.59	1.29	1.34
Semitendinosus	7.88	0.92	1.20
Rectus femoris	7.81	1.61	3.34***
Cooked			
Biceps femoris	10.94	1.77	2.58*
Semimembranosus	12.06	1.85	1.76
Semitendinosus	8.68	1.78	2.74**
Rectus femoris	7.20	0.93	1.02

*Significant at the 5 per cent level.

**Significant at the 1 per cent level.

***Significant at the 0.5 per cent level.

Table 35. Drip, volatile and total cooking losses of cooked hams

Code no.	Backfat thickness	Drip loss	Volatile loss	Total loss
	in.	%	%	%
1	1.0	7.1	7.4	14.6
2	1.0	7.9	6.5	14.4
3	1.0	8.4	6.7	15.2
4	1.0	6.0	7.8	13.8
Average	1.0	7.4	7.1	14.5
5	1.1	5.7	6.6	12.4
6	1.1	6.4	5.2	11.5
7	1.1	7.9	6.6	14.5
8	1.1	7.9	9.7	17.6
Average	1.1	7.0	7.0	14.0
9	1.2	5.7	6.6	12.3
10	1.2	5.2	7.0	12.3
11	1.2	9.1	8.4	17.5
12	1.2	7.6	8.9	16.5
Average	1.2	6.9	7.7	14.6
13	1.3	5.4	6.8	12.3
14	1.3	6.1	6.1	12.2
15	1.3	6.6	6.9	13.5
Average	1.3	6.0	6.6	12.7
16	1.4	9.4	5.0	14.4
17	1.4	7.5	7.7	15.2
18	1.4	10.8	7.0	17.8
Average	1.4	9.2	6.6	15.8
19	1.5	5.8	5.8	11.6
20	1.5	7.3	7.5	14.8
21	1.5	8.1	7.4	15.5
Average	1.5	7.1	6.9	14.0
22	1.6	7.6	6.3	13.9
23	1.6	8.9	8.0	16.9
24	1.6	6.7	6.4	13.2
Average	1.6	7.7	6.9	14.7

Table 35. - (Continued)

Code no.	Backfat thickness	Drip loss	Volatile loss	Total loss
	in.	%	%	%
25	1.7	8.7	6.7	15.3
26	1.7	6.9	8.0	14.8
27	1.7	9.4	5.5	15.0
28	1.7	8.8	7.8	16.5
Average	1.7	8.4	7.0	15.4
29	1.8	8.5	6.9	15.4
30	1.8	9.5	6.9	16.4
31	1.8	7.6	7.1	14.7
32	1.8	9.1	5.7	14.8
Average	1.8	8.7	6.6	15.3
33	1.9	8.6	5.0	13.6
34	1.9	9.2	7.0	16.1
35	1.9	7.9	5.6	13.5
36	1.9	11.3	5.6	16.9
Average	1.9	9.2	5.8	15.0
37	2.0	11.7	8.4	20.1
38	2.0	10.5	7.1	17.5
39	2.0	10.4	7.6	18.0
Average	2.0	10.9	7.7	18.5
40	2.1	12.0	7.2	19.2
41	2.1	12.8	7.4	20.2
42	2.1	10.9	5.5	16.4
Average	2.1	11.9	6.7	18.6
43	2.2	12.2	6.3	18.5
44	2.2	9.8	7.4	17.3
45	2.2	10.3	7.7	17.9
Average	2.2	10.8	7.1	17.9
46	2.3	12.1	6.5	18.6
47	2.3	11.1	5.9	17.0
48	2.3	14.7	6.8	21.5
Average	2.3	12.6	6.4	19.0
Overall average		8.7	6.9	15.6

Table 36. Chemical composition of biceps femoris of raw ham

Code no.	Backfat thickness	Moisture	Fat	Protein	Residual
	in.	%	%	%	%
1	1.0	70.4	4.2	20.9	4.5
2	1.0	71.2	6.0	18.4	4.4
3	1.0	74.1	2.6	19.1	4.2
4	1.0	73.7	2.2	21.1	3.0
Average	1.0	72.4	3.8	19.9	4.0
5	1.1	70.5	7.0	17.2	5.3
6	1.1	72.9	3.2	19.8	4.1
7	1.1	72.8	3.9	18.0	5.3
8	1.1	72.2	4.2	17.8	5.8
Average	1.1	72.1	4.6	18.2	5.1
9	1.2	72.7	4.1	18.8	4.4
10	1.2	71.6	4.6	19.1	4.7
11	1.2	71.1	3.0	20.4	5.5
12	1.2	71.6	3.4	19.3	5.7
Average	1.2	71.8	3.8	19.4	5.1
13	1.3	72.4	3.0	20.4	4.2
14	1.3	71.7	6.0	17.0	5.3
15	1.3	73.0	2.0	20.1	4.9
Average	1.3	72.4	3.7	19.2	4.8
16	1.4	68.1	12.0	15.4	4.5
17	1.4	72.0	2.8	19.4	5.8
18	1.4	70.9	5.1	18.1	5.9
Average	1.4	70.3	6.6	17.6	5.4
19	1.5	73.8	3.2	19.4	3.6
20	1.5	71.4	4.1	18.4	6.1
21	1.5	71.2	6.0	17.5	5.3
Average	1.5	72.1	4.4	18.4	5.0
22	1.6	72.7	3.9	18.4	5.0
23	1.6	70.3	6.2	17.8	5.7
24	1.6	69.2	4.4	21.5	4.9
Average	1.6	70.7	4.8	19.2	5.2

Table 36. (Continued)

Code no.	Backfat thickness	Moisture	Fat	Protein	Residual
	in.	%	%	%	%
25	1.7	72.8	4.9	17.6	4.7
26	1.7	71.0	4.0	19.8	5.2
27	1.7	71.5	4.6	18.3	5.6
28	1.7	71.1	4.4	19.4	5.1
Average	1.7	71.6	4.5	18.8	5.2
29	1.8	71.6	5.2	18.5	5.1
30	1.8	72.7	3.3	18.8	5.2
31	1.8	71.4	6.0	18.3	4.3
32	1.8	71.7	4.1	19.6	4.6
Average	1.8	71.8	4.6	18.8	4.8
33	1.9	71.3	6.1	17.4	5.2
34	1.9	70.6	4.3	20.0	5.1
35	1.9	71.0	7.3	16.8	4.9
36	1.9	74.3	3.5	16.6	5.6
Average	1.9	71.8	5.3	17.7	5.2
37	2.0	73.4	3.1	17.5	6.0
38	2.0	71.6	5.3	19.2	3.9
39	2.0	72.8	4.8	18.0	4.4
Average	2.0	72.6	4.4	18.2	4.8
40	2.1	69.6	8.0	16.8	5.6
41	2.1	72.2	4.3	18.7	4.8
42	2.1	72.3	3.7	18.9	5.1
Average	2.1	71.4	5.3	18.1	5.2
43	2.2	70.1	4.2	19.3	6.4
44	2.2	72.9	3.6	18.2	5.3
45	2.2	72.0	3.7	19.5	4.8
Average	2.2	71.7	3.8	19.0	5.5
46	2.3	69.9	7.2	17.9	5.0
47	2.3	73.5	3.6	17.5	5.4
48	2.3	71.2	5.0	17.4	6.4
Average	2.3	71.5	5.3	17.6	5.6
Overall average		71.8	4.6	18.6	5.0

