COMPARISON OF RARE, MEDIUM- AND WELL-DONE ROASTS FROM CERTAIN BEEF MUSCLES

by

MARILYN STAYTON BUNYAN

B. A., Southwestern College
Winfield, Kansas, 1954

A THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Foods and Nutrition

KANSAS STATE COLLEGE
OF AGRICULTURE AND APPLIED SCIENCE

1958

TABLE OF CONTENTS

INTRODUCTION

Tenderness is an important factor in determining the acceptability of meat. A better understanding is needed of the effect that the degree of cooking has on the tenderness of meat. Generally, it is believed that during heating, the muscle fibers become less tender when the protoplasmic proteins coagulate; whereas, simultaneously tenderness may be increased as the connective tissue is softened and partially hydrolyzed. At times these changes in connective tissue may increase the tenderness of cooked meat more than the coagulation of the protoplasmic proteins decrease tenderness.

The purpose of this study was to determine the changes that occur, mainly in tenderness, during the oven roasting of cuts from certain beef muscles. The roasts were cooked to internal temperatures of 55°, 70° and 85°C. which represented rare, medium and well-done, respectively. Differences in tenderness as well as other palatability factors were measured subjectively and objectively to determine any changes that might occur which could be attributed to the internal temperature to which the meat was roasted.

REVIEW OF LITERATURE

Muscle Composition and Structure

All muscles are made up of elongated, cylindrical and multinucleated fibers surrounded by sarcolemma (Lowe, 1955). These fibers may originate or terminate in a tendon or within a muscle and are made up of fibrils which are bathed in an interfibrillar substance, sarcoplasm. Fibers are surrounded by endomysium and are grouped together as bundles or fasciculi and these are surrounded by the perimysium. Several bundles in turn, are surrounded by the epimysium or muscle sheath and constitute a muscle.

Muscle Fibers. The fibrils in a muscle fiber are made up of alternate dark (A or Q) and light (I or J) bands which are coin-shaped and are called sarcomers (Szent-Györgi, 1951 and Lowe, 1955). In some fibers a dark band (Z) is found dividing the light band. These bands or sarcomers are thought to give muscle fibers a cross-striated appearance; whereas, the fibrils themselves are responsible for the longitudinal striations. The longitudinal striations are associated with tenderness as they are more distinct right after death and then less distinct as the meat is aged. The number of fibers in an animal are predetermined and remain constant after birth (Lowe, 1955). The muscle fibers in 50 bundles from four muscles were counted by Brady (1937). He also measured the diameter of 50 fibers. No significant difference in fiber diameter was found between muscles but there was a significant difference in number of fibers per bundle from the different muscles. He noted that the larger bundles indicated finer texture and consequently resulted in more tender meat.

The proteins thus far isolated in muscle fibers were listed by Lowe (1955) as globulin x, myoalbumin, tropomyosin, myogen and myosin combined with actin. The latter two were considered by Szent-Györgi (1951) as the most important of these and were noted to be colloidal in nature. Myosin was thought by Szent-Györgi (1948) to be an inactive skeleton to which were attached a number of globular proteins called protins without which myosin was inactive. Other chemical constituents found in muscle are water, inorganic and organic salts, carbohydrates, fat, lipids, pigments, enzymes, vitamins, nitrogenous substances and non-nitrogenous substances such as lactic acid (Maximow and Bloom, 1952; Lowe, 1955 and Szent-Györgi, 1951).

Connective Tissues. A small number of cells and much intercellular substance is characteristic of connective tissue. It has many forms, some is loose as between the organs, some is compact as in tendon and other is dense as in cartilage (Lowe, 1955). It can be distinguished as collagenous or elastic and as amorphous ground substance. All three types of connective tissue usually are found together and thus the classification of a given area of connective tissue will be that which is most predominate.

The thickness of the perimysium and the epimysium and the amount of sarcoplasm have a direct effect on tenderness; the more of these present, the less tender the meat.

Collagenous Connective Tissue. The main function of collagenous tissue is to bind and support other tissues. The collagenous fibers often occur in bundles, are flexible but not elastic, are wavy in appearance and may be stretched until the waves disappear (Lowe, 1955). The fibers in themselves are colorless and birefringent but when bunched together appear white and the tissue often is called white connective tissue. Tendons, blood vessels and the sarcolemma are composed mainly of collagenous connective tissue.

Collagen is the main protein in this tissue. The chemical composition of collagen has been considered to be similar to that of gelatin as collagen may be converted to gelatin to some extent in the presence of heat and water (Lowe, 1955 and Winegarden et al., 1952). Proline and hydroxyproline were indicated as the main amino acid residues in gelatin. Probably, the sequence of the collagen backbone chain could be proline, glycine, another amino acid and hydroxyproline. X-ray patterns of collagen indicated that the chains were of a somewhat compact, folded, spiral alpha form and upon denaturation were changed to a beta form.

Elastic Connective Tissue. Elastin is the major protein found in elastic connective tissue. The fibers of this tissue are straight in their natural position but often appear wavy when teased onto a slide (Maximow and Bloom, 1952). They yield easily to stretching and when released return practically to their former length (Lowe, 1955). This tissue often is called yellow connective tissue as when elastic fibers are massed together in a ligament they appear to have a yellow color. When heated in the presence of water, the elastic connective tissue is softened slightly but not to the same extent as the collagenous connective tissue.

Amorphous Ground Substance. The collagenous and elastic fibers of connective tissue are embedded in a homogenous matrix called the amorphous ground substance which has a consistency that varies from a fluid to a gel. In general, little is known about this substance. However, Miller and Kastelic (1956) postulated that ground substance is composed of mucopolysaccharides and mucopolysaccharide-protein complexes present in different degrees of polymerization.

Adipose Tissue. Adipose tissue consists mainly of fat, but other substances such as water, minerals and proteins are present. As fat is deposited in certain cells of a beef animal, the cell walls, composed mainly of collagenous connective tissue, become thinner and finally rupture. Connective tissue then becomes a part of fatty tissue (Lowe, 1955). The deposition of fat occurs first in subcutaneous areas and around the internal organs, then around and between muscles and finally intramuscularly which may be between a few or many muscle fibers. The amount of intramuscular fat deposited varies in different muscles.

Some workers have agreed that fat plays a part in the tenderness of meat. Wang et al. (1954) indicated that the manner in which fat was distributed throughout the muscle appreciably affected the tenderness. This distribution, they called the protein-fat interphase, that is the amount of surface contact between the fat cell and muscle protein (either or both, actomyosin and collagen). According to these workers, this distribution of fat in raw samples could be determined quantitatively by measuring the longest axis of each fat island and expressing the sum as "linear" fat. The scores for tenderness of broiled beef steaks correlated well with the "linear" fat of the raw muscle. The higher the amount of "linear" fat, the more tender the cooked meat. These data could assist in explaining the possible beneficial effect of marbling. Hiner et al. (1955) also agreed that beef from well-fattened animals usually was more tender than meat from lean animals.

Variations in Tenderness

Differences Within a Muscle. Tenderness of certain of the beef muscles has been shown to vary within a given muscle. This was true in the semimembranosus muscle (Paul and Bratzler, 1955b) in which steaks from the anterior portion were more tender than those from the center portion which in turn were more tender than those from the posterior end. In another study by these same workers (1955a), steaks from eight pairs of longissimus dorsi muscles from U. S. Prime, Good and Commercial grade beef animals were, in most cases, more tender from the anterior portion of the muscle than those from the posterior end. In contrast, Ramsbottom et al. (1945) found that in the longissimus dorsi muscle from three U. S. Good carcasses, the posterior end was more tender than the anterior. Noble et al. (1934) used roasts from 11 Choice and Medium grade beef animals and found no pronounced tendency for the longissimus dorsi to become less tender from the posterior to the anterior end.

The psoas major was found to vary slightly in tenderness by Ramsbottom et al. (1945), in that, lower shear values were noted for the cores for the middle section than for those for either the anterior or posterior end. Steaks from the adductor muscle from U. S. Prime and Good beef carcasses also were quite uniform in shear tenderness regardless of position of the steak, treatment or grade of animal (Paul and Bratzler, 1955b).

Differences Between Muscles. The relative tenderness of 50 muscles of a beef carcass was determined by Ramsbottom and Strandine (1948) by the use of shear values on raw and cooked samples. The raw muscles were ranked in order of most to least tender as follows: longissimus dorsi, psoas major, adductor, vastus lateralus, semimembranosus, rectus femoris and semitendinosus. Whereas, the cooked muscles ranked thus in order of most to least tender: psoas major, longissimus dorsi, rectus femoris, adductor, semitendinosus, vastus lateralus and semimembranosus. The psoas major also was reported as the most tender of all cooked beef muscles in an earlier paper from this same laboratory (Ramsbottom et al., 1945) and is in agreement with studies by Jacobson and Fenton (1956) and Hiner and Hankins (1950). The results of a study reported by Clark and VanDuyne (1949) were in conflict with those of Ramsbottom and Strandine (1948). The Illinois workers found that the cooked semimembranosus muscle of U. S. Prime and Choice beef animals was significantly more tender than the adductor muscle.

Differences Between Animals. The tenderness of beef carcasses varies considerably even within a U. S. grade. Paul and Bratzler (1955b) compared the tenderness of the semimembranosus muscle from U. S. Prime and Good carcasses. They found more variation in tenderness among the muscles from carcasses of the same grade (U. S. Good) than among muscles from carcasses of the two grades. Similar results were not obtained with other muscles. These same workers (Paul and Bratzler, 1955a) reported that U. S. Prime grade steaks from the longissimus dorsi muscle were more tender than U. S. Good or Commercial grade steaks from the same muscle. Differences in tenderness and other palatability factors of meat from U. S. Choice, Good and Commercial grade beef carcasses were reported by Simone et al. (1958) to become more apparent with increasingly wider differences in the degree of finish and carcass grade. These differences were not apparent unless carcasses with a moderate finish were compared with carcasses of a rather high degree of finish.

Factors Affecting Tenderness

Age and Nutritional Level. Meat from animals of varying ages often differ in tenderness. In a study by Hiner and Hankins (1950), it was noted that generally as age of the animals increased, tenderness of each of the muscle samples representing nine principal cuts decreased. The beef muscles used were from cows, heifers, steers, steer calves and veal calves. No significant difference in tenderness was noted between the muscle samples from veal and those from steer calves, but the difference between the samples from veal calves and those from cows was highly significant. A decrease in tenderness of beef muscles with an increase in age of the animal also was noted by Mackintosh et al. (1936) and Jacobson and Fenton (1956).

Nutritional level of the animal as well as age has an effect on the tenderness of beef muscles. Jacobson and Fenton (1956) maintained 24 heifers, 32 to 80 weeks old, at high, medium and low levels of nutrition. The longissimus dorsi muscle from the animals on the higher nutrition level showed significantly higher tenderness scores than for this muscle from animals on the lower level. This was not true of the psoas major, in that, tenderness scores were similar regardless of nutritional level of the animal.

Aging Time, Temperature and Humidity. The tenderness of a carcass is affected by the conditions under which it is aged. Rigor mortis or the stiffening of muscles occurs soon after the death of an animal. This rigidity of the muscle (Szent-Györgi, 1951) was attributed to the permanent combination of the muscle proteins, myosin and actin, into actomyosin, the disintegration of adenosine triphosphate (ATP) and the breakdown of glycogen into lactic acid. With death this contraction reaction is irreversible whereas in normal muscle, contraction is reversed by relaxation.

The histological appearance of the fibers of beef also changes with the onset and passing of rigor. Paul et al. (1952) have described the fibers of fresh beef as straight, poorly differentiated but with quite prominent longitudinal striations. With the severe contraction of muscle and the onset of rigor, rigor nodes and Z-Z contractions appeared in the muscle fibers. As rigor diminished, the muscles tended to relax and the fibers became fairly straight. They thought that active muscle contraction contributed to the toughness of beef; whereas, with relaxation, passing of rigor, and consequent breakdown of the fibers, the meat became more tender. This process takes place by enzymatic action when the beef carcass is aged usually at refrigerator temperatures.

The extent of aging following slaughter is one of the important determinants of tenderness (Paul, 1957). Beef from 10 U. S. Choice to Common grade carcasses was used by Ramsbottom and Strandine (1949) to study the changes in tenderness during a 12 day holding period at 35°F. The beef was more tender at two hours following slaughter than at any time thereafter up to six days. However, from the sixth to the twelfth day of aging, the beef progressively increased in tenderness. By the twelfth day, the beef was considerably more tender than it was at two hours after slaughter. In contrast, 14 beef carcasses were aged at 33° to 35°F. for longer periods by Deatherage and Harsham (1947). When the initial tenderness was high as in the case of two carcasses, only a small increase in tenderness was noted following aging. However, in the other 12 carcasses, tenderness usually increased up to 17 days and then developed a plateau. At 24 days there was a slight drop in tenderness and at 31 days there was some increase beyond that for the 17 day level. These workers stated that this work indicated that unless beef was to be aged over four weeks, it needed only two and one-half weeks of aging. However, a shorter aging period was recommended by Paul et al. (1956) who indicated that beef aged more than seven days did not increase significantly in tenderness.

Ten beef carcasses were subjected to three series of storage treatments by Griswold and Wharton (1941). They found small differences in tenderness between meat stored at 34°F. for nine or 37 days. There was little difference in tenderness of meat stored for 48 hours at 60°F. without ultra-violet irradiation and that stored at 60°F. for 48 hours with ultra-violet light. But when meat stored at 36°F. without irradiation was compared with meat stored at 60°F. with irradiation, the tenderness was slightly greater in the meat stored at the higher temperature. Sleeth et al. (1958) stored U. S. Choice and Good beef hindquarters, forequarters and wholesale ribs at temperatures of 36°, 40°, 57°, 68°, 76°, and 86°F. under relative humidities of 80 to 90 percent and air velocities of 15 to 20 lineal feet per minute. Ultra-violet light was used with the elevated temperatures to control microbial growth. Tenderness scores for the beef quarters aged two to three days at the higher temperatures under ultra-violet were comparable to those aged 12 to 14 days at 36° to 40°F. They found that proper humidity was needed in the aging room to lessen shrinkage and discoloration of the meat when higher storage temperatures were used.

Rate of Heat Penetration and Method of Cooking. Many changes occur in meat when it is cooked. Rate of heat penetration and subsequent coagulation of the muscle proteins are important determinants of these changes. The temperature at which coagulation begins is dependent on the rate at which cooking occurs. Lowe (1955) indicated that in most cases coagulation of the muscle proteins begins at approximately 60°C.

Beef roasts always were found by Cover (1943) to be tender when the rate of heat penetration was slow enough to require 30 hours or more for the meat to lose its pink color. Three pair of beef roasts were cooked well-done and one pair rare at oven temperatures of 80° and 125°C.

The right and left semimembranosus muscles were divided into thick and thin cuts and roasted at 300° and 350°F., respectively by Hood et al. (1955) to an internal temperature of 176°F. The internal temperature of these cuts was recorded every three minutes until 170°F. was reached and then after every minute until the end temperature was obtained. The internal temperatures tended to lag around 160°F. for the thin cuts cooked at 350°F. and at 150°F. for the thick cuts cooked at 300°F.

The right and left semitendinosus and biceps femoris muscles were dissected from six beef animals by Paul et al. (1952) and divided into three adjacent pairs of one-inch steaks and three to four-inch roasts. The roasts were cooked in the oven at 163°C. to an internal temperature of 63°C.; the steaks were cooked in deep-fat at 147°C. to 63°C. The deep-fat cooking required less time than the roasting which reflected the efficiency of heat transfer.

Roasts from beef muscles rather than steaks were cooked in deep-fat by Visser (1957). Fairly straight heat penetration curves were noted for the smaller roasts; whereas, the more blocky, compact roasts had longer more sloping curves. However, the rate of heat penetration had no effect on either the tenderness scores or shear force values for the roasts. The larger roasts appeared to be more "done" than the smaller ones cooked to the same internal temperature. In preliminary work by Jacobson and Fenton (1956) large roasts also seemed to be more "done" than small roasts cooked to the same internal temperature.

Effect of Cooking

Meat is cooked to make it more palatable and certain changes occur with cooking. The extent of these changes might be slight or great and are dependent upon the degree to which the meat is cooked. Some of the more prominent changes that occur are in color, aroma, flavor, tenderness and juiciness.

On Color. Myoglobin is the main pigment in muscle tissue and has a close relationship in structure to hemoglobin (Lowe, 1955). It is mainly responsible for the dark red color of freshly cut beef and with exposure to air, it is combined with oxygen to form oxymyoglobin, a bright red pigment. With continued exposure to air, the oxymyoglobin may be oxidized to metmyoglobin, a brown pigment.

The myoglobin pigment, like hemoglobin, is unstable to heat (Lowe, 1955). Decomposition products are formed when fresh meat is heated to sufficiently high temperatures and according to Lowe (1955) this change begins when internal temperatures of approximately 65° to 70°C. are reached. At these temperatures the globulin portion of the pigment molecule begins to coagulate and the newly-formed hematin pigment is responsible for the gray or brown color. The rate of heat penetration may effect the temperature at which myoglobin starts to coagulate. With long, slow cooking the decomposition of this pigment may take place at lower internal temperatures than if the meat is heated rapidly.

On Aroma and Flavor. Aroma and flavor are two components of palatability that are difficult to differentiate. It has been said (Howe, 1927) that in cooked meat, the most prominent flavors are found as odors.