Table 37. Chemical composition of _semimembranosus_ of raw ham

Code no.	Backfat thickness	Moisture	Fat
	in.	%	%
1	1.0	70.2	3.8
2	1.0	72.3	3.1
3	1.0	73.4	2.6
4	1.0	73.0	2.1
Average	1.0	72.2	2.9
5	1.1	70.5	4.6
6	1.1	71.4	2.8
7	1.1	72.0	3.3
8	1.1	68.9	6.1
Average	1.1	70.7	4.2
9	1.2	73.5	2.1
10	1.2	70.8	3.6
11	1.2	69.8	3.7
12	1.2	72.2	2.6
Average	1.2	71.6	3.0
13	1.3	72.6	3.0
14	1.3	69.5	7.3
15	1.3	72.3	2.5
Average	1.3	71.5	4.3
16	1.4	71.6	6.8
17	1.4	71.8	1.7
18	1.4	70.0	4.4
Average	1.4	71.1	4.3
19	1.5	72.4	2.8
20	1.5	72.3	3.2
21	1.5	71.4	4.9
Average	1.5	72.0	3.6
22	1.6	72.2	3.1
23	1.6	70.0	5.8
24	1.6	69.8	2.1
Average	1.6	70.7	3.6

Table 37. (Continued)

Code no.	Backfat thickness	Moisture	Fat
	in.	%	%
25	1.7	72.2	3.7
26	1.7	70.8	2.7
27	1.7	71.7	3.8
28	1.7	71.8	3.4
Average	1.7	71.6	3.4
29	1.8	71.2	4.1
30	1.8	71.7	3.9
31	1.8	72.2	4.5
32	1.8	71.9	3.0
Average	1.8	71.8	3.9
33	1.9	73.9	3.3
34	1.9	70.9	4.0
35	1.9	70.5	6.9
36	1.9	73.3	2.6
Average	1.9	72.2	4.2
37	2.0	70.5	3.4
38	2.0	72.8	3.5
39	2.0	72.4	3.7
Average	2.0	71.9	3.6
40	2.1	71.0	5.0
41	2.1	73.3	2.2
42	2.1	72.7	2.5
Average	2.1	72.3	3.2
43	2.2	70.2	3.1
44	2.2	71.0	4.6
45	2.2	71.6	2.4
Average	2.2	70.9	3.4
46	2.3	72.8	3.6
47	2.3	72.2	3.3
48	2.3	73.0	2.8
Average	2.3	72.6	3.2
Overall average		71.7	3.6

Table 38. Chemical composition of semitendinosus of raw ham

Code no.	Backfat thickness	Moisture	Fat
	in.	%	%
1	1.0	69.6	7.5
2	1.0	72.8	5.1
3	1.0	72.0	5.8
4	1.0	73.4	4.6
Average	1.0	72.0	5.8
5	1.1	68.3	10.9
6	1.1	72.6	5.6
7	1.1	70.6	7.0
8	1.1	70.5	5.4
Average	1.1	70.5	7.2
9	1.2	73.2	4.5
10	1.2	71.3	6.5
11	1.2	70.1	6.2
12	1.2	72.2	5.0
Average	1.2	71.7	5.6
13	1.3	71.8	5.2
14	1.3	70.1	8.7
15	1.3	71.5	5.0
Average	1.3	71.1	6.3
16	1.4	65.4	16.4
17	1.4	74.1	4.3
18	1.4	69.5	7.7
Average	1.4	69.7	9.5
19	1.5	73.0	4.8
20	1.5	70.5	7.6
21	1.5	71.4	7.7
Average	1.5	71.8	6.7
22	1.6	72.2	5.1
23	1.6	69.4	8.5
24	1.6	67.7	6.5
Average	1.6	69.8	6.7

Table 38. (Continued)

Code no.	Backfat thickness	Moisture	Fat
	in.	%	%
25	1.7	70.6	8.9
26	1.7	70.4	5.6
27	1.7	71.1	6.7
28	1.7	71.1	6.1
Average	1.7	70.8	6.8
29	1.8	70.1	7.2
30	1.8	72.9	5.2
31	1.8	73.0	5.6
32	1.8	71.0	5.7
Average	1.8	71.8	5.9
33	1.9	72.4	6.1
34	1.9	69.7	7.3
35	1.9	68.4	10.9
36	1.9	71.8	6.3
Average	1.9	70.6	7.6
37	2.0	72.1	5.3
38	2.0	72.6	5.4
39	2.0	71.8	7.5
Average	2.0	72.2	6.1
40	2.1	69.8	8.3
41	2.1	71.5	5.7
42	2.1	72.4	3.6
Average	2.1	71.2	5.9
43	2.2	69.9	4.0
44	2.2	71.2	6.7
45	2.2	74.0	4.0
Average	2.2	71.7	4.9
46	2.3	70.4	6.7
47	2.3	73.1	6.1
48	2.3	74.7	2.7
Average	2.3	72.7	5.2
Overall average		71.2	6.4

Table 39. Chemical composition of rectus femoris of raw ham

Code no.	Backfat thickness	Moisture	Fat	Protein	Residual
	in.	%	%	%	%
1	1.0	71.4	2.2	23.0	3.4
2	1.0	76.0	2.8	16.5	4.7
3	1.0	73.5	2.2	20.2	4.1
4	1.0	76.8	1.2	17.1	4.9
Average	1.0	74.4	2.1	19.2	4.3
5	1.1	71.9	4.0	20.8	3.3
6	1.1	71.6	1.9	22.7	3.8
7	1.1	73.0	2.5	20.4	4.1
8	1.1	71.1	2.6	22.0	4.3
Average	1.1	71.9	2.8	21.5	3.9
9	1.2	74.0	2.1	--	--
10	1.2	70.3	2.6	22.4	4.7
11	1.2	71.1	2.3	22.7	3.9
12	1.2	69.4	2.5	23.7	4.4
Average	1.2	71.2	2.4	22.9	4.3
13	1.3	70.2	2.8	--	--
14	1.3	73.8	3.4	18.3	4.5
15	1.3	71.2	2.1	23.0	3.7
Average	1.3	71.7	2.8	20.6	4.1
16	1.4	71.4	6.1	18.6	3.9
17	1.4	72.5	1.8	21.3	4.4
18	1.4	72.2	2.0	21.5	4.3
Average	1.4	72.0	3.3	20.5	4.2
19	1.5	73.0	2.1	21.2	3.7
20	1.5	72.2	2.1	21.7	4.0
21	1.5	72.2	3.6	21.1	3.1
Average	1.5	72.5	2.6	21.3	3.6
22	1.6	70.4	3.1	22.6	3.9
23	1.6	70.3	3.5	22.3	3.9
24	1.6	73.5	1.8	--	--
Average	1.6	71.4	2.8	22.4	3.9

Table 39. (Continued)

Code no.	Backfat thickness	Moisture	Fat	Protein	Residual
	in.	%	%	%	%
25	1.7	72.9	3.5	18.9	4.7
26	1.7	72.8	2.0	20.8	4.4
27	1.7	72.6	2.1	--	--
28	1.7	72.8	2.1	19.3	5.8
Average	1.7	72.8	2.4	19.7	5.0
29	1.8	73.0	2.1	20.8	4.1
30	1.8	74.8	1.7	18.7	4.8
31	1.8	71.5	2.9	20.5	5.1
32	1.8	72.6	1.8	19.8	5.8
Average	1.8	73.0	2.1	20.0	5.0
33	1.9	71.5	3.5	21.1	3.9
34	1.9	73.0	1.9	21.2	3.9
35	1.9	73.5	2.8	19.6	4.1
36	1.9	72.8	2.3	20.8	4.1
Average	1.9	72.7	2.6	20.7	4.0
37	2.0	74.0	2.2	20.5	3.3
38	2.0	73.9	2.6	19.6	3.9
39	2.0	74.4	2.3	18.9	4.4
Average	2.0	74.1	2.4	19.7	3.9
40	2.1	72.8	3.3	18.3	5.6
41	2.1	72.9	2.3	20.3	4.5
42	2.1	70.3	2.6	23.6	3.5
Average	2.1	72.0	2.7	20.7	4.5
43	2.2	67.4	3.1	25.6	3.9
44	2.2	73.6	1.7	19.6	5.1
45	2.2	73.5	2.6	19.0	4.9
Average	2.2	71.5	2.5	21.4	4.6
46	2.3	72.3	3.2	21.2	3.3
47	2.3	72.8	2.5	20.6	4.1
48	2.3	71.0	3.4	--	--
Average	2.3	72.0	3.0	20.9	3.7
Overall average		72.4	2.6	20.7	4.2