Crocker (1948) found that the flavor of raw meat was mostly in the juices and was weak, sweet, salty and blood-like. This characteristic raw meat flavor sometimes could be detected in beef cooked to low internal temperatures. The flavor of cooked meat was attributed mainly to the breakdown of the side chain amino acid units of muscle fiber proteins. The breakdown compounds isolated were ammonia, amines, hydrogen sulfide and various acids which indicated that a variety of amino acids were changed during cooking. The characteristic flavors of cooked meat increased with longer cooking up to about three hours but with prolonged cooking these flavors seemed to be lost (Crocker, 1948).

On Tenderness. Tenderness of meat is closely related to other palatability factors and has considerable influence on its acceptance. The ease with which a piece of meat is chewed is related to the fineness of the grain, the quantity of connective tissue and the hardness of the fibers.

Tenderness has been measured organoleptically by subjective scoring and by the recording of the number of chews needed to completely masticate a sample of meat of standard surface area and thickness. Paul and Bean (1956) found that counting the number of chews was an effective method for measuring tenderness, but they had difficulty in obtaining similar size pieces of meat for each trial.

Shear values obtained on the Warner-Bratzler shearing apparatus are used as an objective measurement for tenderness. Two sizes of shear cores, one-inch and one-half-inch, have been used for the determination of shear force values. The latter size usaully has been used on small pieces of meat. Significant correlation coefficients between the shear values for one-half and for one-inch cores of cooked beef muscle roasts were found by Paul and Bratzler (1955b) and therefore, it was concluded that either size could be used for the determination of shear force values.

There is disagreement in the literature as to the effect that cooking has on the tenderness of beef. The adductor, longissimus dorsi and semitendinosus muscles were noted by Ramsbottom et al. (1945) to become less tender with cooking. This was true when the shear values of the cooked muscles were compared with those from the raw muscles. However, Satorius and Child (1938a) found that tenderness of the adductor muscle from animals of High Medium to Good grade was not affected by cooking, but that the longissimus dorsi became more tender with the increased degree of cooking. The semitendinosus muscle, too, increased in tenderness with coagulation of the muscle proteins up to 67°C. but decreased in tenderness from 67° to 75°C.

<u>On Juiciness</u>. Juiciness of cooked meat is thought to be related to its moisture and fat content. During cooking the fat

of the adipose tissue is softened and thus contributes to juiciness. Juiciness of beef muscles is evaluated subjectively by taste panels and compared with such objective measurements as total cooking losses, including volatile and dripping losses, cooking time and press fluid yields. Press fluid yields do not always correlate with juiciness scores because they are only a measure of the amount of juice expressible under certain conditions and do not involve other factors such as the flow of saliva which takes place when a piece of meat is tasted (Satorius and Child, 1938b).

The location of the fat in the various forms of connective tissue in and around a muscle, as well as the total amount of fat present may contribute to the juiciness of meat (Lowe, 1955). However, either the total amount or location of fat in the muscle did not make a difference in the juiciness scores of meat in a study reported by Siemers and Hanning (1953). These workers used small pieces of semimembranosus beef muscle and covered them with a suet sheath to simulate a covering of fat, or ground the lean and suet together to simulate fat within a piece of meat. The lean and lean-suet combined pieces (either with the sheath or ground) were cooked in centrifuge tubes in a water bath at 85°C. Juiciness scores for all samples decreased with an increase in cooking time and the taste panel was unable to detect a significant difference in juiciness between lean and lean-suet samples.

A decrease in juiciness scores for beef muscle was found by Clark et al. (1955) and Hay et al. (1953) as the cooking losses and cooking times increased. This relationship also was found by

Aldrich and Lowe (1954) when they cooked beef muscles an additional hour beyond the time required to reach an internal temperature of 90°C. at an oven temperature of 150°C. Cooking losses were found by Child and Satorius (1938) to increase with an increase in oven temperature when the semitendinosus muscle of beef was cooked to 58°C. at oven temperatures of 120°, 150°, 175° and 200°C. The greater cooking losses were attributed to greater evaporation or volatile losses. However, no difference was found in press fluid yields from this muscle cooked at these various oven temperatures.

PROCEDURE

The long hindquarters from six U. S. Good beef carcasses with unknown past history were obtained from a Kansas City packing house. The weights of a pair of long hindquarters ranged from 284 to 350 pounds. Approximately two or three days after the carcasses were received at Kansas State College, certain paired muscles were dissected and trimmed of most of the exterior fat. The muscles used were the psoas major, adductor, rectus femoris, vastus lateralus, semimembranosus (posterior), semimembranosus (anterior), semitendinosus, longissimus dorsi (loin) and longissimus dorsi (rib). The first six muscles each were cut into two roasts; the other three muscles into three roasts. Plates I through VIII are photographs of representative muscles used in this study. The paired roasts were coded and a randomized block design was used for those cut into two pieces and cooked to either 55° and 70°C. or to 70° and 85°C. end-point temperatures. A

EXPLANATION OF PLATE I

Top of plate:

Psoas major muscle, right side from Animal Y.

Bottom of plate:

Psoas major muscle from left side of Animal X, divided into roasts A1 (anterior end) and B1 (posterior end).

PLATE I

EXPLANATION OF PLATE II

Top of plate:

Adductor muscle, right side from Animal X.

Bottom of plate:

Adductor muscle from left side of Animal X, divided into roasts C1 (proximal end) and D1 (distal end).

PLATE II

EXPLANATION OF PLATE III

Top of plate:

Rectus femoris muscle, right side from Animal VII.

Bottom of plate:

Rectus femoris muscle from left side of Animal VII, divided into roasts E1 (proximal end) and F1 (distal end).

PLATE III

EXPLANATION OF PLATE IV

Top of plate:

Vastus lateralus muscle, right side from Animal V.

Bottom of plate:

Vastus lateralus muscle from left side of Animal V, divided into roasts G1 (proximal end) and H1 (distal end).

PLATE IV

EXPLANATION OF PLATE V

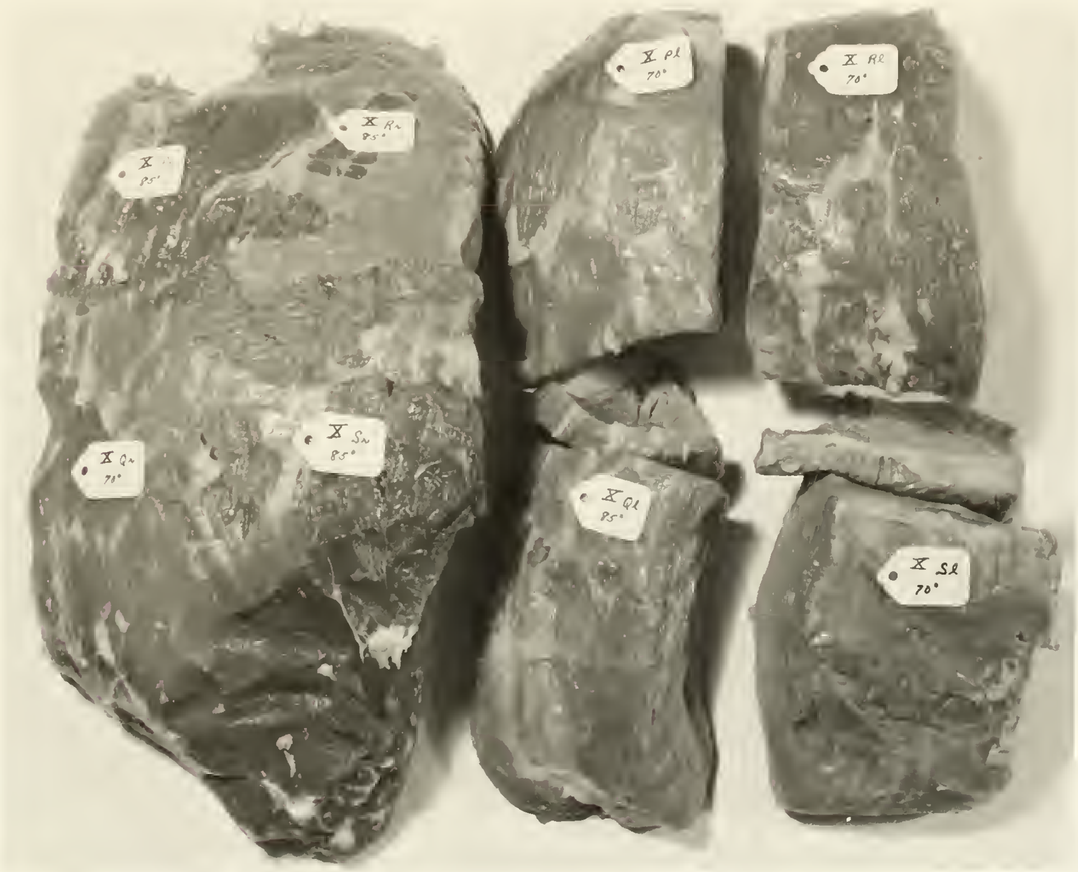
Left side of plate:

Semimembranosus muscle, right side from Animal X.

Right side of plate:

Semimembranosus muscle from left side of Animal X, divided into roasts P1 (posterior side, proximal end), Q1 (posterior side, distal end), R1 (anterior side, proximal end) and S1 (anterior side, distal end). The slices between the roasts removed for chemical analyses also are shown.

PLATE V



EXPLANATION OF PLATE VI

Top of plate:

Semitendinosus muscle, right side from Animal X.

Bottom of plate:

Semitendinosus muscle from left side of Animal X, divided into roasts J1 (proximal end), L1 (distal end) and K1 (center).

PLATE VI

EXPLANATION OF PLATE VII

Top of plate:

Loin section of the longissimus dorsi muscle, right side from Animal VII.

Bottom of plate:

Loin section of the longissimus dorsi muscle from left side of Animal VII, divided into roasts M1 (anterior end), O1 (posterior end) and N1 (center). The slices between the roasts removed for chemical analyses also are shown.

PLATE VII

EXPLANATION OF PLATE VIII

Top of plate:

Rib section of the longissimus dorsi muscle, right side from Animal X.

Bottom of plate:

Rib section of the longissimus dorsi muscle from left side of Animal X, divided into roasts T1 (anterior end), V1 (posterior end) and U1 (center). The slices between the roasts removed for chemical analyses also are shown.

PLATE VIII

randomized incomplete block design was used for those cut into three roasts and cooked to 55°, 70° and 85°C. end-point temperatures (Tables 1 and 2).

The roasts were wrapped in 0.0015 gauge aluminum foil and frozen in an upright home freezer maintained at -10°F. Approximately 48 hours previous to cooking, the wrapped roasts were defrosted in a refrigerator (42° to 46°F.). Following that time, the roasts were unwrapped and centigrade thermometers were inserted into the mid-portion of the thickest section of the cut. The roasts then were cooked on racks in aluminum pans in a preheated rotary hearth oven maintained at 300°F. All roasts from one paired muscle were cooked at each period.

The internal temperatures of the roasts were noted before they were placed into the oven. The time required for each 5°C. rise in temperature until the roasts had reached 55°C. was recorded and thereafter each 2°C. rise was noted. Following removal of the roasts from the oven, they were allowed to stand for a period of time in order that any rise in internal temperature could be recorded. Appropriate weights of the roasts were taken in order that volatile, dripping and total cooking losses could be calculated.

When the meat was cool enough to handle, a one-inch core was taken from each roast and shear values were determined on a Warner-Bratzler shearing apparatus. These cores were taken parallel to the fibers and before samples were removed for palatability tests. The Warner-Bratzler shearing apparatus indicated the number of pounds it took for a dull blade to cut through the

Table 1. Randomized complete block design for roasting cuts from certain right (R) and left (L) beef muscles.

Muscles	Code	ANIMALS											
		III		VI		VII		VIII		X		XII	
		R	L	R	L	R	L	R	L	R	L	R	L
Psoas major	A	70	55	70	55	55	70	55	70	70	55	55	70
	B	55	70	55	70	55	70	55	70	55	70	55	70
Adductor	C	85	70	85	70	70	85	85	70	85	70	70	85
	D	85	70	85	70	85	70	70	85	85	70	70	85
Rectus femoris	E	70	85	85	70	70	85	85	70	85	70	85	70
	F	85	70	85	70	85	70	85	70	70	85	70	85
Vastus lateralus	G	70	85	70	85	85	70	70	85	85	70	85	70
	H	85	70	85	70	85	70	70	85	85	70	70	85
Semimembranosus (posterior)	P	70	85	85	70	70	85	85	70	85	70	85	70
	Q	70	85	85	70	70	85	85	70	70	85	85	70
Semimembranosus (anterior)	R	85	70	70	85	70	85	85	70	85	70	70	85
	S	70	85	85	70	85	70	70	85	85	70	85	70

A - Roasts from anterior end of muscle.
B - Roasts from posterior end of muscle.
C, E, G, P, R - Roasts from proximal end of muscle.
D, F, H, Q, S - Roasts from distal end of muscle.

Table 2. Randomized incomplete block design for roasting cuts from certain right (R) and left (L) beef muscles.

Muscles	Code	ANIMALS											
		III		VI		VII		VIII		X		XII	
		R	L	R	L	R	L	R	L	R	L	R	L
Semitendinosus	J	55	85	70	55	55	70	85	55	55	85	55	85
	K	55	70	85	70	85	55	85	70	70	55	70	55
	L	85	70	85	55	85	70	55	70	85	70	85	70
Longissimus dorsi (loin)	M	70	85	70	85	70	55	70	85	55	85	85	70
	N	70	55	70	55	55	85	70	55	55	70	70	55
	O	55	85	85	55	85	70	85	55	85	70	55	85
Longissimus dorsi (rib)	T	85	55	55	85	85	55	55	70	70	55	55	85
	U	55	70	85	70	70	55	85	55	70	85	85	70
	V	70	85	70	55	70	85	70	85	85	55	55	70

J - Roasts from proximal end of muscle.
K, N, U - Roasts from mid-section of muscle.
L - Roasts from distal end of muscle.
M, T - Roasts from anterior end of muscle.
O, V - Roasts from posterior end of muscle.

core of meat. Five shear values were obtained on a one-inch core and averages were used for the final shear value of each roast.

Slices from each roast were cut one-eighth inch thick on a General home slicer and samples from the same position from each roast were given to each of the members of the palatability committee at each scoring period. Ten judges scored the samples for aroma, flavor, juiciness, tenderness and recorded number of chews to completely masticate a sample of meat. A ten-point scale was used with ten indicating extremely good and one, extremely poor (Form 1, Appendix). Each judge also ranked the samples according to his preference for juiciness and for tenderness.

The remainder of the meat was trimmed and that with the pieces of the sheared cores was ground in an Universal No. 3 meat grinder and stored in a refrigerator overnight. The following day, the ground meat samples were allowed to come to room temperature (approximately one hour) before press fluid determinations were made. Each sample was done in duplicate.

For press fluid measurements 25 grams of the ground meat were packed in three layers in a cheesecloth lined metal cylinder. The layers each were separated by No. 1 Whatman filter papers. A leather disk and a metal plunger were placed on the meat and the packed cylinder was set on a stainless steel pan and placed on a Carver Laboratory Press. Pressure was applied according to the following schedule:

Time in minutes	Pressure in pounds*
1.0	5,000
2.0	7,500
3.0	10,000
5.0	10,000
7.5	12,500
10.0	15,000
11.0	16,000
15.0	16,000

Three minutes after the pressure was released the press fluid was poured into 15 ml. graduated centrifuge tubes. All the excess juice was scraped from the cylinder and pan into the tubes and these tubes were placed in a refrigerator over night. Total volume of press fluid, as well as the volume of serum and fat was recorded the following morning.

The data collected in this study were analyzed statistically to determine the effect that the degree of cooking had on total, volatile and dripping losses; cooking time; shear force values; total press fluid yields and the palatability factors, aroma, flavor, tenderness, juiciness and preference for tenderness and juiciness. Analyses of variance and where appropriate, least significant differences, were run on data from the muscles that were cooked to three internal temperatures. The t-test was used to analyze data from the muscles cooked to two internal temperatures.

Also, correlation coefficients were determined for tenderness

*The pressure in the schedule refers to the load on the 1.25-inch ram of the test cylinder. The maximum load on the meat was 4,000 pounds per square inch.

scores and shear force values; juiciness scores and cooking losses (total, volatile and dripping); juiciness scores and press fluid yields; and cooking losses (total, volatile and dripping) and press fluid yields. The correlation coefficients were run on the data for roasts from each muscle cooked to each internal temperature.

Histological samples, raw and cooked, were taken from all roasts. Slides from these samples will be studied for type and amount of elastic and collagenous connective tissue, amount and deposition of fat and width of muscle fibers. Samples for chemical determinations were removed from the raw and cooked roasts of the semimembranosus (anterior), semimembranosus (posterior), longissimus dorsi (loin) and longissimus dorsi (rib) muscles. Determinations will be made for total nitrogen, collagen-nitrogen, water soluble nitrogen and heat coagulable water soluble nitrogen. The histological and chemical data will be reported in another manuscript.

RESULTS AND DISCUSSION

The discussion presented here will be concerned mainly with the changes in palatability that occur during the cooking of roasts from beef muscles.

Rate of Heat Penetration

When meat is cooked, temperatures often rise rapidly until protein coagulation begins. At this time, the slope of a heat penetration curve becomes more gradual and a plateau may occur in the curve if sufficient coagulation is taking place at one time. The flattened portion of the heat penetration curve may be attributed to the absorption of heat because protein coagulation is an endothermic reaction.

The rate of heat penetration curves for this study are given in Figs. 1 through 15. Most of the curves tended to rise rather sharply until the internal temperature in the meat was 40°C., after that, the curves flattened out gradually until the end-point temperatures were reached. The curves for the roasts from the right muscles were similar to those from the corresponding left muscles. In the psoas major, adductor, vastus lateralus, semitendinosus and longissimus dorsi (rib) the curves for the right and for the left roasts almost could be superimposed on each other.

For some of the muscles, the proximal or anterior end roasts showed longer curves with more gradual inclines than those for the roasts from the distal or posterior ends; whereas, in other muscles, the opposite was true. In the case of the semimembranosus (posterior), left, the rate of heat penetration for the proximal and distal ends was similar in that the average time for the internal temperature of each to rise to 85°C. was the same. The rate of rise in the internal temperature for the distal roasts of the left rectus femoris was slower than that for the proximal roasts of the same muscle until 70°C. was reached. Thereafter, a rather sudden rise for the distal roasts was noted until 85°C. was reached; whereas, the temperature rise of the proximal roasts was gradual until 85°C. was obtained. No consistent pattern for rate

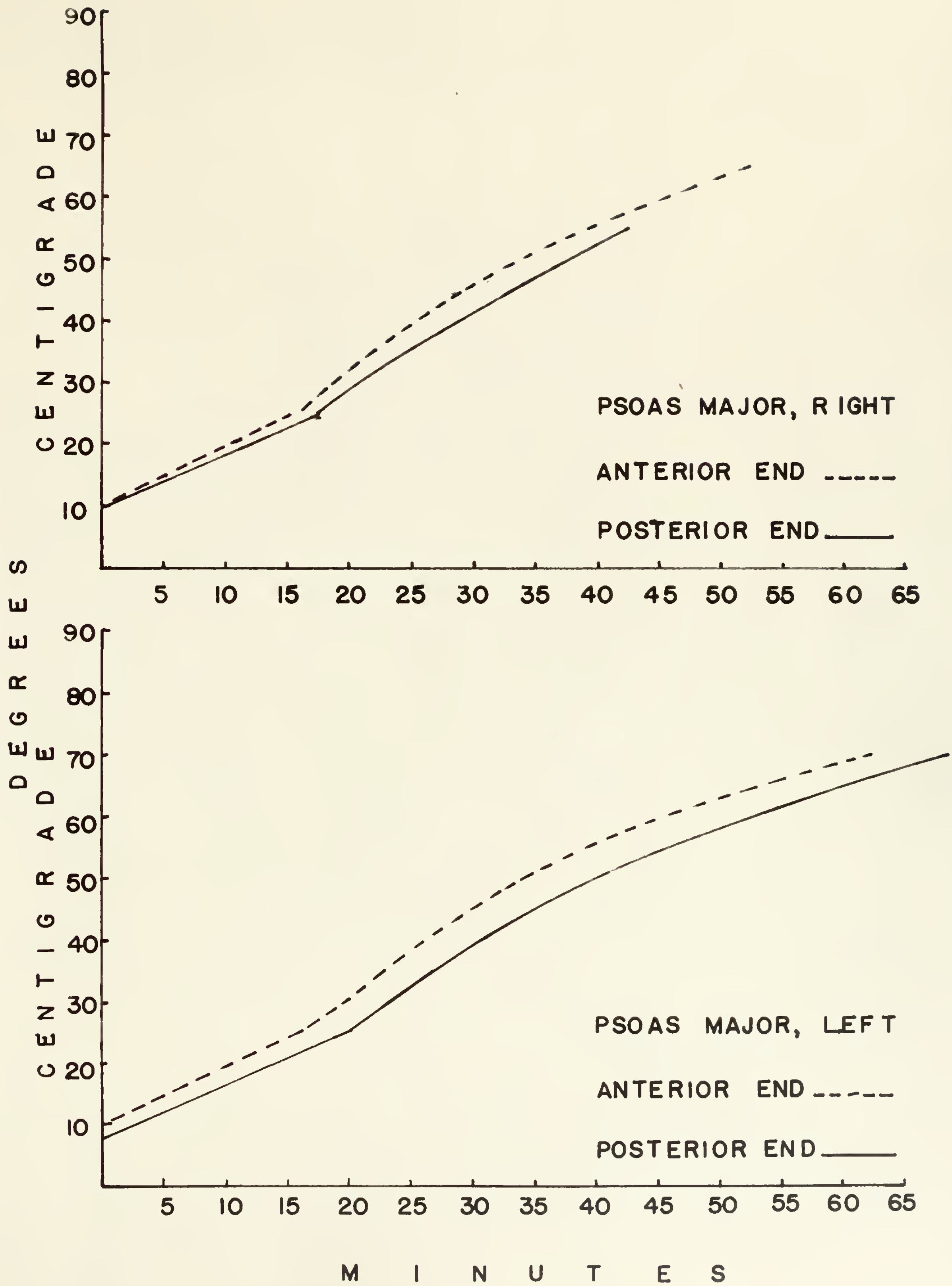


Fig. 1. Average heat penetration curves for the psoas major muscle. Top of figure, right muscle; bottom, left muscle.

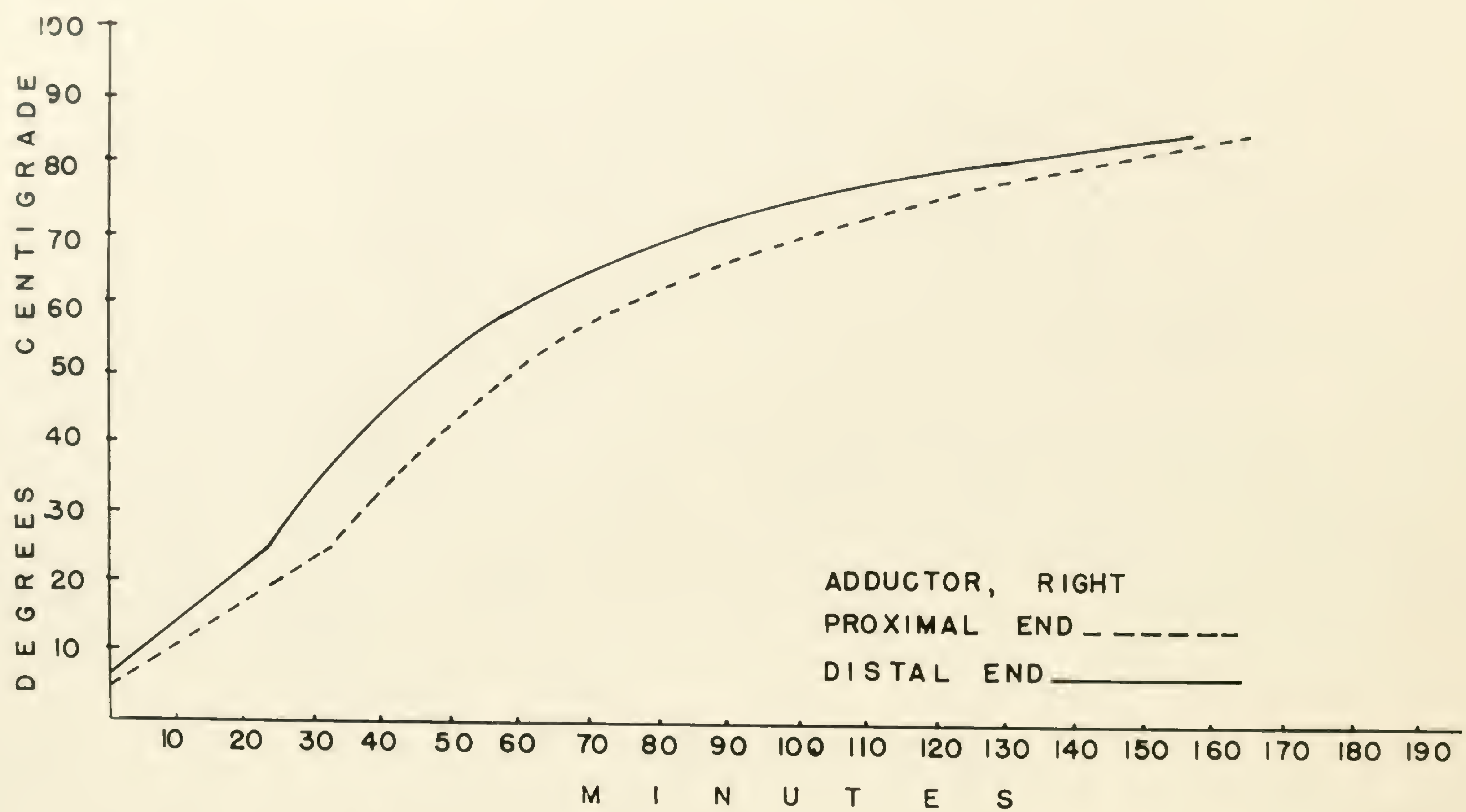


Fig. 2. Average heat penetration curves for the right adductor muscle.

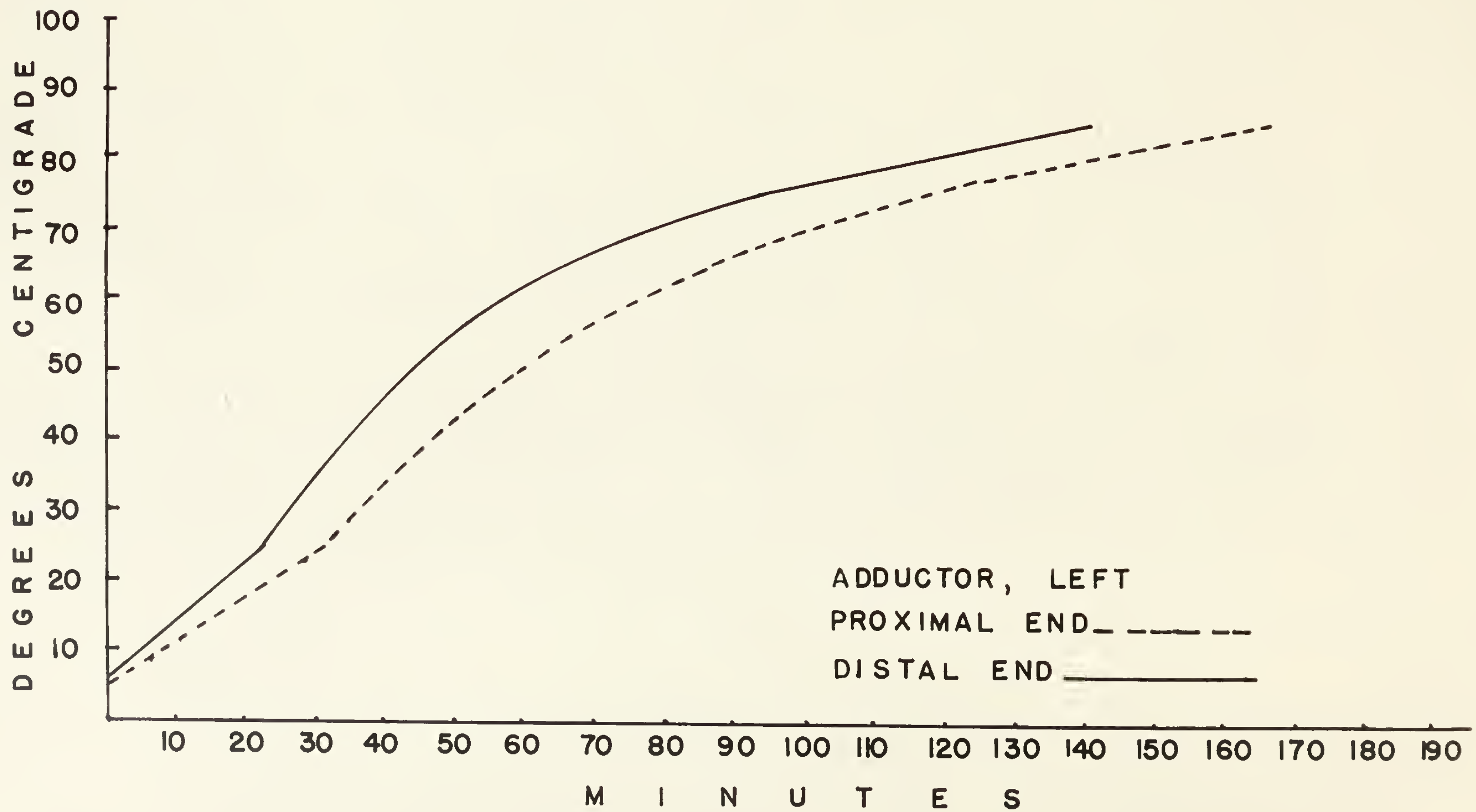


Fig. 3. Average heat penetration curves for the left adductor muscle.

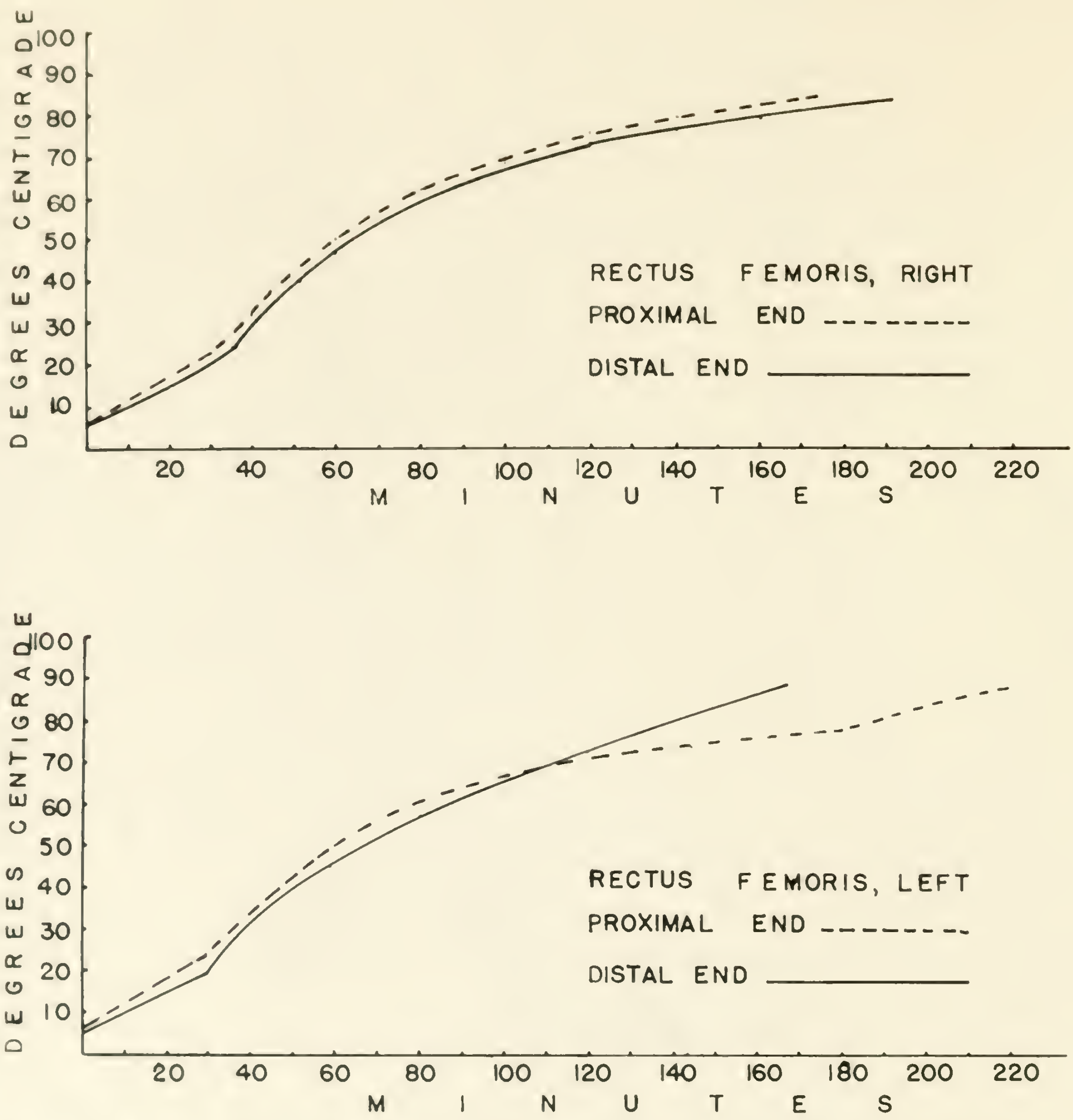


Fig. 4. Average heat penetration curves for the rectus femoris muscle. Top of figure, right muscle; bottom, left muscle.