Table 40. Chemical composition of biceps femoris of cooked ham

Code no.	Backfat thickness	Moisture	Fat	Protein	Residual
	in.	%	%	%	%
1	1.0	66.8	5.6	23.6	4.0
2	1.0	70.8	5.6	16.4	7.2
3	1.0	67.1	4.0	21.0	7.9
4	1.0	69.5	3.4	23.5	3.6
Average	1.0	68.6	4.6	21.1	5.7
5	1.1	65.4	11.1	19.9	3.6
6	1.1	69.1	5.8	21.1	4.0
7	1.1	68.4	6.3	21.5	3.8
8	1.1	65.8	6.0	24.0	4.2
Average	1.1	67.2	7.3	21.6	3.9
9	1.2	67.8	4.2	21.1	6.9
10	1.2	70.0	5.2	19.8	5.0
11	1.2	65.6	5.6	24.5	4.3
12	1.2	65.8	5.0	23.9	5.3
Average	1.2	67.3	5.0	22.3	5.4
13	1.3	65.9	5.4	23.4	5.3
14	1.3	66.7	9.1	20.2	4.0
15	1.3	68.2	3.1	24.6	4.1
Average	1.3	66.9	5.9	22.7	4.5
16	1.4	63.0	15.9	18.0	3.1
17	1.4	70.0	3.6	22.6	3.8
18	1.4	66.9	5.5	23.5	4.1
Average	1.4	66.6	8.3	21.4	3.7
19	1.5	70.0	3.9	21.9	4.2
20	1.5	65.8	6.5	23.9	3.8
21	1.5	66.3	8.3	21.8	3.6
Average	1.5	67.4	6.2	22.5	3.9
22	1.6	67.5	6.9	18.1	7.5
23	1.6	65.9	8.4	21.7	4.0
24	1.6	68.2	4.6	22.8	4.4
Average	1.6	67.2	6.6	20.9	5.3

Table 40. (Continued)

Code no.	Backfat thickness	Moisture	Fat	Protein	Residual
	in.	%	%	%	%
25	1.7	69.8	6.3	--	--
26	1.7	67.6	4.5	23.3	4.6
27	1.7	67.7	6.2	21.4	4.7
28	1.7	68.1	4.9	22.4	4.6
Average	1.7	68.3	5.5	22.4	4.6
29	1.8	69.5	5.9	19.6	5.0
30	1.8	69.3	5.0	--	--
31	1.8	68.5	5.6	22.4	3.5
32	1.8	69.6	4.9	21.5	4.0
Average	1.8	69.2	5.4	21.2	4.2
33	1.9	69.4	6.7	18.9	5.0
34	1.9	65.2	7.1	21.7	2.0
35	1.9	67.0	10.5	18.8	3.7
36	1.9	66.0	7.5	22.4	4.7
Average	1.9	66.9	8.0	20.4	3.7
37	2.0	67.8	4.1	23.6	4.5
38	2.0	66.3	6.9	23.0	3.8
39	2.0	68.1	7.5	19.9	4.5
Average	2.0	67.4	6.2	22.2	4.3
40	2.1	65.3	10.2	19.4	5.1
41	2.1	61.8	8.0	23.6	6.6
42	2.1	68.6	5.9	21.6	3.9
Average	2.1	65.2	8.0	21.5	5.2
43	2.2	65.9	5.7	24.1	4.3
44	2.2	70.4	4.7	--	--
45	2.2	67.8	5.4	22.8	4.0
Average	2.2	68.0	5.3	23.4	4.2
46	2.3	64.4	9.1	21.5	5.0
47	2.3	71.0	4.3	20.9	3.8
48	2.3	67.0	6.7	22.1	4.2
Average	2.3	67.5	6.7	21.5	4.3
Overall average		67.5	6.3	21.7	4.5

Table 41. Chemical composition of semimembranosus of cooked ham

Code no.	Backfat thickness	Moisture	Fat
	in.	%	%
1	1.0	68.6	3.4
2	1.0	72.5	2.7
3	1.0	69.8	2.7
4	1.0	71.0	2.0
Average	1.0	70.5	2.7
5	1.1	71.7	5.0
6	1.1	71.0	2.6
7	1.1	69.4	3.6
8	1.1	69.3	3.3
Average	1.1	70.3	3.6
9	1.2	72.2	2.0
10	1.2	66.9	2.6
11	1.2	67.0	3.3
12	1.2	68.2	3.0
Average	1.2	68.6	2.7
13	1.3	71.0	2.3
14	1.3	70.8	3.9
15	1.3	68.8	2.0
Average	1.3	70.2	2.7
16	1.4	68.1	8.8
17	1.4	73.2	2.3
18	1.4	66.5	4.5
Average	1.4	69.2	5.2
19	1.5	71.8	2.5
20	1.5	69.7	2.9
21	1.5	69.5	5.4
Average	1.5	70.3	3.6
22	1.6	70.2	2.8
23	1.6	69.7	4.0
24	1.6	70.1	2.4
Average	1.6	70.0	3.1

Table 41. (Continued)

Code no.	Backfat thickness	Moisture	Fat
	in.	%	%
25	1.7	71.6	3.7
26	1.7	68.1	2.9
27	1.7	71.8	3.3
28	1.7	68.9	2.8
Average	1.7	70.1	3.2
29	1.8	69.2	3.8
30	1.8	70.4	2.5
31	1.8	72.3	3.0
32	1.8	71.0	3.0
Average	1.8	70.7	3.1
33	1.9	69.7	3.8
34	1.9	67.8	3.6
35	1.9	72.5	4.2
36	1.9	70.1	2.8
Average	1.9	70.0	3.6
37	2.0	69.7	2.8
38	2.0	70.4	3.6
39	2.0	70.7	3.7
Average	2.0	70.3	3.4
40	2.1	70.4	5.0
41	2.1	65.8	3.6
42	2.1	69.4	3.2
Average	2.1	68.5	3.9
43	2.2	67.2	2.8
44	2.2	70.0	2.7
45	2.2	70.5	2.6
Average	2.2	69.2	2.7
46	2.3	70.2	4.8
47	2.3	71.4	2.6
48	2.3	70.8	3.3
Average	2.3	70.8	3.5
Overall average		69.9	3.3

Table 42. Chemical composition of semitendinosus of cooked ham

Code no.	Backfat thickness	Moisture	Fat
	in.	%	%
1	1.0	71.7	6.3
2	1.0	74.3	4.8
3	1.0	70.8	3.5
4	1.0	70.4	4.9
Average	1.0	71.8	4.9
5	1.1	70.9	7.9
6	1.1	73.0	5.0
7	1.1	68.1	8.0
8	1.1	72.2	3.7
Average	1.1	71.0	6.2
9	1.2	75.1	2.8
10	1.2	71.5	4.0
11	1.2	68.8	5.8
12	1.2	68.8	4.6
Average	1.2	71.0	4.3
13	1.3	72.3	4.7
14	1.3	70.2	6.4
15	1.3	73.3	3.4
Average	1.3	72.0	4.8
16	1.4	64.3	17.0
17	1.4	71.7	4.1
18	1.4	68.9	5.5
Average	1.4	68.3	8.9
19	1.5	71.4	4.5
20	1.5	68.5	6.8
21	1.5	70.0	8.0
Average	1.5	70.0	6.4
22	1.6	71.3	4.8
23	1.6	68.9	8.0
24	1.6	73.0	2.6
Average	1.6	71.1	5.1

Table 42. (Continued)

Code no.	Backfat thickness	Moisture	Fat
	in.	%	%
25	1.7	67.9	10.2
26	1.7	69.0	5.5
27	1.7	75.0	4.0
28	1.7	68.2	5.3
Average	1.7	70.0	6.2
29	1.8	72.8	5.1
30	1.8	72.5	5.3
31	1.8	70.4	5.2
32	1.8	72.4	4.3
Average	1.8	72.0	5.0
33	1.9	70.8	5.9
34	1.9	69.0	5.8
35	1.9	68.5	9.4
36	1.9	72.2	4.8
Average	1.9	70.1	6.5
37	2.0	71.2	4.9
38	2.0	70.1	5.8
39	2.0	71.7	6.0
Average	2.0	71.0	5.6
40	2.1	67.8	8.4
41	2.1	61.1	12.7
42	2.1	73.0	3.2
Average	2.1	67.3	8.1
43	2.2	71.4	3.2
44	2.2	73.2	3.9
45	2.2	73.0	4.5
Average	2.2	72.6	3.9
46	2.3	69.8	6.8
47	2.3	72.3	5.4
48	2.3	73.6	3.7
Average	2.3	71.9	5.3
Overall average		70.8	5.8

Table 43. Chemical composition of rectus femoris of cooked ham

Code no.	Backfat thickness	Moisture	Fat	Protein	Residual
	in.	%	%	%	%
1	1.0	70.0	2.4	24.1	3.5
2	1.0	72.2	3.6	20.3	3.9
3	1.0	67.8	2.2	25.0	5.0
4	1.0	74.0	1.7	20.1	4.2
Average	1.0	71.0	2.5	22.4	4.2
5	1.1	71.4	4.0	19.9	4.7
6	1.1	69.8	2.9	23.6	3.7
7	1.1	72.0	2.6	19.8	5.6
8	1.1	68.6	3.0	23.6	4.8
Average	1.1	70.4	3.1	21.7	4.7
9	1.2	70.1	2.6	-	-
10	1.2	68.8	2.8	24.5	3.9
11	1.2	66.6	2.8	27.6	3.0
12	1.2	63.1	3.9	28.9	4.1
Average	1.2	67.2	3.0	27.0	3.7
13	1.3	69.8	2.5	-	-
14	1.3	66.7	4.6	25.2	3.5
15	1.3	70.2	2.2	23.8	3.8
Average	1.3	68.9	3.1	24.5	3.6
16	1.4	71.4	6.0	18.6	4.0
17	1.4	69.6	2.5	23.7	4.2
18	1.4	70.5	2.6	22.6	4.3
Average	1.4	70.5	2.6	22.6	4.2
19	1.5	70.0	2.5	23.4	4.1
20	1.5	73.4	2.2	20.4	4.0
21	1.5	67.2	4.3	25.1	3.4
Average	1.5	70.2	3.0	23.0	3.8
22	1.6	68.4	3.4	23.7	4.5
23	1.6	69.6	4.0	22.1	4.3
24	1.6	66.7	2.9	-	-
Average	1.6	68.2	3.4	22.9	4.4

Table 43. (Continued)

Code no.	Backfat thickness	Moisture	Fat	Protein	Residual
	in.	%	%	%	%
25	1.7	69.7	3.9	21.9	4.5
26	1.7	70.4	2.5	21.5	5.6
27	1.7	69.8	2.7	-	-
28	1.7	69.3	3.0	23.3	4.4
Average	1.7	69.8	3.0	22.2	4.8
29	1.8	69.8	2.9	21.5	5.8
30	1.8	73.3	1.9	20.2	4.6
31	1.8	66.9	3.7	25.4	4.0
32	1.8	71.2	2.3	22.2	4.3
Average	1.8	70.3	2.7	22.3	4.7
33	1.9	70.4	3.0	21.0	5.6
34	1.9	71.4	2.3	22.4	3.9
35	1.9	70.0	3.7	22.6	3.7
36	1.9	72.8	2.0	20.3	4.9
Average	1.9	71.2	2.8	21.6	4.5
37	2.0	68.6	3.3	24.0	4.1
38	2.0	68.6	3.6	24.0	3.8
39	2.0	69.3	4.2	21.9	4.6
Average	2.0	68.8	3.7	23.3	4.2
40	2.1	72.4	3.7	18.2	5.7
41	2.1	66.4	3.8	27.1	2.7
42	2.1	70.0	2.7	22.4	4.9
Average	2.1	69.6	3.4	22.6	4.4
43	2.2	70.4	2.9	22.7	4.0
44	2.2	72.6	2.1	20.6	4.7
45	2.2	71.7	3.0	20.4	4.9
Average	2.2	71.6	2.7	21.2	4.5
46	2.3	68.4	3.9	23.7	4.0
47	2.3	68.8	3.0	24.2	4.0
48	2.3	65.9	4.4	27.2	2.5
Average	2.3	67.7	3.8	25.0	3.5
Overall average		69.7	3.1	22.8	4.3

Table 44. Taste panel scores for flavor, tenderness and juiciness of *biceps femoris* of cooked ham

Code no.	Backfat thickness	Flavor	Tenderness	Juiciness
	in.			
1	1.0	8.0	7.5	7.5
2	1.0	7.0	6.7	7.3
3	1.0	5.4	7.1	5.7
4	1.0	6.1	7.4	7.1
Average	1.0	6.6	7.2	6.9
5	1.1	6.2	7.2	6.7
6	1.1	5.8	6.3	7.0
7	1.1	7.2	6.8	7.0
8	1.1	7.0	7.7	6.8
Average	1.1	6.6	7.0	6.9
9	1.2	6.8	7.6	7.6
10	1.2	7.4	7.1	5.5
11	1.2	6.9	7.0	6.0
12	1.2	7.0	7.3	5.7
Average	1.2	7.0	7.2	6.2
13	1.3	6.0	6.2	7.3
14	1.3	7.3	6.8	6.9
15	1.3	6.7	6.8	6.8
Average	1.3	6.7	6.6	7.0
16	1.4	6.3	6.2	6.8
17	1.4	7.0	6.4	6.6
18	1.4	6.1	5.6	6.0
Average	1.4	6.5	6.1	6.5
19	1.5	6.2	6.1	6.3
20	1.5	6.8	6.1	6.7
21	1.5	6.8	6.8	7.2
Average	1.5	6.6	6.3	6.7
22	1.6	6.8	7.4	7.1
23	1.6	6.3	6.8	6.5
24	1.6	5.8	6.5	5.6
Average	1.6	6.3	6.9	6.4

Table 44. (Continued)

Code no.	Backfat thickness	Flavor	Tenderness	Juiciness
	in.			
25	1.7	6.9	7.3	8.0
26	1.7	7.4	6.7	6.6
27	1.7	6.1	7.2	7.8
28	1.7	7.3	7.8	7.1
Average	1.7	6.9	7.2	7.4
29	1.8	7.4	7.4	7.5
30	1.8	6.8	6.7	7.6
31	1.8	6.8	7.7	7.5
32	1.8	6.1	6.3	7.8
Average	1.8	6.8	7.0	7.6
33	1.9	7.2	7.0	7.3
34	1.9	7.0	7.8	6.6
35	1.9	5.7	7.3	7.8
36	1.9	6.1	5.0	7.0
Average	1.9	6.5	6.8	7.2
37	2.0	6.7	7.2	7.2
38	2.0	6.0	6.7	6.6
39	2.0	6.9	7.8	7.4
Average	2.0	6.5	7.2	7.1
40	2.1	6.6	7.4	7.4
41	2.1	ham did not take cure		
42	2.1	6.7	7.3	7.4
Average	2.1	6.6	7.4	7.4
43	2.2	7.0	7.7	7.1
44	2.2	6.6	7.0	7.4
45	2.2	6.8	7.3	7.1
Average	2.2	6.8	7.3	7.2
46	2.3	6.3	7.0	7.0
47	2.3	7.1	7.1	8.4
48	2.3	7.0	7.2	7.3
Average	2.3	6.8	7.1	7.6
Overall average		6.7	7.0	7.0

Table 45. Taste panel scores for flavor, tenderness and juiciness of semimembranosus of cooked ham