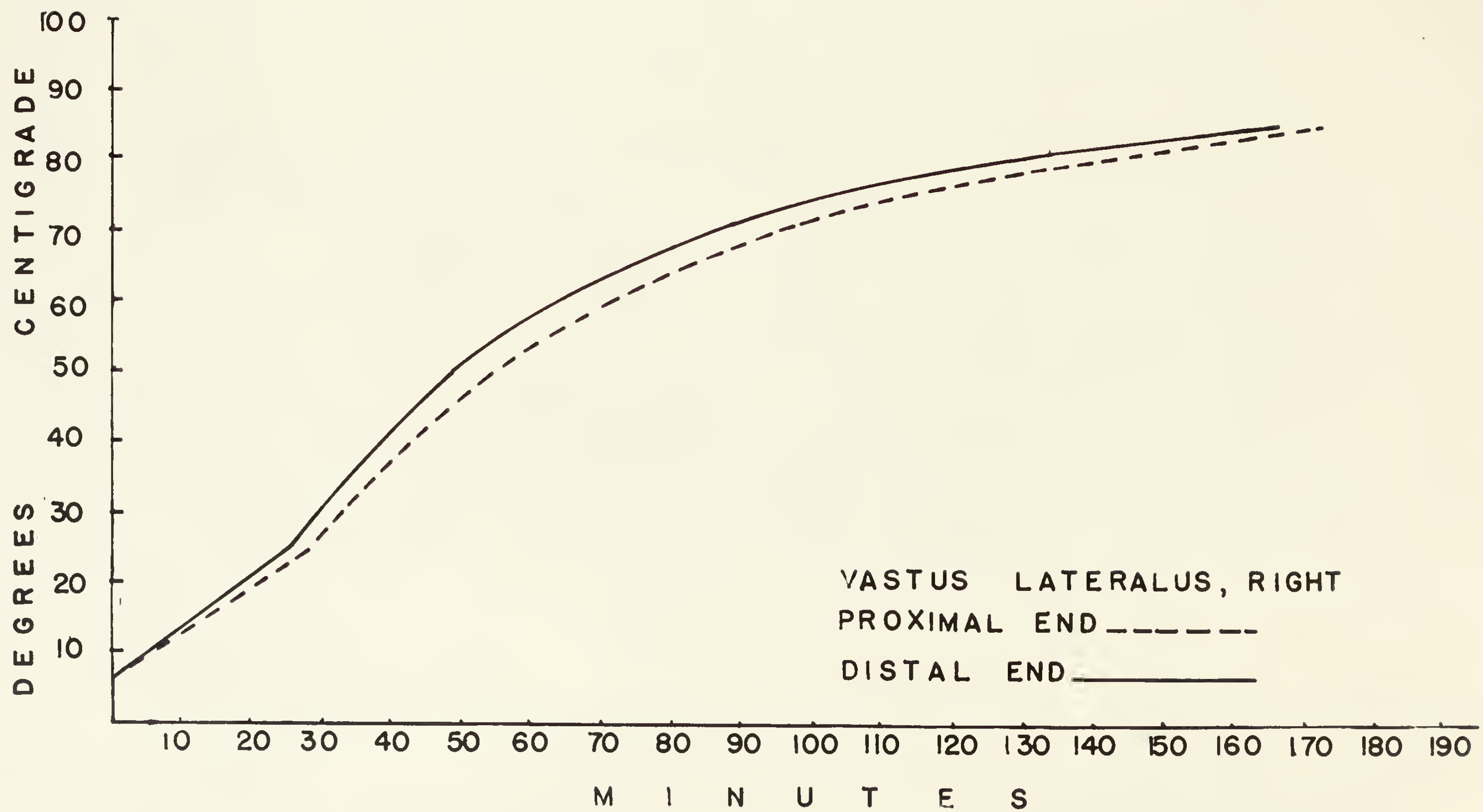


Fig. 5. Average heat penetration curves for the right vastus lateralus muscle.

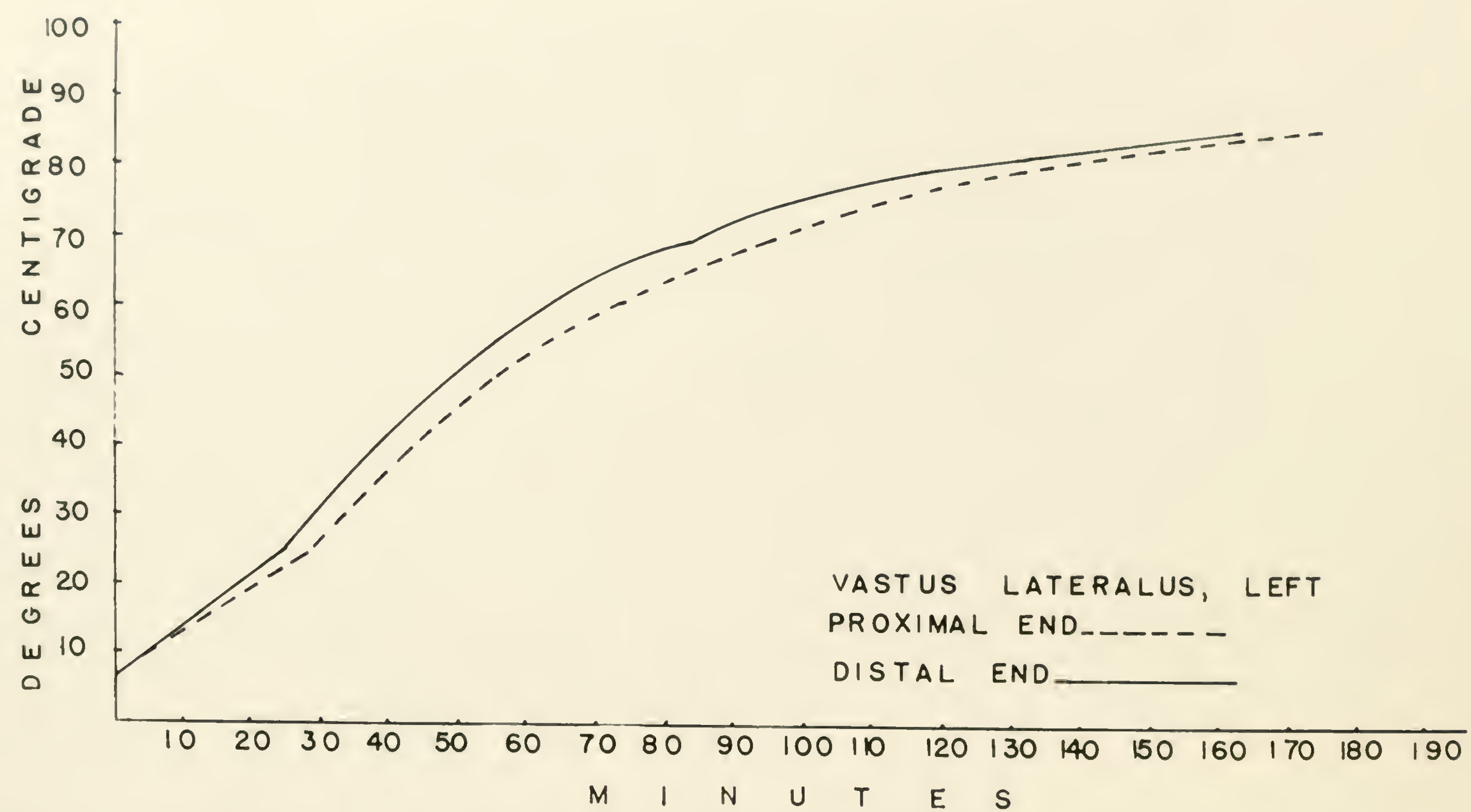


Fig. 6. Average heat penetration curves for the left vastus lateralus muscle.

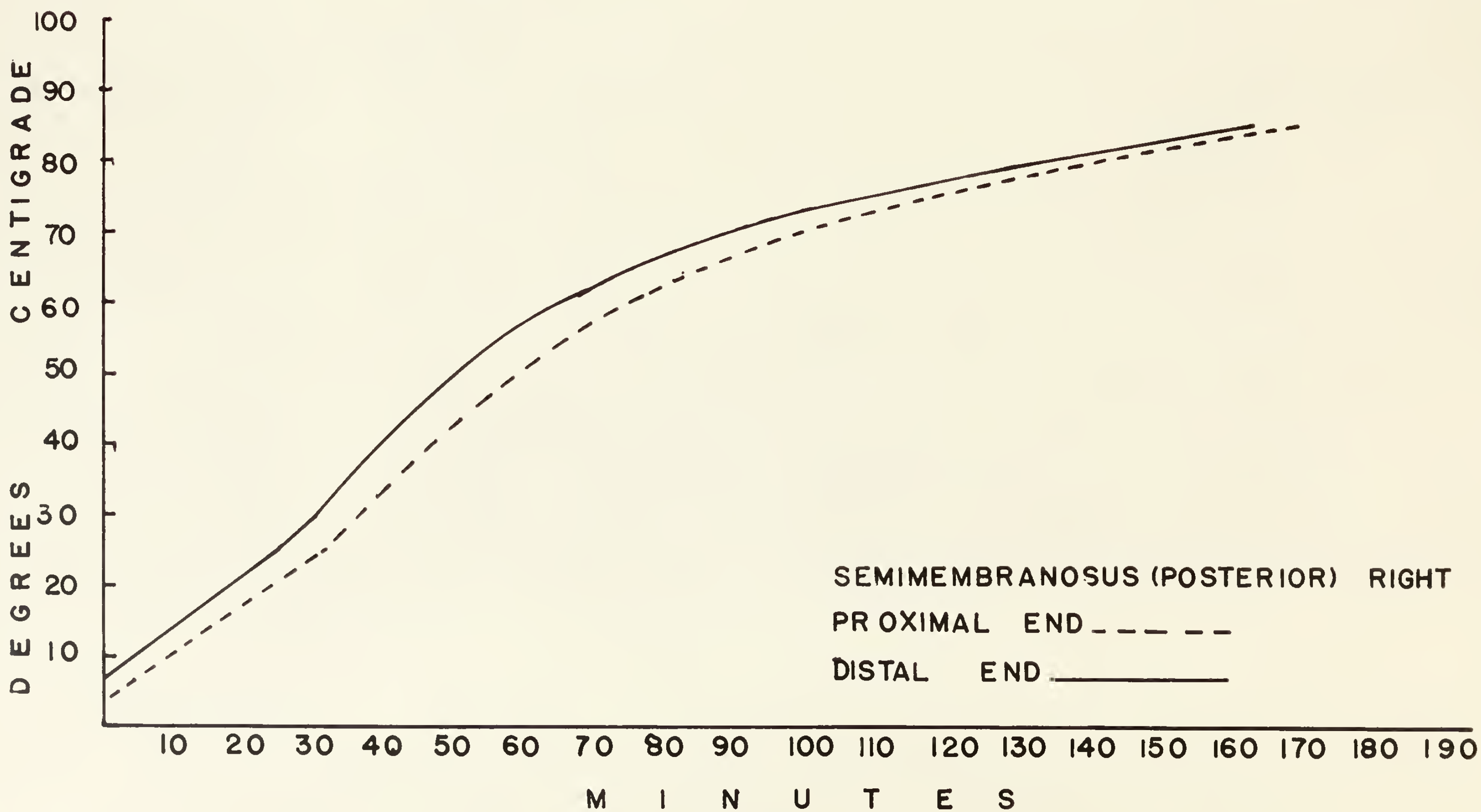


Fig. 7. Average heat penetration curves for the right semimembranosus (posterior) muscle.

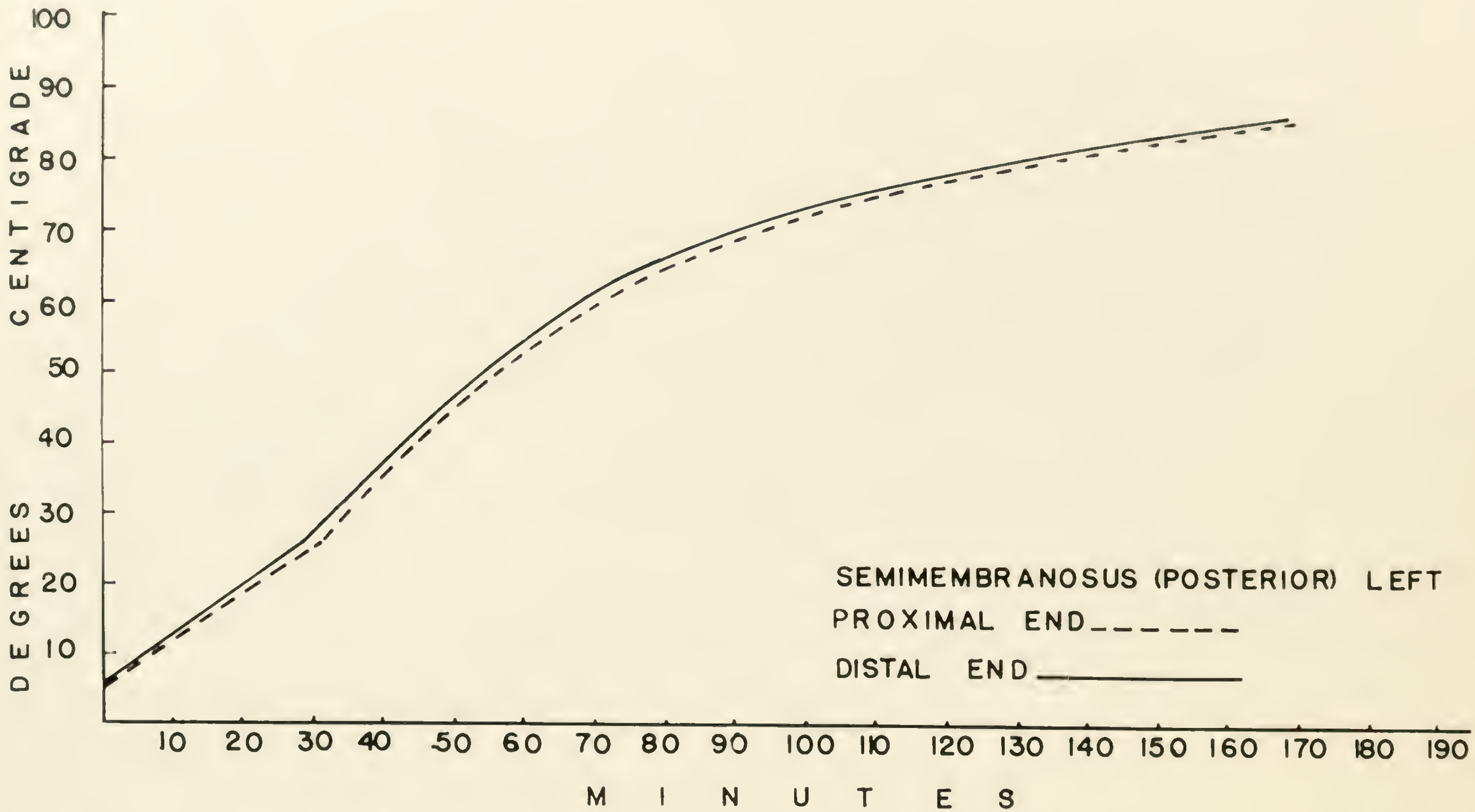


Fig. 8. Average heat penetration curves for the left semimembranosus (posterior) muscle.

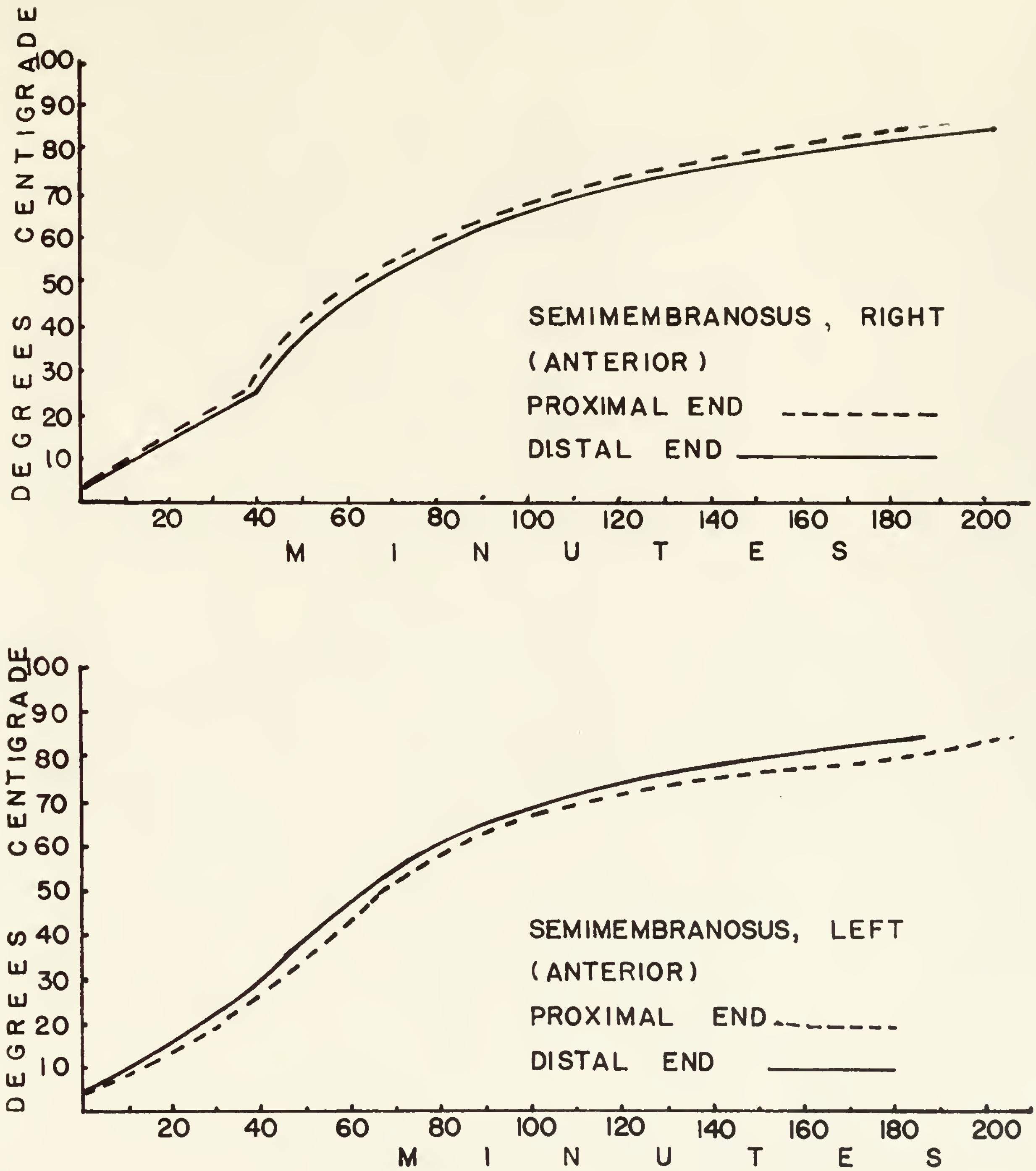


Fig. 9. Average heat penetration curves for the semimembranosus (anterior) muscle. Top of figure, right muscle; bottom, left muscle.