Code no.	Backfat thickness	Flavor	Tenderness	Juiciness
	in.			
1	1.0	7.2	7.7	6.6
2	1.0	7.2	7.5	6.8
3	1.0	8.3	7.8	7.3
4	1.0	7.1	7.3	5.9
Average	1.0	7.4	7.6	6.6
5	1.1	6.8	6.3	6.0
6	1.1	6.7	7.7	7.1
7	1.1	7.6	7.2	7.2
8	1.1	8.0	7.7	7.1
Average	1.1	7.3	7.2	6.8
9	1.2	6.8	7.7	7.2
10	1.2	6.9	6.7	7.1
11	1.2	8.0	7.4	7.1
12	1.2	7.8	6.9	5.8
Average	1.2	7.4	7.2	6.8
13	1.3	6.5	6.7	7.8
14	1.3	7.2	7.6	7.3
15	1.3	7.7	7.4	6.8
Average	1.3	7.1	7.2	7.3
16	1.4	7.5	8.1	7.3
17	1.4	7.6	7.6	7.5
18	1.4	7.4	6.8	6.1
Average	1.4	7.5	7.5	7.0
19	1.5	6.9	6.4	5.5
20	1.5	7.3	6.8	6.5
21	1.5	8.0	7.7	7.5
Average	1.5	7.4	7.0	6.5
22	1.6	8.1	7.1	7.6
23	1.6	7.3	7.7	6.3
24	1.6	6.2	7.5	7.1
Average	1.6	7.2	7.4	7.0

Table 45. (Continued)

Code no.	Backfat thickness	Flavor	Tenderness	Juiciness
	in.			
25	1.7	8.2	7.4	7.6
26	1.7	7.1	7.4	6.0
27	1.7	7.2	7.2	7.8
28	1.7	8.2	7.9	7.8
Average	1.7	7.7	7.5	7.3
29	1.8	7.2	7.7	7.5
30	1.8	7.7	7.2	7.2
31	1.8	7.7	7.7	7.3
32	1.8	7.7	7.3	6.7
Average	1.8	7.6	7.5	7.2
33	1.9	7.5	7.2	7.3
34	1.9	7.5	7.8	6.3
35	1.9	6.3	7.8	7.8
36	1.9	7.0	6.2	7.0
Average	1.9	7.1	7.2	7.1
37	2.0	7.5	7.3	6.8
38	2.0	7.5	7.2	6.8
39	2.0	7.8	8.1	7.2
Average	2.0	7.6	7.5	6.9
40	2.1	7.9	7.9	7.2
41	2.1	Ham did not take cure		
42	2.1	8.1	7.4	7.5
Average	2.1	8.0	7.6	7.4
43	2.2	7.5	7.2	6.3
44	2.2	7.9	7.3	7.5
45	2.2	7.2	7.4	7.8
Average	2.2	7.5	7.3	7.2
46	2.3	7.5	8.0	8.1
47	2.3	8.0	7.7	7.5
48	2.3	7.5	8.1	7.6
Average	2.3	7.7	7.9	7.7
Overall average		7.4	7.4	7.0

Table 46. Taste panel scores for flavor, tenderness and juiciness of semitendinosus of cooked ham

Code no.	Backfat thickness	Flavor	Tenderness	Juiciness
	in.			
1	1.0	6.4	8.8	7.9
2	1.0	6.8	8.6	8.2
3	1.0	7.0	8.4	7.9
4	1.0	6.1	8.5	7.1
Average	1.0	6.6	8.6	7.8
5	1.1	5.2	8.3	7.3
6	1.1	5.0	8.4	7.6
7	1.1	6.1	8.6	7.8
8	1.1	7.2	8.4	7.3
Average	1.1	5.9	8.4	7.5
9	1.2	5.2	8.2	7.4
10	1.2	6.2	8.0	7.7
11	1.2	6.4	8.5	6.8
12	1.2	6.7	8.3	6.8
Average	1.2	6.1	8.2	7.2
13	1.3	5.8	8.3	8.2
14	1.3	6.0	8.8	7.1
15	1.3	6.2	8.1	7.4
Average	1.3	6.0	8.4	7.6
16	1.4	6.5	8.8	8.0
17	1.4	6.5	8.3	6.8
18	1.4	5.9	8.0	6.9
Average	1.4	6.3	8.4	7.2
19	1.5	4.9	7.9	6.3
20	1.5	6.3	7.5	7.3
21	1.5	6.8	8.9	8.3
Average	1.5	6.0	8.1	7.3
22	1.6	6.8	8.6	7.8
23	1.6	5.5	8.7	7.1
24	1.6	5.0	8.0	6.7
Average	1.6	5.8	8.4	7.2

Table 46. (Continued)

Code no.	Backfat thickness	Flavor	Tenderness	Juiciness
	in.			
25	1.7	6.2	8.3	8.2
26	1.7	6.5	8.2	7.1
27	1.7	4.8	8.3	8.0
28	1.7	7.0	8.9	8.0
Average	1.7	6.1	8.4	7.8
29	1.8	5.7	8.1	7.8
30	1.8	6.7	8.5	8.2
31	1.8	6.2	8.8	8.1
32	1.8	6.5	8.3	7.2
Average	1.8	6.3	8.4	7.8
33	1.9	5.7	8.8	7.1
34	1.9	6.0	8.8	7.3
35	1.9	5.2	8.5	7.7
36	1.9	5.8	8.1	7.9
Average	1.9	5.7	8.6	7.5
37	2.0	5.8	8.6	7.3
38	2.0	5.7	8.3	6.5
39	2.0	6.8	9.0	7.5
Average	2.0	6.1	8.6	7.1
40	2.1	6.4	8.7	7.8
41		ham did not take cure		
42	2.1	6.4	8.6	7.6
Average	2.1	6.4	8.6	7.7
43	2.2	6.8	8.8	7.6
44	2.2	6.3	8.6	8.0
45	2.2	6.3	8.6	7.8
Average	2.2	6.5	8.7	7.8
46	2.3	6.3	8.8	8.4
47	2.3	6.1	8.2	7.9
48	2.3	6.7	8.8	8.2
Average	2.3	6.4	8.6	8.2
Overall average		6.1	8.4	7.6

Table 47. Analysis of variance of taste panel scores for flavor, tenderness and juiciness of *biceps femoris*, *semimembranosus* and *semitendinosus* of cooked hams

Source of variation	d.f.	M.S.	F values
Flavor			
biceps femoris			
Treatment	13	0.26	0.77
Error	11	0.34	
Total	24		
semimembranosus			
Treatment	13	0.23	2.65
Error	11	0.08	
Total	24		
semitendinosus			
Treatment	13	0.10	0.54
Error	11	0.19	
Total	24		
Tenderness			
biceps femoris			
Treatment	13	0.37	0.53
Error	11	0.69	
Total	24		
semimembranosus			
Treatment	13	0.20	0.71
Error	11	0.28	
Total	24		
semitendinosus			
Treatment	13	0.11	1.18
Error	11	0.09	
Total	24		
Juiciness			
biceps femoris			
Teeatment	13	0.66	0.62
Error	11	1.07	
Total	24		
semimembranosus			
Treatment	13	0.45	1.57
Error	11	0.28	
Total	24		
semitendinosus			
Treatment	13	0.23	0.92
Error	11	0.25	
Total	24		

Table 48. Ration fed to all pigs

72 tons of pig grower (16%)

<u>Grower to be mixed as follows:</u>	
Ground shelled corn (No. 1 or 2 yellow-medium grind)	1340 lbs.
Cane molasses (Blackstrap)	50
Soybean meal (Solvent-44% protein)	400
Fish solubles, 50% solids, 32% protein	50
Distillers dried solubles, 26% protein	50
Dried whey (70% lactose), 12% protein	50
Ground limestone, 38% calcium	19
Dicalcium phosphate, 26% Ca, 18% protein	20
Salt, iodized	10
Trace mineral premix (swine) Cal Carb, Co. Premix for swine or equivalent	4
Copper sulfate	1
Hugromix (Lilly)	5
Vitamin A, 2.5 million I.U.	
Vitamin D_2, 1 million I.U.	
Vitamin B12, -20 milligrams	
Riboflavin - 3 grams	
Pantothenic acid - 5 grams	
Niacin - 20 grams	
Aureomycin, 50 grams	
Antioxidant (25% BHT or equivalent) 1 lb.	
	1996 + lbs.

72 tons of 14% protein complete swine fattening ration

<u>Ration to be mixed as follows:</u>	
Ground (medium) shelled corn, No. 2 yellow	1600 lbs.
Meat and bone scrap 50% protein	50
Soybean meal, solvent 44% protein	225
Fish solubles, 32% protein, 50% solids	50
Dehydrated alfalfa meal, 17% protein	50
Ground limestone, 38% Ca	11
Dical, Phosphate 26% Ca, 18% phos.	2
Salt, iodized	8
Trace mineral mixture (Swine)	2
Vitamin B_{12} - 15 milligrams	
Aureomycin - 20 grams	
Vitamin D_2 - 1 million I.U.	
Riboflavin - 3 grams	
Pantothenic acid - 5 grams	
Niacin - 12 grams	
	1998 + lbs.

Table 49. Backfat thickness, grade, age, live weight, total carcass weight and weight of hams[a]

Code no.	Breed	Backfat thickness	Grade	Age	Live weight	Total carcass weight	Weight of ham		
							Fresh	Cured	
								Before	After
		in.		mo.	lbs.	lbs.	lbs.	lbs.	lbs.
1	Duroc	1.5	1	5	201	141.0	13.4	14.1	-[b]
2	Duroc	1.4	1	5	208	137.5	12.0	14.4	14.1
3	Duroc	1.7	2	5	214	141.5	13.8	16.6	14.0
4	Duroc	1.8	2	5	226	156.5	14.5	14.6	12.1
5	Duroc	1.8	2	5	210	142.0	13.2	12.8	13.4
6	Duroc	1.7	2	5	217	150.0	14.6	13.4	14.3
7	Duroc	1.7	2	5	211	151.5	14.2	14.4	14.1
8	Duroc	1.5	1	5	199	140.5	13.4	14.2	15.3
1	Hampshire	1.1	1	5	212	149.0	14.6	14.7	15.2
2	Hampshire	1.4	1	5	200	142.0	13.9	14.5	12.1
3	Hampshire	1.2	1	5	200	137.0	14.5	14.1	14.1
4	Hampshire	1.3	1	5	208	147.0	14.8	14.4	15.8
5	Hampshire	1.3	1	5	213	155.0	17.1	17.4	18.1
6	Hampshire	1.3	1	5	200	137.0	13.6	12.7	13.2
7	Hampshire	1.4	1	5	212	148.5	14.8	14.5	15.7
8	Hampshire	1.3	1	5	200	145.0	15.1	15.6	17.2

[a]Data supplied by Animal Husbandry Department, Iowa State University of Science and Technology, Ames, Iowa, and Hormel Packing Company, Fort Dodge, Iowa.

[b]Ham did not take cure.

Table 50. Percent total fat in three muscles of raw fresh, cooked fresh and cured smoked and fully cooked ham

Breed and animal	Biceps femoris			Semitendinosis			Rectus femoris		
	R[a]	C[b]	S[c]	R[a]	C[b]	S[c]	R[a]	C[b]	S[c]
	%	%	%	%	%	%	%	%	%
Duroc									
1	6.10	10.98	7.98	9.45	12.78	8.96	3.36	5.30	5.88
2	6.99	7.70	6.05	11.05	8.32	10.56	4.49	4.04	4.10
3	5.96	8.26	6.14	11.53	13.09	10.42	3.35	7.68	4.82
4	4.61	7.34	5.58	14.10	9.82	7.00	3.07	4.28	3.56
5	4.08	7.90	5.04	10.34	12.04	8.58	4.88	5.00	5.14
6	3.36	6.24	5.40	10.60	10.75	6.26	2.45	3.06	3.50
7	5.32	9.66	2.45	10.54	13.46	8.32	3.96	6.13	3.38
8	7.01	10.37	---[d]	14.22	15.27	---	7.58	7.12	---
Average	5.43	8.56	5.52	11.48	11.94	8.58	4.14	5.33	4.34
Hampshire									
1	6.32	7.86	4.36	11.92	12.80	6.65	4.46	6.39	3.34
2	3.54	7.92	3.00	7.88	11.00	6.62	5.90	5.60	2.68
3	6.47	11.54	4.14	15.51	18.72	11.80	3.56	6.72	3.32
4	4.30	5.23	3.36	10.50	11.90	8.48	4.62	4.16	1.92
5	3.88	6.40	3.35	11.61	15.68	8.16	3.76	4.59	3.33
6	4.32	7.55	4.52	9.44	9.84	7.21	3.14	4.30	3.08
7	6.22	6.71	4.74	11.80	15.00	13.00	3.76	5.92	3.90
8	3.98	4.03	2.69	7.10	6.82	5.90	2.22	2.58	3.04
Average	4.88	7.16	3.77	10.72	12.72	8.48	3.93	5.03	3.08

[a]R = raw.

[b]C = cooked.

[c]S = smoked.

[d]Ham did not take cure.

Table 51. Analyses of variance of total fat in 3 muscles of ham from Duroc and Hampshire pigs

Source of variation	d.f.		MS	F
Breed	1		19.6	1.23
Animal within breed	14		16.0	
Muscle	2		527.3	161.5**
Muscle by breed	2		3.88	1.19
Muscle by animal within breed	28		3.26	
Treatment	2		86.7	33.5**
Raw vs cooked		1	69.2	26.7**
Raw + cooked vs smoked		1	104.2	40.2**
Cooked vs smoked		1	169.0	65.2**
Raw vs cooked + smoked		1	4.41	1.70
Raw vs smoked		1	21.93	8.46**
Treatment by breed	2		3.97	1.53
Treatment by animal within breed	28		2.59	
Treatment by muscle	4		9.82	9.27**
Treatment by muscle by breed	4		1.69	1.60
Treatment by muscle by animal within breed	56		1.06	
Total	143			

**Significant at the 1% level.

Table 52. Fatty acid percentage in rectus femoris of Duroc pigs

Treatment	Myristic acid	Palmitic acid	Palmitoleic acid	Stearic acid	Oleic acid	Linoleic acid
Animal	%	%	%	%	%	%
Raw fresh						
1	1.75	26.7	3.87	13.0	41.7	12.9
2	1.72	25.4	6.37	11.1	44.0	11.4
3	1.84	26.4	4.61	12.4	39.9	14.8
4	1.66	26.3	5.56	11.8	44.0	10.8
5	1.63	25.1	6.26	11.1	41.3	14.6
6	1.71	27.8	4.70	12.0	42.6	11.2
7	1.77	26.8	5.34	11.6	42.7	11.8
8	1.73	29.1	3.30	14.4	40.9	10.6
Average	1.73	26.7	5.00	12.2	42.1	12.3
Cooked fresh						
1	1.72	25.6	5.75	12.8	42.8	11.5
2	1.60	25.9	6.30	11.2	44.0	10.9
3	1.62	24.4	6.03	12.8	40.3	14.8
4	1.52	24.8	5.89	11.3	44.0	12.5
5	1.36	26.1	4.06	13.0	41.0	14.6
6	1.64	26.0	5.98	11.4	43.9	11.1
7	1.52	27.2	4.02	12.1	43.0	12.2
8	1.52	28.8	5.38	13.6	40.3	11.2
Average	1.56	26.1	5.43	12.3	42.4	12.4
Cured smoked						
1	1.54	25.1	5.33	13.3	41.9	12.9
2	1.60	27.5	5.57	11.9	44.8	8.60
3	1.30	25.8	6.29	13.5	38.2	14.9
4	1.53	25.3	4.50	12.7	44.2	11.8
5	1.29	25.1	6.50	11.8	41.2	14.1
6	1.72	26.1	6.36	10.2	45.6	10.0
7	1.50	26.9	4.82	12.0	42.8	11.7
8	1.50	28.9	4.94	13.4	39.8	11.4
Average	1.50	26.3	5.54	12.4	42.3	11.9