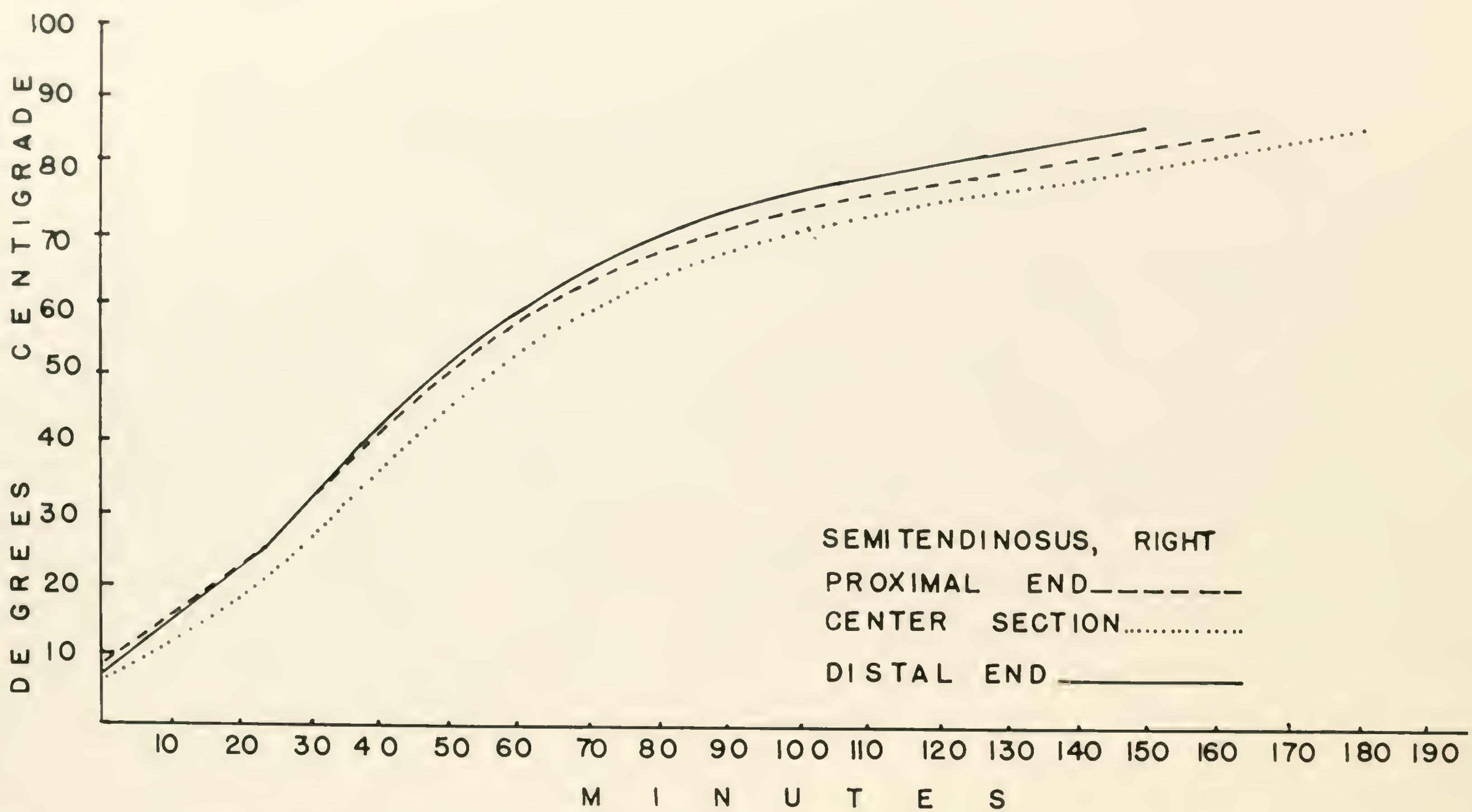


Fig. 10. Average heat penetration curves for the right semitendinosus muscle.

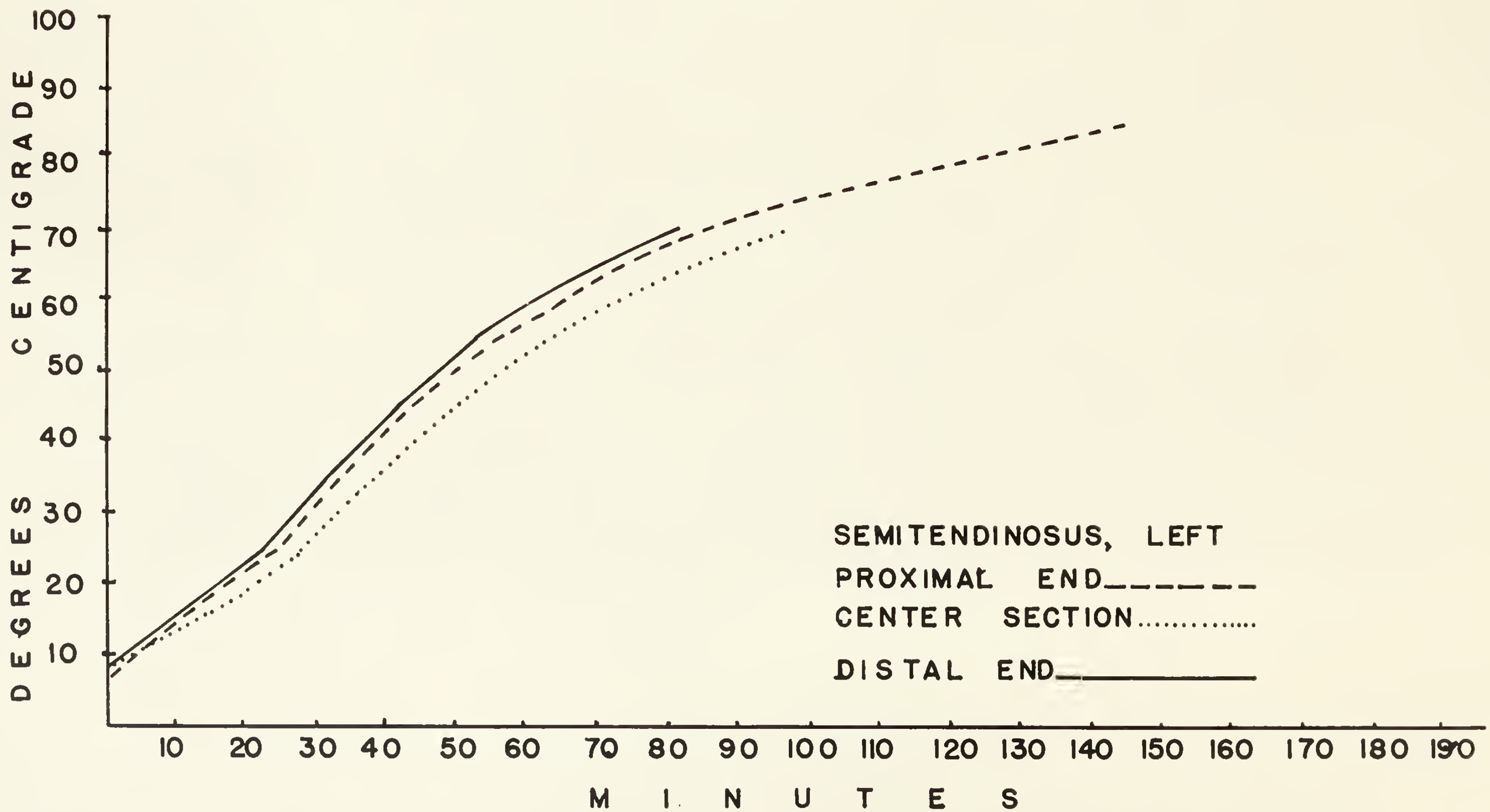


Fig. 11. Average heat penetration curves for the left semitendinosus muscle.

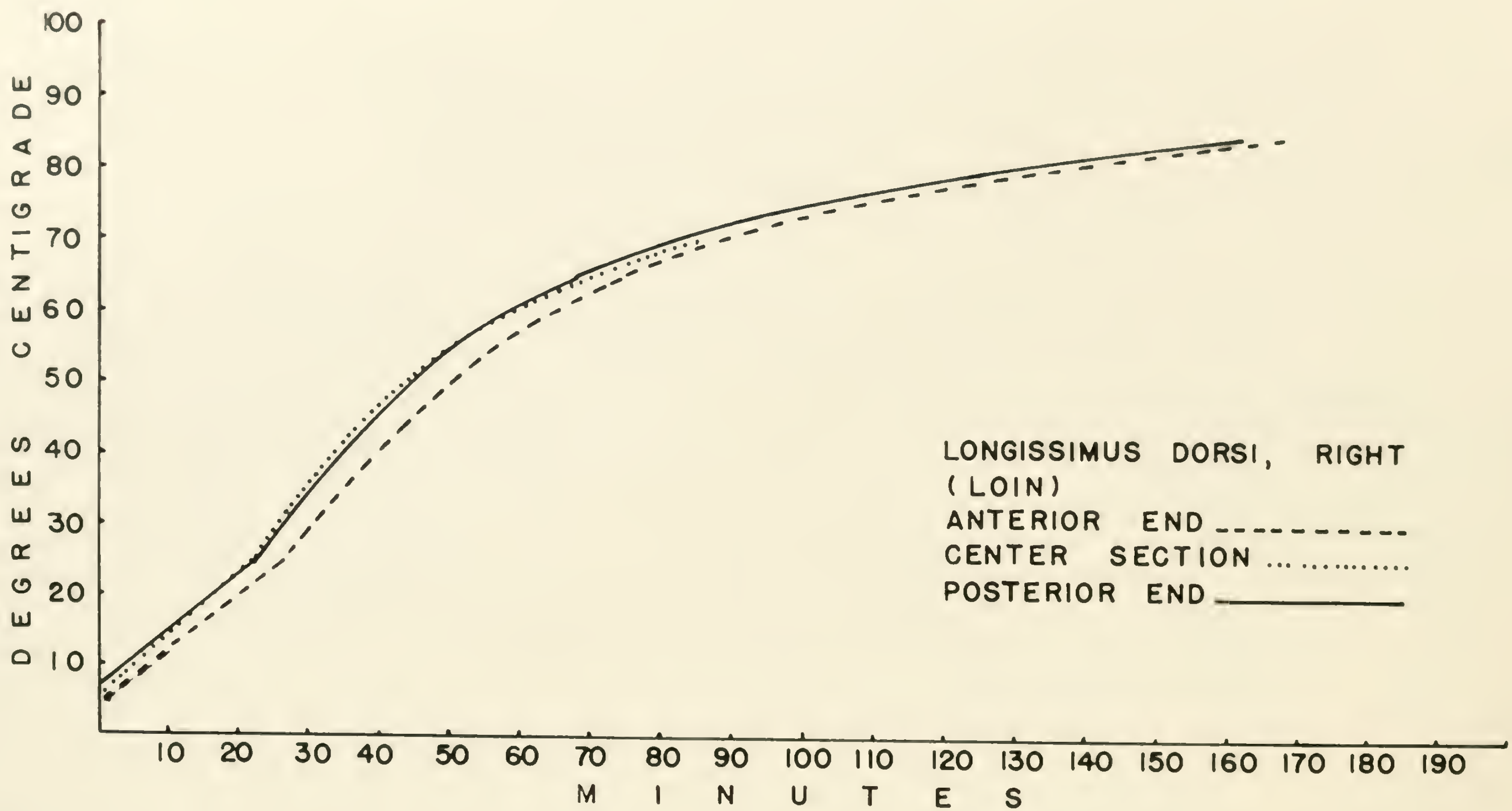


Fig. 12. Average heat penetration curves for the right longissimus dorsi (loin) muscle.

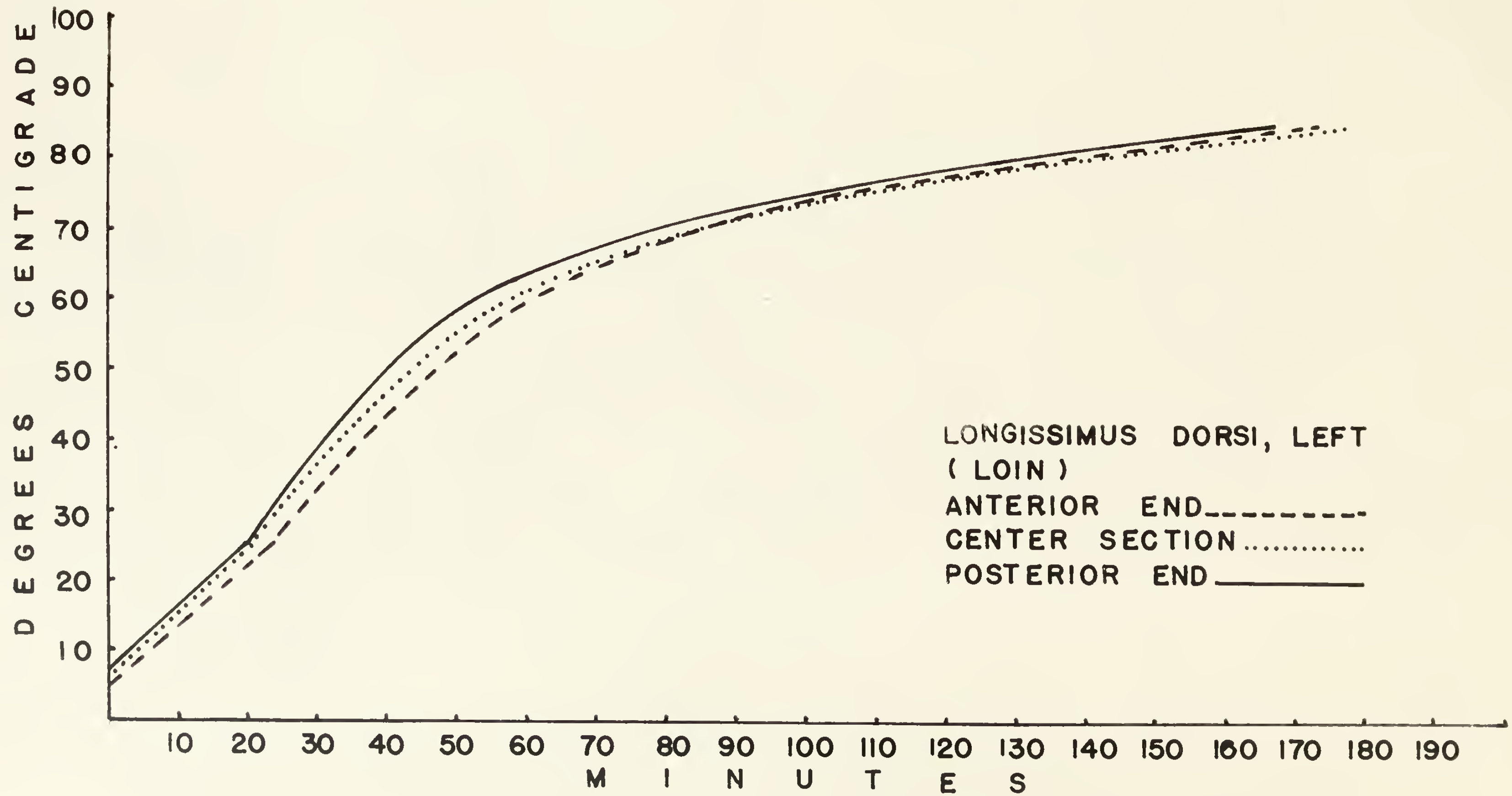


Fig. 13. Average heat penetration curves for the left longissimus dorsi muscle.