Table 53. Fatty acid percentage in rectus femoris of Hampshire pigs

Treatment	Myristic acid	Palmitic acid	Palmitoleic acid	Stearic acid	Oleic acid	Linoleic acid
	%	%	%	%	%	%
Raw fresh						
1	1.03	24.1	3.60	12.8	43.8	14.6
2	1.50	24.9	3.61	13.2	39.3	17.5
3	1.22	24.5	5.42	10.5	43.7	14.7
4	1.64	25.1	4.56	14.0	35.7	19.0
5	1.53	24.3	3.80	11.8	41.8	16.6
6	1.06	24.8	3.84	12.3	41.0	17.0
7	1.11	24.0	3.92	12.2	43.6	15.1
8	1.16	25.2	3.72	11.7	47.8	10.6
Average	1.28	24.6	4.06	12.3	42.1	15.6
Cooked fresh						
1	1.12	24.3	3.57	12.9	44.1	14.0
2	1.08	25.2	3.01	13.9	35.8	21.0
3	1.46	24.2	4.73	11.2	45.4	13.1
4	1.46	25.9	4.20	14.0	38.4	16.1
5	1.17	24.6	4.61	11.6	43.8	14.2
6	1.24	24.6	3.11	12.7	42.0	16.2
7	1.07	24.0	3.84	11.5	47.9	11.8
8	0.93	25.5	3.80	12.5	41.7	15.7
Average	1.19	24.8	3.86	12.5	42.4	15.3
Cured, smoked						
1	1.37	24.8	3.78	12.1	44.0	14.0
2	1.06	24.1	3.22	14.4	38.8	18.8
3	1.11	23.8	4.49	11.7	44.4	14.5
4	1.20	25.7	2.82	13.6	38.5	18.2
5	1.71	23.6	3.71	12.7	42.5	15.6
6	1.12	25.6	2.74	12.3	42.1	16.1
7	1.06	22.7	3.99	12.8	45.5	14.2
8	1.21	24.9	4.02	12.7	40.4	16.8
Average	1.23	24.4	3.60	12.8	42.0	16.0

Table 54. Fatty acid percentage in biceps femoris of Duroc pigs

Treat-ment	Myristic acid	Palmitic acid	Palmitoleic acid	Stearic acid	Oleic acid	Linoleic acid
	%	%	%	%	%	%
Raw fresh						
1	1.56	25.2	4.21	11.6	44.6	12.80
2	1.70	25.9	5.08	11.2	46.6	9.57
3	1.66	26.1	5.25	12.0	45.5	9.38
4	1.79	27.6	3.87	13.0	43.7	6.57
5	1.88	25.7	6.38	11.8	45.1	9.16
6	1.74	26.5	6.64	11.0	46.0	8.06
7	1.71	24.7	5.10	12.4	45.5	10.60
8	1.58	24.7	5.60	12.2	47.8	8.15
Average	1.70	25.8	5.27	11.9	45.6	9.29
Cooked fresh						
1	1.51	25.2	4.53	11.7	44.3	12.90
2	1.40	25.7	5.96	9.9	46.2	10.90
3	1.70	26.9	5.28	10.9	45.8	9.38
4	1.60	29.2	3.46	13.6	45.2	6.78
5	1.68	26.3	4.38	12.8	47.0	7.94
6	1.63	25.0	6.80	11.2	45.7	9.68
7	1.45	25.1	4.93	12.2	46.7	9.56
8	1.26	24.7	4.74	11.5	49.0	8.84
Average	1.53	26.0	5.01	11.7	46.2	9.50
Cured smoked						
1	1.40	25.8	4.89	10.5	46.1	11.30
2	1.56	25.8	6.45	9.5	44.3	12.30
3	1.59	26.2	5.93	10.9	46.0	8.37
4	1.67	28.3	4.49	13.0	45.4	7.16
5	1.42	24.3	6.93	12.0	46.4	8.93
6	1.67	25.7	6.40	11.5	47.3	7.35
7	1.41	25.5	6.12	11.3	46.2	9.67
8	1.48	23.4	5.12	11.1	49.8	9.10
Average	1.52	25.6	5.79	11.2	46.4	9.27

Table 55. Fatty acid percentage in biceps femoris of Hampshire pigs

Treatment	Myristic acid	Palmitic acid	Palmitoleic acid	Stearic acid	Oleic acid	Linoleic acid
Animal	%	%	%	%	%	%
Raw fresh						
1	1.12	22.9	4.03	10.7	51.4	9.9
2	1.24	25.0	3.48	12.2	44.2	13.9
3	1.64	22.4	5.37	9.9	50.7	10.1
4	1.61	24.0	4.09	12.1	45.6	12.6
5	1.59	24.3	4.61	10.6	47.1	11.8
6	1.18	24.2	4.06	11.1	48.7	10.8
7	1.06	24.3	3.51	13.2	43.4	14.5
8	1.16	23.1	4.98	12.8	47.6	10.3
Average	1.32	23.8	4.27	11.6	47.3	11.7
Cooked fresh						
1	1.26	23.0	3.78	11.7	49.4	10.9
2	1.27	22.8	3.73	12.2	44.3	15.6
3	1.42	25.9	4.44	10.1	48.6	9.53
4	1.40	24.8	3.98	12.0	46.6	11.3
5	1.23	22.6	4.25	12.5	48.0	11.3
6	1.03	23.6	3.92	10.5	49.6	11.4
7	1.07	24.4	3.91	12.4	43.4	14.7
8	1.24	24.4	3.92	10.5	47.4	12.6
Average	1.24	23.9	3.99	11.5	47.2	12.2
Cured smoked						
1	1.07	22.9	3.46	11.9	51.0	9.7
2	1.31	24.6	3.67	13.3	43.1	14.1
3	1.31	24.3	4.48	10.1	46.8	11.5
4	1.19	25.5	3.80	12.7	44.0	12.9
5	1.13	25.3	4.51	10.3	47.5	11.2
6	1.14	22.0	2.94	12.6	50.9	10.5
7	1.04	24.5	3.88	11.9	49.8	9.0
8	1.31	22.4	3.91	12.0	49.4	10.8
Average	1.19	23.9	3.83	11.8	47.8	11.2

Table 56. Fatty acid percentage in <u>semitendinosus</u> of Duroc pigs

Treatment	Myristic acid	Palmitic acid	Palmitoleic acid	Stearic acid	Oleic acid	Linoleic acid
Animal	%	%	%	%	%	%
Raw fresh						
1	1.49	26.2	5.09	14.7	41.6	10.80
2	1.77	27.2	4.72	11.2	47.7	7.40
3	1.66	26.9	4.62	11.0	45.2	10.60
4	1.70	29.6	3.62	14.4	44.4	6.25
5	1.70	28.1	5.40	11.1	46.4	7.31
6	1.83	28.0	5.36	11.8	44.8	8.36
7	1.42	28.7	3.60	13.0	45.6	7.70
8	1.45	26.8	4.14	12.4	49.1	6.00
Average	1.63	27.7	4.57	12.4	45.6	8.05
Cooked fresh						
1	1.52	26.2	3.88	12.4	45.6	10.30
2	1.64	24.7	4.85	10.8	49.2	8.81
3	1.80	26.9	4.53	11.7	46.1	9.14
4	1.54	29.4	3.14	14.2	45.4	6.30
5	1.80	28.2	4.48	13.0	45.8	6.80
6	2.00	28.3	5.12	11.2	46.4	6.90
7	1.34	26.8	4.00	13.1	47.0	7.81
8	1.38	26.8	3.81	12.3	48.6	7.20
Average	1.63	27.2	4.23	12.3	46.8	7.91
Cured smoked						
1	1.35	25.9	5.81	11.8	46.2	9.05
2	1.74	25.4	4.92	11.1	47.4	9.47
3	1.62	26.4	4.85	11.3	46.4	9.58
4	1.64	29.8	4.28	13.9	44.5	5.91
5	1.41	26.0	5.06	12.8	47.4	7.30
6	1.57	27.7	4.67	11.3	48.6	6.08
7	1.49	27.2	3.77	13.7	46.5	7.22
8	1.34	26.8	3.95	12.8	48.4	6.80
Average	1.52	26.9	4.66	12.3	46.9	7.68