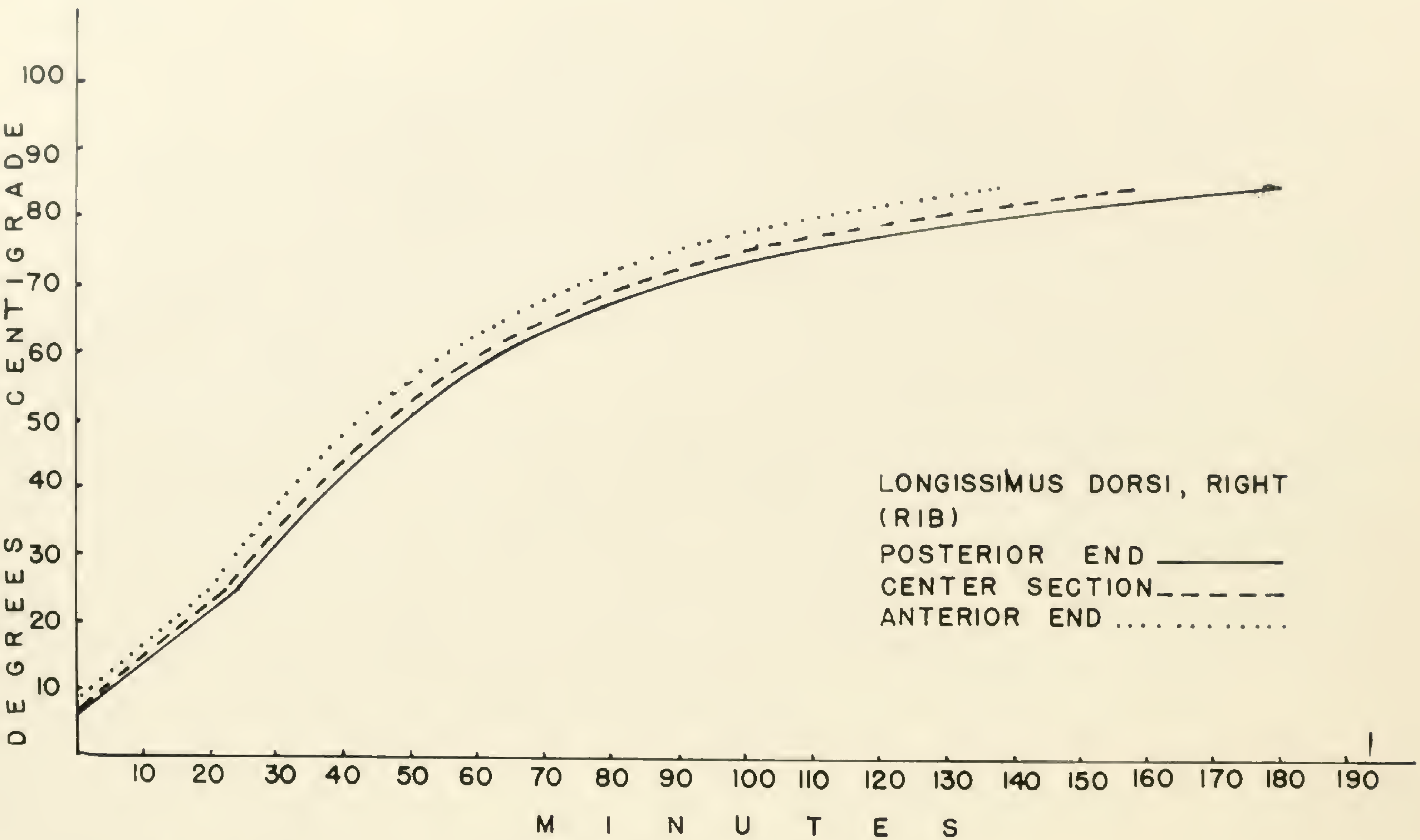


Fig. 14. Average heat penetration curves for the right longissimus dorsi (rib) muscle

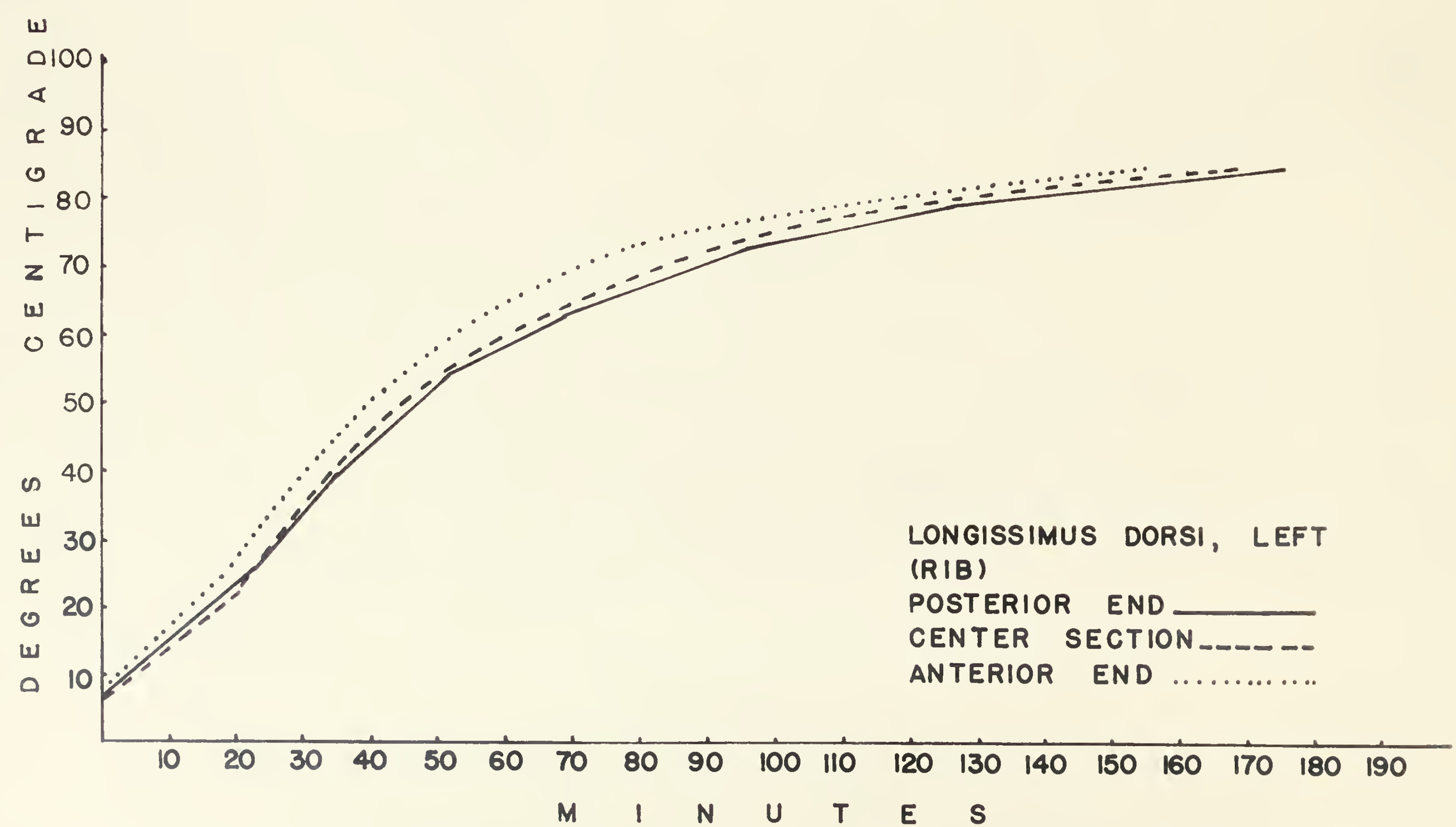


Fig. 15. Average heat penetration curves for the left longissimus dorsi (rib) muscle.

of heat penetration was noted for the center cuts from the semitendinosus, longissimus dorsi (loin) and longissimus dorsi (rib) muscles.

The roasts from the psoas major had the shortest and those from the rectus femoris the longest cooking times as shown by the rate of heat penetration curves. The psoas major roasts (average weight, 1.1 pounds) were the smallest ones cooked but the rectus femoris cuts (average weight, 1.5 pounds) were not the largest ones roasted. The anterior semimembranosus roasts (average weight, 1.9 pounds) also had long curves but they were not as long as those for the rectus femoris. The roasts from the other muscles were similar in weight and showed similar rates of heat penetration. The curves of the posterior semimembranosus and vastus lateralus roasts were of average length even though these muscles weighed slightly more than the rectus femoris roasts.

Aroma and Flavor

In this study, as the aroma scores increased the scores for flavor also tended to increase (Tables 3 and 4). Aroma mean scores for all roasts became higher as the end-point temperatures increased. That is, the aroma scores for the roasts cooked to 70°C. were slightly higher than the scores for those cooked to 55°C., and the aroma scores for the roasts cooked to 85°C. were higher than the scores for those cooked to 70°C. A larger increase in aroma scores was noted between the roasts cooked to 70°C. and those roasted to 85°C. than was found between those

Table 3. Average of mean values for factors related to aroma, flavor and tenderness for roasts from the muscles cooked to two internal temperatures.

Muscles	Int. temp. °C.	Aroma scores[1]	Flavor scores[1]	Tender-ness scores[1]	Tender-ness pref.[2]	Shear force lbs.
Psoas major	55	7.46	8.12	9.37	2.38	14.78
		*	*		*	***
	70	7.66	8.37	9.32	2.61	12.18
Adductor	70	7.73	7.82	8.08	2.34	20.43
		***				*
	85	8.66	8.08	7.92	2.65	24.65
Rectus femoris	70	7.78	8.02	8.52	2.26	17.23
		***	**	*	**	
	85	8.68	8.42	8.31	2.79	18.07
Vastus lateralus	70	7.52	8.03	7.82	2.42	19.59
		***				
	85	8.50	8.18	8.02	2.58	19.54
Semimembranosus (posterior)	70	7.75	8.02	7.82	2.48	24.32
		***				
	85	8.60	8.00	7.81	2.54	23.76
Semimembranosus (anterior)	70	7.80	7.68	7.88	2.32	24.07
		***				
	85	8.69	7.85	7.71	2.69	26.35

1 - Maximum score possible, 10.
2 - Lower values indicate higher preferences.
* - Significant at the five percent level.
** - Significant at the one percent level.
*** - Significant at the one-tenth percent level.

Table 4. Average of mean values for factors related to aroma, flavor and tenderness for roasts from the muscles cooked to three internal temperatures.

Muscles	Int. temp. °C.	Aroma scores[1]	Flavor scores[1]	Tenderness scores[1]	Tenderness pref.[2]	Shear force lbs.
Semitendinosus	55	7.50	7.85	8.51	3.32	30.82
		*	*			*
	70	7.82	8.11	8.43	3.53	20.32 *
		*	*			
	85	8.53	8.42	8.47	3.62	20.01
lsd		0.22	0.22	----	----	4.77
Longissimus dorsi (loin)	55	7.42	7.87	8.86	2.89	14.33
		*	*	*	*	
	70	7.93	8.24 *	8.62 *	3.72 *	14.02
		*				
	85	8.68	8.31	8.59	3.88	15.32
lsd		0.20	0.30	0.17	0.69	----
Longissimus dorsi (rib)	55	7.61	8.01	9.05	2.86	15.03
		*	*		*	
	70	8.00	8.43 *	8.85 *	3.54 *	14.37
		*				
	85	8.88	8.54	8.65	4.13	17.52
lsd		0.22	0.22	0.28	0.69	----

1 - Maximum score possible, 10.
2 - Lower values indicate higher preferences.
* - Significant at the five percent level.
lsd - Least significant difference.

cooked to 55°C. and those roasted to 70°C. Aroma scores for all roasts cooked to two end-point temperatures (70° and 85°C.) were very significantly higher for those roasted to 85°C. than for those roasted to 70°C. Significantly higher aroma scores were found for the 70°C. psoas major roasts than for the 55°C. roasts. Also, significant differences were found among the aroma scores for the roasts cooked to the three end-point temperatures (55°, 70° and 85°C.).

Mean flavor scores also showed a tendency to increase as the end-point temperatures increased. This was true for roasts from all muscles except from the semimembranosus (posterior) in which the average flavor scores were practically the same for those roasts cooked to 70°C. and to 85°C. Flavor scores for the roasts from the psoas major, semitendinosus, longissimus dorsi (loin) and longissimus dorsi (rib) were significantly higher for those cooked to 70°C. than for those roasted to 55°C. Also, flavor scores for the 85°C. roasts from the longissimus dorsi (loin) and longissimus dorsi (rib) were significantly greater than for the 55°C. roasts. The flavor scores for the semitendinosus and rectus femoris roasts cooked to 85°C. were significantly and highly significantly greater, respectively, than for those roasted to 70°C.

Tenderness and Shear Force Values

Tenderness scores, preference for tenderness and shear force values are closely related and were used in this study to evaluate the tenderness of beef. The tenderness scores were determined by the number of chews required by the judge to completely masticate a sample of meat. Each judge was asked to set up his own range for the number of chews that would be equal to a given tenderness score.

On the whole, average tenderness scores were similar for roasts cooked to each of the end-point temperatures (Tables 3 and 4). Significant differences in tenderness attributable to internal temperature were found only for the roasts from the rectus femoris, longissimus dorsi (loin) and longissimus dorsi (rib). Tenderness scores for the roasts from the last two muscles mentioned above were significantly higher for the roasts cooked to 55°C. than for the roasts cooked to 85°C. No significant difference attributable to end-point temperatures was noted for tenderness scores for the roasts from the other muscles.

The taste panel was asked to rank the samples in order of their preference for tenderness. Later the rankings were given a numerical value, with lower numbers used to indicate the higher preferences. As the end-point temperatures increased the average tenderness preference values for the samples decreased slightly. The tenderness preferences for roasts from the psoas major, longissimus dorsi (loin) and longissimus dorsi (rib) were significantly in favor of the 55°C. cuts when compared with the 70°C. roasts. The tenderness of the rectus femoris 70°C. roasts was highly significantly preferred to that for the 85°C. roasts. Also, the 55°C. longissimus dorsi (loin) and longissimus dorsi (rib) roasts had significantly better tenderness preferences than for the 85°C. roasts. Even though the tenderness preferences for the roasts decreased with each rise in end-point temperature, the ranking for other roasts not mentioned above were similar.

Shear force values were used as an objective method of measuring tenderness. Generally, the shear force values increased as the tenderness scores decreased. In this study the average tenderness scores decreased slightly as end-point temperatures increased; however, some of the shear force values decreased, whereas, other shear force values increased with an increase in end-point temperatures. The adductor roasts cooked to 85°C. had shear force values that were significantly lower than those for roasts cooked to 70°C. The psoas major roasts cooked to 70°C. had very highly significantly lower shear force values than those roasted to 55°C. The shear force values for the semitendinosus roasts cooked to 70°C. and those roasted to 85°C. were significantly lower than those for roasts cooked to 55°C.

Other muscles showed no significant difference in shear force values attributable to end-point temperatures. The average shear force values from the rectus femoris roasts cooked to 70°C. were slightly lower than those for the 85°C. roasts; whereas, the semimembranosus (posterior) 85°C. roasts had lower shear force values than the 70°C. roasts. The longissimus dorsi (rib) roasts cooked to 70°C. were lower in shear force values than the values for those roasted to 55°C. The vastus lateralus shear force values from roasts cooked to 70° and to 85°C. were similar.

Negative correlation coefficients between tenderness scores and shear force values were noted for 19 of the 21 relationships investigated (Table 5). The correlation coefficients for tenderness scores and shear force values were significant for 85°C. rectus femoris roasts, highly significant for 85°C. vastus lateralus and longissimus dorsi (loin and rib) roasts and very highly significant for 85°C. adductor roasts.

There has been disagreement in the literature as to the correlation of tenderness scores and shear force values. Cover and Smith (1956) found highly significant correlation coefficients for these factors when they studied two cooking methods for two beef muscles (longissimus dorsi and biceps femoris); whereas, Paul et al. (1956) noted that tenderness scores and shear force values were not well correlated when samples from the semitendinosus, semimembranosus and adductor muscles from two types of U. S. Commercial grade beef animals were used.

Juiciness and Related Factors

Juiciness scores, preference for juiciness, press fluid yields, total, volatile and dripping losses and cooking time are thought to be closely related factors and will be discussed in this section. The a verage juiciness scores for all roasts decreased as the end-point temperatures increased (Tables 6 and 7). The roasts cooked to 55°C. showed slightly higher juiciness scores than those roasted to 70°C., but greater differences in scores were noted between those roasts cooked to 70°C. and those roasted to 85°C. Significant decreases in juiciness scores were noted as

Table 5. Correlation coefficients for tenderness scores and shear force values; press fluid yields and cooking losses (total, volatile and dripping).

Factors	55°C.	70°C.	85°C.
Tenderness scores and shear values			
Psoas major	-.458	-.633*	
Adductor		-.566	-.914***
Rectus femoris		-.500	-.624*
Vastus lateralus		-.506	-.701**
Semimembranosus (posterior)		-.364	-.495
Semimembranosus (anterior)		.110	-.248
Semitendinosus	.059	-.307	-.456
Longissimus dorsi (loin)	-.554	-.001	-.715**
Longissimus dorsi (rib)	-.373	-.397	-.729**
Press fluid and total losses			
Psoas major	.417	.266	
Adductor		-.175	-.207
Rectus femoris		-.185	-.728**
Vastus lateralus		.021	-.428
Semimembranosus (posterior)		.130	-.283
Semimembranosus (anterior)		.360	.288
Semitendinosus	-.524	.352	-.666*
Longissimus dorsi (loin)	-.085	-.096	-.290
Longissimus dorsi (rib)	-.087	-.570	-.554
Press fluid and volatile losses			
Psoas major	.427	.411	
Adductor		-.264	-.194
Rectus femoris		-.217	-.676*
Vastus lateralus		-.098	-.458
Semimembranosus (posterior)		.280	-.332
Semimembranosus (anterior)		.356	.270
Semitendinosus	-.492	.447	-.659*
Longissimus dorsi (loin)	-.134	-.048	-.261
Longissimus dorsi (rib)	-.117	-.594*	-.612*
Press fluid and dripping losses			
Psoas major	.531	-.002	
Adductor		.105	-.108
Rectus femoris		-.117	-.074
Vastus lateralus		.227	.358
Semimembranosus (posterior)		-.388	.873***
Semimembranosus (anterior)		.201	.098
Semitendinosus	-.528	-.015	-.065
Longissimus dorsi (loin)	.170	-.301	-.396
Longissimus dorsi (rib)	.118	-.310	.644*

* - Significant at the five percent level.
** - Significant at the one percent level.
*** - Significant at the one-tenth percent level.

Table 6. Average of mean values for factors related to juiciness, cooking losses and cooking time for roasts from the muscles cooked to two internal temperatures.

Muscles	Int. temp. °C.	Juiciness scores[1]	Juiciness pref.[2]	Press fluid ml/25g	Ckg. losses pct	Volat. losses pct	Drip. losses pct	Wt. lbs.	Ckg. time min/lb
Psoas major	55	9.24	2.26	9.10	8.42	7.61	0.80	1.1	38.94
		**	**		***	***	*		***
	70	8.98	2.73	9.44	14.58	13.37	1.08	1.1	62.32
Adductor	70	8.20	1.76	8.38	21.55	18.61	2.78	1.2	72.94
		***	***	***	***	***	**		***
	85	6.02	3.23	6.85	36.00	33.81	2.06	1.3	128.43
Rectus femoris	70	8.62	1.86	8.38	20.57	18.30	2.20	1.5	68.13
		***	***	***	***	***			***
	85	6.91	3.16	6.62	36.18	34.32	1.86	1.5	123.19
Vastus lateralus	70	8.62	1.62	8.26	19.89	16.58	3.30	1.6	55.43
		***	***	***	***	***	***		***
	85	6.72	3.19	7.05	35.34	33.36	1.98	1.7	103.69
Semimembranosus (posterior)	70	8.51	1.76	8.54	18.55	16.26	2.22	1.6	60.39
		***	***	**	***	***	***		***
	85	6.58	3.25	7.34	32.98	31.24	1.62	1.5	112.70
Semimembranosus (anterior)	70	8.08	1.78	8.55	21.10	18.86	2.28	1.9	61.25
		***	***	***	***	***	*		***
	85	6.12	3.23	7.15	37.13	35.39	1.72	1.9	104.26

1 - Maximum score possible, 10.
2 - Lower values indicate higher preferences.
* - Significant at the five percent level.
** - Significant at the one percent level.
*** - Significant at the one-tenth percent level.

Table 7. Average of mean values for factors related to juiciness, cooking losses and cooking time for roasts from the muscles cooked to three internal temperatures.

Muscles	Int. temp. °C.	Juici-ness scores[1]	Juici-ness pref.[2]	Press fluid ml/25g	Ckg. losses pct	Volat. losses pct	Drip. losses pct	Wt. lbs.	Ckg. time min/lb
Semitendinosus	55	9.07	2.30	9.35	10.89	9.72	1.10	1.2	48.17
		*	*		*	*	*		*
	70	8.37	3.03	8.94 *	18.78	16.68	2.06 *	1.3	70.55
		*	*	*	*	*			*
	85	6.62	5.18	7.40	33.36	31.62	1.72	1.2	136.27
lsd		0.37	0.58	0.53	1.54	1.31	0.57		9.64
Longissimus dorsi (loin)	55	9.44	2.38	8.86	10.01	8.39	1.48	1.4	35.08
		*	*		*	*			*
	70	8.76	3.16	8.78 *	17.82	15.87	1.92	1.5	59.04
		*	*	*	*	*			*
	85	6.38	5.00	6.37	35.62	33.91	1.62	1.4	122.54
lsd		0.40	0.46	0.66	1.70	1.34	----		8.09
Longissimus dorsi (rib)	55	9.54	2.29	8.71	9.10	8.07	0.99	1.4	38.45
		*	*		*	*	*		*
	70	8.82	3.22	8.90 *	16.21	14.68	1.48 *	1.4	60.63
		*	*	*	*	*			*
	85	6.82	5.02	6.32	33.61	32.09	1.36	1.3	127.71
lsd		0.40	0.41	0.57	1.76	1.89	0.28		9.40

1 - Maximum score possible, 10.
2 - Lower values indicate higher preferences.
* - Significant at the five percent level.
lsd - Least significant difference.

end-point temperatures for the semitendinosus, longissimus dorsi (loin) and longissimus dorsi (rib) roasts increased from 55° to 70° to 85°C. Juiciness scores for the psoas major 55°C. roasts were highly significantly greater than for the 70°C. roasts. The adductor, rectus femoris, vastus lateralus, semimembranosus (posterior) and semimembranosus (anterior) roasts cooked to 70°C. had very highly significantly larger juiciness scores than those cooked to 85°C. Significant differences were found among juiciness scores for all roasts as the end-point temperatures increased from 55°C. (rare) to 85°C. (well-done). Siemers and Hanning (1953) also found highly significant differences in juiciness scores between meat cooked to rare and that cooked well-done.

The judges were asked to rate the beef samples in order of preference for juiciness and to use smaller numbers to indicate the higher preferences. As shown in Tables 6 and 7 the average juiciness preferences decreased as the roasts were cooked to the higher end-point temperatures. The greatest range in juiciness preference values was found between those roasts cooked to 70°C. and those to 85°C., the lowest preference was for the 85°C. roasts. Significant differences for juiciness preference were found between each increase in end-point temperature (55°, 70° and 85°C.) for the semitendinosus, longissimus dorsi (loin) and longissimus dorsi (rib) roasts. Highly significant differences were noted between the juiciness preference for psoas major roasts cooked to 55°C. and those cooked to 70°C., with the roasts cooked to 55°C. being preferred. The roasts cooked to 70°C. from the adductor, rectus femoris, vastus lateralus, semimembranosus (posterior) and semimembranosus (anterior) showed a very highly significant juiciness preference over those roasted to 85°C.

Press fluid yields are used as an objective method for indicating juiciness, but many workers have indicated that press fluid might not measure the same thing that is measured by a taste panel. Generally, the average press fluid yields for most roasts decreased with an increase in end-point temperature (Tables 6 and 7). The semitendinosus roasts cooked to 55°C. had greater press fluid yields than those roasts from this muscle cooked to 70°C. This is in agreement with Child and Fogarty (1935) who also found greater press fluid yields from the semitendinosus muscle that was cooked to 58°C. than was found for those which were cooked to 75°C. No significant differences in press fluid yields were noted between those from 55°C. roasts and those from 70°C. roasts. The press fluid yields of the semitendinosus, longissimus dorsi (loin) and longissimus dorsi (rib) 85°C. roasts showed a significant decrease when compared with those from the 55°C. roasts and with those from the 70°C. roasts. Press fluid yields from the semimembranosus (posterior) roasts cooked to 85°C. were highly significantly lower than for those roasted to 70°C.; whereas, those for the 85°C. roasts from the adductor, rectus femoris, vastus lateralus and semimembranosus (anterior) were very highly significantly lower than those for the 70°C. roasts.

The juiciness scores always decreased with an increase in end-point temperature, but the press fluid yields did not always show a similar relationship. The roasts that had the highest of lowest juiciness scores were not necessarily the same roasts that had the highest or lowest press fluid yields.

Positive correlation coefficients between juiciness scores and press fluid yields were noted for 16 of the 21 relationships investigated (Table 8). The correlation coefficients for these two factors for the 70°C. semitendinosus and 85°C. adductor roasts were significant and highly significant, respectively. This finding is in general disagreement with Satorius and Child (1938b) who found no correlation between the quantity of juice of beef muscle as shown by the judges scores and the press fluid yields obtained.

The total cooking losses of roasts increased with each increase in end-point temperature (Tables 6 and 7). The psoas major roasts cooked to 70°C. showed very highly significantly greater total cooking losses than those roasted to 55°C. Total cooking losses were very highly significantly greater for the adductor, rectus femoris, vastus lateralus, semimembranosus (posterior) and semimembranosus (anterior) roasts cooked to 85°C. than for those roasted to 70°C. The roasts from the semitendinosus, longissimus dorsi (loin) and longissimus dorsi (rib) cooked to 55°, to 70° and to 85°C. showed significant increases in total cooking losses with each increase in end-point temperature.

In this study, total cooking losses had negative correlation coefficients with the juiciness scores for the majority of the roasts cooked (Table 8). That is, the total cooking losses

Table 8. Correlation coefficients for juiciness scores and press fluid yields and juiciness scores and cooking losses (total, volatile and dripping).

Factors	55°C.	70°C.	85°C.
Juiciness scores and press fluid			
Psoas major	.091	.445	
Adductor		-.463	.713**
Rectus femoris		.446	.254
Vastus lateralus		.236	.007
Semimembranosus (posterior)		.393	-.374
Semimembranosus (anterior)		-.261	.334
Semitendinosus	.447	.659*	.457
Longissimus dorsi (loin)	-.568	-.258	.173
Longissimus dorsi (rib)	.032	.515	.432
Juiciness scores and total losses			
Psoas major	.068	.341	
Adductor		.100	-.178
Rectus femoris		-.488	-.502
Vastus lateralus		-.888***	-.492
Semimembranosus (posterior)		-.462	-.182
Semimembranosus (anterior)		-.224	-.114
Semitendinosus	-.480	.274	-.709**
Longissimus dorsi (loin)	.492	-.305	.026
Longissimus dorsi (rib)	-.262	-.108	-.598*
Juiciness scores and volat. losses			
Psoas major	.038	.325	
Adductor		.220	-.168
Rectus femoris		-.607*	-.605*
Vastus lateralus		-.783**	-.466
Semimembranosus (posterior)		-.339	-.150
Semimembranosus (anterior)		-.500	-.129
Semitendinosus	-.558	.262	-.626*
Longissimus dorsi (loin)	.516	-.452	-.016
Longissimus dorsi (rib)	-.310	-.061	-.576*
Juiciness scores and drip. losses			
Psoas major	.062	.248	
Adductor		-.252	.095
Rectus femoris		.105	.640*
Vastus lateralus		-.823***	-.269
Semimembranosus (posterior)		-.567	-.424
Semimembranosus (anterior)		.263	.172
Semitendinosus	-.377	.075	-.163
Longissimus dorsi (loin)	.072	.188	.335
Longissimus dorsi (rib)	-.152	-.196	.213

* - Significant at the five percent level.
** - Significant at the one percent level.
*** - Significant at the one-tenth percent level.

increased as the juiciness scores decreased. A very highly significant negative correlation coefficient between juiciness scores and total cooking losses was found for the 70°C. vastus lateralus roasts. The longissimus dorsi (rib) 85°C. roasts had a significant correlation coefficient between juiciness scores and total cooking losses; whereas, the semitendinosus roasts at 85°C. had a highly significant correlation coefficient for these two factors.

Negative correlation coefficients for press fluid yields and total cooking losses were found for 14 of the 21 relationships studied (Table 5). Significant correlation coefficients between press fluid yields and total cooking losses were found for the roasts cooked to 70°C. from the longissimus dorsi (rib) and for the roasts cooked to 85°C. from the semitendinosus. The rectus femoris 85°C. roasts showed highly significant correlation coefficients for these two factors.

Generally, the average of mean volatile losses increased as the end-point temperatures increased, from 55° to 70° and to 85°C. (Tables 6 and 7). Similar significant differences were found for volatile losses as were noted for total cooking losses. On the whole, negative correlation coefficients were noted for volatile losses and juiciness scores. Significant correlation coefficients for these factors were found for the roasts from the rectus femoris, semitendinosus and longissimus dorsi (rib) cooked to 85°C. and for 70°C. rectus femoris roasts; whereas, a highly significant correlation coefficient was noted for the 70°C. vastus lateralus roasts (Table 8). Negative correlation coefficients between press fluid yields and volatile losses were found for most roasts. Significant correlation coefficients were noted for the roasts from the longissimus dorsi (rib) at 70° and at 85°C. and for those from the 85°C. semitendinosus roasts.

Dripping losses for some roasts tended to decrease; whereas, that for others increased as the end-point temperatures increased (Tables 6 and 7). However, the dripping losses from roasts from the psoas major significantly increased as the end-point temperatures increased from 55° to 70°C. The dripping losses from roasts (semitendinosus, longissimus dorsi, loin and longissimus dorsi, rib) were greater for those cooked to 70°C. than for those cooked to 55°C.; and those cooked to 85°C. had smaller losses than for the 70°C. roasts, but these were greater than those for the 55°C. roasts. Significantly smaller dripping losses were noted for the 55°C. roasts (semitendinosus and longissimus dorsi, rib) than for the 70°C. ones and significantly larger losses were found for those roasted to 85°C. than for those to 55°C. Roasts from the semimembranosus (anterior) cooked to 85°C. had a significant decrease in dripping losses when compared with those roasted to 70°C. A highly significant decrease was found in dripping losses for 85°C. adductor roasts when this was compared with those roasted to 70°C. Vastus lateralus and semimembranosus (posterior) 85°C. roasts showed very highly significantly lower dripping losses than for those roasted to 70°C.

As shown in Table 8, approximately one-half of the relationships had positive correlation coefficients between dripping losses and juiciness scores. A significant positive correlation coefficient between dripping losses and juiciness scores was noted for the rectus femoris 85°C. roasts; whereas, a very highly significant negative correlation coefficient was found for the vastus lateralus 70°C. roasts. Since both a significant positive and a significant negative correlation coefficient were found, this might indicate that dripping losses are not the best method for evaluating the juiciness of beef muscles. Also, approximately one-half of the relationships showed positive correlation coefficients for dripping losses and press fluid yields. Very highly significant positive correlation coefficients for dripping losses and press fluid yields were found for the 85°C. roasts from the semimembranosus (posterior) and significant correlation coefficients were shown for the longissimus dorsi (rib) 85°C. roasts (Table 5). Since only a small number of significant correlation coefficients were noted between dripping losses and press fluid yields, dripping losses might not be good criteria for estimating the press fluid yields of beef muscles.

In this study, cooking time for all roasts increased with each increase in end-point temperature (Tables 6 and 7). Because of the size of the roasts used (average weight, 1.1 to 1.9 pounds), the average cooking time in minutes per pound was long. The average of mean juiciness scores decreased and the total cooking losses increased, as the cooking time increased. However, roasts from the semitendinosus at 55°C. and those from the adductor at 70°C. were the only ones that had the highest cooking losses with the longest cooking times. Cooking time was significantly longer for roasts from the semitendinosus, longissimus dorsi (loin and rib) for each increase in end-point temperature. Roasts from the psoas major cooked to 70°C. had a very highly significant increase in cooking time over those roasted to 55°C. The 85°C. roasts from the adductor, rectus femoris, vastus lateralus, semimembranosus (posterior) and semimembranosus (anterior) muscles had very highly significantly longer cooking times than those roasted to 70°C.

SUMMARY

Roasts from certain muscles of six U. S. Good long hindquarters of beef were used to study the changes, mainly in palatability, that occur during the oven-roasting of meat. A randomized incomplete block design was used for cooking roasts from the semitendinosus, longissimus dorsi (loin) and longissimus dorsi (rib) muscles. Three roasts were cut from each of the previously mentioned muscles and cooked to end-point temperatures of 55°, 70° and 85°C. Two roasts were cut from the psoas major, adductor, rectus femoris, vastus lateralus, semimembranosus (posterior) and semimembranosus (anterior). A randomized complete block design was used for cooking of the roasts either to end-point temperatures of 55° and 70°C. or 70° and 85°C. from the last muscles mentioned.

The defrosted roasts were cooked in a pre-heated rotary hearth oven maintained at 300°F. The rate of rise in internal temperature

was noted during cooking. After removing the roasts from the oven, weights were taken from which data for total, volatile and dripping cooking losses were obtained. Shear force values for one-inch cores of meat, press fluid yields and palatability scores were obtained. The data were analyzed statistically; the analyses of variance were run on data from the roasts cooked to three end-point temperatures and t-tests were done on data from those roasted to two end-point temperatures.

No particular difference was noted in the rate of heat penetration between the roasts from paired right and left muscles. Most of the curves tended to rise rather sharply until the internal temperature in the meat was 40°C., after that, the curves flattened out gradually until the end-point temperatures were reached. For some of the muscles, the roasts from the proximal or anterior end had the slower rate of heat penetration; whereas, in the remaining muscles the distal or posterior end roasts had the slower rates. The center cuts showed no consistent pattern for rate of heat penetration. The average weight of the roasts ranged from 1.1 to 1.9 pounds, but the largest roasts did not require the longest cooking time.

Aroma and flavor scores for roasts increased with an increase in end-point temperatures. Significant and very highly significant increases in mean aroma scores were found with each increase in end-point temperature. Approximately one-half of the muscles had significant differences in mean flavor scores that could be attributed to an increase in end-point temperature. In most cases, the tenderness scores for roasts decreased slightly with an increase in end-point temperature, but an increase in end-point temperature had little real effect on the tenderness scores of the roasts, because significant differences in tenderness attributable to degree of cooking were noted in only a few cases. Tenderness preference decreased with an increase in end-point temperature. An increase in end-point temperature had no consistent effect on the shear force values, since they increased for some of the roasts but decreased for others. Significant negative correlation coefficients for tenderness scores and shear force values were found for the majority of the roasts cooked to 85°C.

Juiciness scores and preference for juiciness decreased with an increase in end-point temperature; whereas, the total cooking losses and cooking times increased with an increase in the degree of cooking. Significant to very highly significant differences for each of these factors were found as the degree of cooking increased. The dripping losses tended to decrease with an increase in end-point temperature and differences were significant for roasts from most muscles. Generally, the average press fluid yields for most roasts decreased significantly with each increase in end-point temperature. The majority of the correlation coefficients between juiciness scores and press fluid yields were positive, however, only two coefficients were significant. Slightly more than half of the correlation coefficients for juiciness scores and cooking losses (total and volatile) were negative and only a few of these were significant. Most of the correlation coefficients for press fluid yields and cooking losses (total and volatile) were negative and only a few of these were significant. No consistent trend was found for the correlation coefficients for dripping losses and juiciness scores or dripping losses and press fluid yields.

ACKNOWLEDGMENTS

Sincere appreciation is expressed to Dr. Grayce Goertz, Associate Professor of Foods and Nutrition, for her help in the direction of this project and for her patience and help in the preparation of this manuscript; to Dr. Dorothy Harrison, Head of the Department of Foods and Nutrition, for her constructive criticism during the research and the reading of this manuscript; to Professor David Mackintosh and his staff of the Department of Animal Husbandry for securing the meat and dissecting the muscles. Appreciation also is expressed to the graduate students and other research workers who served so faithfully on the palatability committee and to my husband, Bill, who gave his moral support throughout the period of research and during the preparation of this manuscript.

LITERATURE CITED

Aldrich, Pearl J. and Belle Lowe.
Comparison of grades of beef rounds: Effect of cooking times on palatability and cost. J. Am. Diet. Assoc. 30:39-43, 1954.

Brady, D. E.
A study of the factors influencing tenderness and texture of beef. Pro. Am. Soc. Animal Prod. 30:246-249, 1937.