Table 57. Fatty acid percentage in semitendinosus of Hampshire pigs

Treatment	Myristic acid	Palmitic acid	Palmitoleic acid	Stearic acid	Oleic acid	Linoleic acid
Animal	%	%	%	%	%	%
Raw fresh						
1	1.26	25.2	3.08	12.1	43.4	9.26
2	1.21	24.4	3.31	11.7	47.0	12.30
3	1.49	26.6	4.44	10.5	48.7	8.33
4	1.38	25.4	3.40	11.9	49.2	8.79
5	1.89	24.2	4.06	11.0	49.2	9.58
6	1.28	24.8	3.40	11.4	50.6	8.48
7	1.20	25.4	3.67	11.2	49.2	9.32
8	1.34	25.6	3.27	11.7	49.9	8.25
Average	1.38	25.2	3.58	11.4	48.4	9.29
Cooked fresh						
1	1.22	25.4	3.25	11.9	49.4	8.76
2	1.41	25.7	3.63	12.0	45.1	12.20
3	1.36	25.9	4.84	10.5	48.5	8.90
4	1.31	24.6	3.90	11.5	48.3	10.40
5	1.24	23.5	3.97	10.9	50.6	9.72
6	1.16	23.9	3.15	12.0	49.3	10.60
7	1.31	24.3	4.46	10.2	50.4	9.27
8	1.40	24.6	3.66	11.6	48.8	9.96
Average	1.30	24.7	3.86	11.3	48.8	9.98
Cured smoked						
1	1.20	23.2	3.28	12.0	50.3	10.00
2	1.37	24.5	3.90	13.9	45.7	10.60
3	1.24	24.9	4.75	10.9	49.3	8.84
4	1.44	25.6	3.91	10.8	47.6	10.80
5	1.29	24.5	3.37	10.5	51.0	9.31
6	1.24	24.2	3.13	12.7	50.0	8.74
7	1.14	24.6	3.83	11.8	49.8	8.62
8	2.24	23.4	3.86	11.0	50.6	8.90
Average	1.40	24.4	3.75	11.7	49.3	9.48

Table 58. Analyses of variance of myristic acid in three muscles of ham from Duroc and Hampshire pigs

Source of variation	d.f.		MS	F
Breed	1		3.45	33.4**
Animal within breed	14		0.10	
Muscle	2		0.06	2.18
Muscle by breed	2		0.06	2.17
Muscle by animal within breed	28		0.02	
Treatment	2		0.20	5.27**
Raw vs cooked		1	0.23	6.30**
Raw + cooked vs smoked		1	0.14	3.69*
Cooked vs smoked		1	0.01	0.17
Raw vs cooked + smoked		1	0.36	9.82**
Treatment by breed	2		0.04	1.12
Treatment by animal within breed	28		0.04	
Treatment by muscle	4		0.02	0.95
Treatment by muscle by breed	4		0.02	1.12
Treatment by muscle by animal within breed	56		0.02	
Total	143			

*Significant at 5% level.

**Significant at 1% level.

Table 59. Analyses of variance of palmitic acid in three muscles of ham from Duroc and Hampshire pigs

Source of variation	d.f.	MS	F
Breed	1	153.3	25.4**
Animal within breed	14	6.04	
Muscle	2	16.2	15.6**
Muscle by breed	2	1.65	1.58
Muscle by animal within breed	28	1.04	
Treatment	2	1.63	2.45
Raw vs cooked	1	0.72	1.08
Raw + cooked vs smoked	1	2.55	3.83*
Cooked vs smoked	1	0.92	1.38
Raw vs cooked + smoked	1	2.35	3.52*
Treatment by breed	2	0.21	0.31
Treatment by animal within breed	28	0.67	
Treatment by muscle	4	0.80	1.45
Treatment by muscle by breed	4	0.33	0.60
Treatment by muscle by animal within breed	56	0.55	
Total	143		

*Significant at 5% level.

**Significant at 1% level.

Table 60. Analyses of variance of palmitoleic acid in three muscles of ham from Duroc and Hampshire pigs

Source of variation	d.f.		MS	F
Breed	1		50.9	23.3**
Animal within breed	14		2.18	
Muscle	2		4.62	12.2**
Muscle by breed	2		1.76	4.66**
Muscle by animal within breed	28		0.38	
Treatment	2		0.22	0.58
Raw vs cooked		1	0.09	
Raw + cooked vs smoked		1	0.34	
Cooked vs smoked		1	0.43	
Raw vs cooked + smoked		1	0.00	
Treatment by breed	2		1.55	4.15**
Treatment by animal within breed	28		0.37	
Treatment by muscle	4		0.21	0.82
Treatment by muscle by breed	4		0.56	2.26
Treatment by muscle by animal within breed	56		0.25	
Total	143			

**Significant at 1% level.

Table 61. Analyses of variance of stearic acid in three muscles of ham from Duroc and Hampshire pigs

Source of variation	d.f.		MS	F
Breed	1		1.40	0.23
Animal within breed	14		5.98	
Muscle	2		7.36	13.9**
Muscle by breed	2		4.50	8.50**
Muscle an animal within breed	28		0.53	
Treatment	2		0.12	0.25
Raw vs cooked		1	0.02	
Raw + cooked vs smoked		1	0.22	
Cooked vs smoked		1	0.22	
Raw vs cooked + smoked		1	0.01	
Treatment by breed	2		1.02	2.20
Treatment by animal within breed	28		0.46	
Treatment by muscle	4		0.30	0.72
Treatment by muscle by breed	4		0.16	0.39
Treatment by muscle by animal within breed	56		0.42	
Total	143			

**Significant at 1% level.

Table 62. Analyses of variance of oleic acid in three muscles of ham from Duroc and Hampshire pigs

Source of variation	d.f.		MS	F
Breed	1		48.4	2.11
Animal within breed	14		22.9	
Muscle	2		408.8	68.9**
Muscle by breed	2		19.1	3.22
Muscle by animal within breed	28		5.93	
Treatment	2		3.49	1.79
Raw vs cooked		1	3.04	1.56
Raw + cooked vs smoked		1	3.94	2.02
Cooked vs smoked		1	0.72	0.37
Raw vs cooked+ smoked		1	6.27	3.22
Treatment by breed	2		0.41	0.21
Treatment by animal within breed	28		1.95	
Treatment by muscle	4		1.48	0.69
Treatment by muscle by breed	4		0.25	0.12
Treatment by muscle by animal within breed	56		2.13	
Total	143			

**Significant at 1% level.

Table 63. Analyses of variance of linoleic acid in three muscles of ham from Duroc and Hampshire pigs

Source of variation	d.f.		MS	F
Breed	1		225.8	13.9**
Animal	14		16.2	
Muscle	2		331.5	120.3**
Muscle by breed	2		9.61	3.49*
Muscle by animal within breed	28		2.76	
Treatment	2		0.86	0.44
Raw vs cooked		1	0.51	0.26
Raw + cooked vs smoked		1	1.20	0.62
Cooked vs smoked		1	1.71	0.88
Raw vs cooked + smoked		1	0.00	0.00
Treatment by breed	2		0.24	0.12
Treatment by animal within breed	28		1.92	
Treatment by muscle	4		0.61	0.69
Treatment by muscle by breed	4		1.29	1.45
Treatment by muscle by animal within breed	56		0.89	
Total	143			

*Significant at 5% level.

**Significant at 1% level.