Child, Alice M. and J. Agnes Fogarty.
Effect of interior temperatures of beef muscle upon the press fluid and cooking losses. J. Agri. Res. 51:655-662, 1935.

Child, Alice M. and Mary J. Satorius.
Effect of exterior temperature upon press fluid, shear force, and cooking losses of roasted beef and pork muscles. J. Agri. Res. 57:865-871, 1938.

Clark, Helen E., Marie C. Wilmeth, Dorothy L. Harrison and Gladys E. Vail.
The effect of braising and pressure saucepan cookery on the cooking losses, palatability and nutritive value of the proteins of round steaks. Food Research 20:35-41, 1955.

Clark, Ruth Keys and Frances O. VanDuyne.
Cooking losses, tenderness, palatability, and thiamine and riboflavin content of beef as affected by roasting, pressure saucepan cooking, and broiling. Food Research 14:221-230, 1949.

Cover, Sylvia.
Effect of extremely low rates of heat penetration on tendering of beef. Food Research 8:388-394, 1943.

Cover, Sylvia and W. H. Smith, Jr.
The effect of two methods of cooking on palatability scores, shear force values, and collagen content of two cuts of beef. Food Research 21:312-321, 1956.

Crocker, E. C.
Flavor of meat. Food Research 13:179-183, 1948.

Deatherage, F. E. and Albert Harsham.
Relation of tenderness of beef to aging time at 33°-35°F. Food Research 12:164-172, 1947.

Griswold, Ruth M. and Marion A. Wharton.
Effect of storage conditions on palatability of beef. Food Research 6:517-528, 1941.

Hay, Pattie P., Dorothy L. Harrison and Gladys E. Vail.
Effects of a meat tenderizer on less tender cuts of beef cooked by four methods. Food Technol. 7:217-220, 1953.

Hiner, R. L., E. E. Anderson and C. R. Fellers.
Amount and character of connective tissue as it relates to tenderness in beef muscle. Food Technol. 9:80-86, 1955.

Hiner, R. L. and O. G. Hankins.
The tenderness of beef in relation to different muscles and age in the animal. J. Animal Sci. 9:347-353, 1950.

Hood, Maude P., Doris W. Thompson and Lenora Mirone.
Effects of cooking methods on low grade beef. Georgia Agri. Exp. Sta. Bul., N. S. 4, 1955.

Howe, Paul E.
The relation of cooking to the study of the quality and palatability of meat. J. Home Econ. 9:8-15, 1927.

Jacobson, Marion and Faith Fenton.
Effects of three levels of nutrition and age of animal on the quality of beef. I. Palatability, cooking data, moisture, fat, and nutrition. Food Research 21:415-426, 1956.

Lowe, Belle.
Experimental cookery from the chemical and physical standpoint, 4th ed., p. 209-220. New York: John Wiley and Sons, Inc., 1955.

Mackintosh, David L., J. Lowe Hall and Gladys E. Vail.
Some observations pertaining to tenderness of meat. Pro. Am. Soc. Animal Prod. 21:285-289, 1936.

Maximow, Alexander A. and William Bloom.
A textbook of histology, 6th ed., p. 49-52, 147-153. Philadelphia: W. B. Saunders Company, 1952.

Miller, Madge and Joseph Kastelic.
Chemical responses of connective tissue of bovine skelatal muscle. J. Agri. and Food Chem. 4:537-543, 1956.

Noble, I. T., E. G. Halliday and H. K. Klass.
Studies on tenderness and juiciness of cooked meat. J. Home Econ. 26:238-242, 1934.

Paul, Pauline.
Tenderness of beef. J. Am. Diet. Assoc. 33:890-894, 1957.

Paul, Pauline and Maura Bean.
Method for braising beef round steaks. Food Research 21:75-86, 1956.

Paul, Pauline, Maura Bean and L. J. Bratzler.
Effect of cold storage and method of cooking on commercial grade cow beef. Mich. Agri. Exp. Sta. Bul. 256, 1956.

Paul, Pauline and L. J. Bratzler.
Studies on tenderness of beef. II. Varying storage times and conditions. Food Research 20:626-634, 1955a.

Paul, Pauline and L. J. Bratzler.
Studies on tenderness of beef. III. Size of shear cores: end to end variation in the semimembranosus and adductor. Food Research 20:635-638, 1955b.

Paul, Pauline, L. J. Bratzler, E. D. Farwell and Katherine Knight.
Studies on tenderness of beef. I. Rate of heat penetration. Food Research 17:504-510, 1952.

Ramsbottom, J. M. and E. J. Strandine.
Comparative tenderness and identification of muscle in wholesale beef cuts. Food Research 13:315-330, 1948.

Ramsbottom, J. M. and E. J. Strandine.
Initial physical and chemical changes in beef as related to tenderness. J. Animal Sci. 8:398-410, 1949.

Ramsbottom, J. M., E. J. Strandine and C. H. Koonz.
Comparative tenderness of representative beef muscles. Food Research 10:497-509, 1945.

Satorius, Mary and Alice M. Child.
Effect of coagulation on press fluid, shear force, muscle-cell diameter and composition of beef muscle. Food Research 3:619-626, 1938a.

Satorius, Mary and Alice M. Child.
Problems in meat research. I. Four comparable cuts from one animal. II. Reliability of judges' scores. Food Research 3:627-635, 1938b.

Siemers, Lorene Larsen and Flora Hanning.
A study of certain factors influencing the juiciness of meat. Food Research 18:113-120, 1953.

Simone, Marion, Floyd Carroll and M. T. Clegg.
Effect of degree of finish on differences in quality factors of beef. Food Research 23:32-39, 1958.

Sleeth, R. B., G. G. Kelley and D. E. Brady.
Shrinkage and organoleptic characteristics of beef aged in controlled environments. Food Technol. 12:86-90, 1958.

Szent-Györgi, Albert.
Chemistry of muscular contraction, 2nd ed., p. 9-19, 25-27. New York: Academic Press Inc., 1951.

Szent-Györgi, Albert.
Nature of life, a study on muscle. p. 28-32. New York: Academic Press Inc., 1948.

Visser, Rosemary.
The palatability of certain beef muscles cooked in deep fat to three degrees of doneness. Unpublished Master's thesis. Kansas State College, Manhattan, Kansas, 1957.

Wang, Hsi, Ellen Rasch, Virginia Bates, F. J. Beard, J. C. Pierce and O. G. Hankins.
Histological observations on fat loci and distribution in cooked beef. Food Research 19:314-322, 1954.

Winegarden, Margaret W., Belle Lowe, Joseph Kastelic, Edwin A. Kline, Alma R. Plagge and P. S. Shearer.
Physical changes of connective tissue of beef during heating. Food Research 17:172-184, 1952.

APPENDIX

Form 1. Score card for beef.

Judge______________ Code______________ Date______________

Sample number	Aroma	Flavor	Juiciness	Tenderness	Number of chews	Comments
1.						
2.						
3.						
4.						
5.						
6.						

Descriptive terms for scoring:

10. Extremely good
9. Very good
8. Good
7. Moderately good
6. Slightly good
5. Slightly poor
4. Moderately poor
3. Poor
2. Very poor
1. Extremely poor

Rate samples according to preference:

For Tenderness	For Juiciness
1. ________	1. ________
2. ________	2. ________
3. ________	3. ________
4. ________	4. ________
5. ________	5. ________
6. ________	6. ________

Description of Abbreviations

1. Sides of beef carcass

   r - right side
   l - left side

2. Muscle position code

A, M, T	- Anterior end
B, O, V	- Posterior end
C, E, G, P, R, J	- Proximal end
D, F, H, Q, S, L	- Distal end
K, N, U	- Mid-section

3. Animal number and total weight of paired long hindquarters

   Animal III - 300 pounds
   Animal VI - 325 pounds
   Animal VII - 284 pounds
   Animal VIII - 311 pounds
   Animal X - 349 pounds
   Animal XII - 350 pounds

4. Preference Ratings

The judges ranked the samples from each trial in order of their preference. A numerical value later was given for each rank, number one for first place, two for second place, etc. If there was a tie such as for first place, the numerical value was an average of the sum of the values for first and second place. Therefore, the sum of the numerical values when four samples were ranked always was 10 and when six samples were ranked always was 21.

Table 9. Average time in minutes for rise in internal temperature for roasts from beef muscles.[1]

Temp. °C.	Roasts											
	Ar	Al	Br	Bl	Cr	Cl	Dr	Dl	Er	El	Fr	Fl
25	15.5	16.0	17.3	19.3	32.2	31.2	23.2	22.7	34.0	33.8	36.2	38.0
30	3.5	3.3	3.5	3.7	4.5	5.0	4.0	3.5	5.2	4.5	5.0	5.0
35	3.5	3.5	3.8	3.7	5.0	5.0	4.0	3.8	4.8	5.2	5.0	4.7
40	3.3	3.5	3.7	4.0	4.8	5.3	4.3	4.2	5.7	5.0	5.7	5.5
45	4.0	3.8	4.5	4.2	5.7	6.3	4.7	4.5	5.5	5.5	5.8	5.8
50	4.0	3.8	4.5	4.5	6.3	6.8	5.2	4.8	6.2	6.3	6.2	7.2
55	5.2	5.0	5.5	5.0	6.7	7.2	6.0	5.8	6.0	7.5	7.7	6.7
57	2.0	2.3		2.5	3.8	3.5	3.3	2.8	3.7	3.5	3.7	3.7
59	2.0	2.3		2.7	3.7	3.7	3.3	3.2	3.3	3.3	3.7	3.5
61	3.0	2.7		2.7	3.8	4.3	3.5	3.0	3.5	4.8	3.7	3.7
63	2.7	3.0		3.2	4.2	3.8	3.7	3.3	4.0	4.7	4.3	4.7
65	3.3	3.0		3.2	4.7	4.7	4.0	4.2	4.2	5.3	4.7	3.8
67	3.3	3.7		3.7	4.8	4.8	4.5	4.0	5.0	5.5	5.2	5.0
69	3.7	3.3		3.5	5.7	6.0	5.0	5.5	5.8	7.7	6.0	5.2
70	2.0	2.7		2.3	3.0	3.0	3.5	3.0	3.5	4.5	3.0	3.0
71					4.8	5.5	5.8	5.0	5.3	8.5	6.5	6.0
73					7.5	7.5	5.8	6.5	7.0	10.5	7.8	10.0
75					8.5	6.5	7.3	6.5	7.3	13.0	11.5	8.5
77					8.0	8.0	8.5	10.0	9.3	16.5	11.5	6.0
79					9.5	9.0	9.5	8.0	11.8	27.5	14.8	9.0
81					8.8	9.0	13.8	8.5	11.8	16.5	14.3	8.5
83					10.8	13.0	14.5	12.5	10.3	12.0	10.5	11.0
85					11.0	10.0	13.0	8.5	12.5	13.0	12.5	6.0
Initial Temp., °C.	9.7	9.2	9.5	7.8	4.8	5.0	6.7	6.0	5.7	6.2	5.5	5.2

Table 9. (cont.)

Temp. °C.	ROASTS											
	Gr	Gl	Hr	Hl	Pr	Pl	Qr	Ql	Rr	Rl	Sr	Sl
25	28.3	29.0	25.3	25.0	31.5	31.0	25.0	29.0	38.3	36.2	39.7	34.2
30	4.7	4.5	4.5	4.3	4.7	4.5	5.7	4.8	5.0	5.2	5.3	5.3
35	5.0	5.2	4.3	4.2	5.2	5.0	3.8	4.5	5.5	5.3	5.7	5.5
40	5.3	5.5	4.5	5.2	5.8	5.0	4.8	5.0	5.8	5.8	5.8	5.5
45	5.7	5.8	5.0	5.2	5.7	5.5	5.5	5.7	7.3	5.7	6.2	5.8
50	5.8	6.2	5.3	5.5	6.6	6.0	5.8	6.0	7.3	6.8	7.3	7.0
55	7.3	7.5	6.5	6.5	6.8	7.3	6.3	6.6	8.7	7.8	8.7	7.8
57	3.5	3.7	3.5	3.3	3.7	3.0	3.5	3.8	3.8	3.7	4.2	3.2
59	3.5	3.5	3.3	3.3	3.5	3.3	4.0	3.2	3.8	4.0	3.8	3.7
61	4.3	4.2	3.0	3.3	3.8	3.7	3.5	3.7	4.8	4.3	5.0	4.5
63	4.0	4.3	4.2	4.0	4.2	4.0	3.8	3.3	4.7	4.8	5.8	4.2
65	4.7	4.5	4.2	4.5	4.7	4.3	4.0	4.2	4.8	5.3	6.2	5.0
67	4.8	4.7	4.2	4.3	4.3	4.2	5.2	4.7	6.7	5.3	5.5	6.0
69	4.8	5.3	5.0	4.5	5.5	5.2	5.7	5.3	6.2	6.2	8.2	7.3
70	3.0	3.7	3.0	2.5	2.5	3.0	3.0	3.0	4.0	3.3	3.0	4.0
71	6.7	5.3	5.8	4.0	6.8	5.5	5.3	5.7	7.3	9.7	8.0	5.0
73	7.3	6.3	6.8	5.0	6.8	6.5	7.3	6.3	6.3	11.3	9.8	7.0
75	7.7	7.0	8.3	6.0	8.5	8.0	9.0	7.7	8.3	13.7	9.8	[illegible]
77	10.0	9.0	7.0	8.0	9.0	9.5	11.3	11.0	13.0	12.7	10.8	10.5
79	11.0	9.7	10.5	10.0	10.5	11.5	10.3	8.7	10.0	14.3	10.8	9.0
81	13.0	10.7	12.5	15.5	9.0	12.0	11.0	11.0	10.3	13.3	12.0	13.0
83	13.0	13.7	14.8	17.0	11.5	12.0	11.0	14.3	11.3	10.7	12.5	14.5
85	11.7	19.0	18.0	14.0	12.0	12.0	12.0	14.0	13.3	12.3	13.8	14.0
Initial Temp., °C.	6.3	6.0	6.3	6.7	4.0	4.8	6.5	4.8	3.3	3.7	3.7	3.8

Table 9. (cont.)

Temp. °C.	ROASTS Jr	Jl	Kr	Kl	Lr	Ll	Mr	Ml	Nr	Nl	Or	Ol
25	24.3	24.8	28.5	28.0	24.0	22.7	26.8	23.6	22.6	20.8	22.8	20.2
30	4.2	4.7	5.5	5.0	4.7	4.7	4.0	4.0	4.0	3.8	3.6	3.7
35	4.8	4.8	5.0	5.5	4.5	4.5	4.2	4.2	4.0	4.2	4.0	3.7
40	5.2	4.8	5.2	5.0	4.3	4.5	4.6	4.6	4.0	4.2	4.4	3.4
45	5.0	5.0	5.5	6.0	5.3	5.0	5.0	4.8	4.8	5.0	4.6	4.2
50	5.5	5.7	6.7	6.5	5.7	5.7	5.0	5.4	4.8	5.2	4.8	4.5
55	7.5	6.7	7.3	7.2	6.0	5.8	6.7	5.8	5.8	6.5	6.0	5.7
57	3.0	3.3	3.4	4.0	2.8	3.2	3.4	3.4	3.8	3.0	3.3	2.3
59	3.5	3.3	3.6	3.3	3.0	3.0	2.8	3.2	3.5	3.0	3.3	3.3
61	3.5	3.0	4.4	4.0	3.0	3.2	3.4	4.0	4.0	3.5	3.5	3.3
63	3.5	3.8	4.2	4.0	3.2	3.8	4.4	3.6	3.8	4.5	3.0	4.0
65	4.5	3.5	4.6	4.3	4.0	3.6	4.2	4.8	5.0	4.0	4.5	4.8
67	5.0	4.3	5.6	6.0	4.2	4.4	5.4	4.0	5.0	6.0	4.5	5.0
69	6.0	4.8	5.6	5.0	4.2	4.6	4.2	6.0	5.3	4.5	5.3	6.3
70	3.0	2.0	4.0	3.0		2.8	3.0	2.0	3.8	5.0		4.5
71	6.0	5.0	7.7		4.6		5.0	5.5		8.0	6.3	5.5
73	7.0	6.0	9.7		5.4		8.0	8.3		9.0	6.5	7.0
75	12.0	7.7	11.0		6.8		9.0	7.8		9.0	8.5	10.0
77	10.0	8.3	14.3		9.8		8.0	10.0		10.0	11.0	20.5
79	10.0	8.3	10.3		10.4		10.0	10.3		11.0	11.8	16.5
81	13.0	8.0	11.0		10.8		11.0	18.3		14.0	12.3	12.5
83	11.0	9.7	11.7		11.0		14.0	17.5		16.0	12.8	12.5
85	11.0	9.0	9.3		11.6		18.0	13.5		21.0	14.5	9.0
Initial Temp., °C.	8.2	6.7	6.5	8.2	7.0	8.0	4.8	4.7	5.8	6.2	6.7	7.0

Table 9. (concl.)

Temp. °C.	ROASTS Tr	Tl	Ur	Ul	Vr	Vl
25	20.3	18.5	22.8	22.5	24.0	22.3
30	3.7	4.0	4.2	4.0	4.2	4.7
35	4.3	3.7	4.5	4.2	4.7	4.2
40	4.0	4.5	4.5	4.5	5.3	4.7
45	4.8	4.2	5.3	5.3	5.5	5.5
50	5.2	5.0	5.5	5.3	5.7	5.0
55	5.7	6.2	6.5	6.5	7.0	6.5
57	3.0	2.3	2.8	3.0	2.8	3.8
59	3.0	2.7	3.2	3.5	3.2	3.8
61	3.0	3.3	3.4	3.8	3.8	3.5
63	3.3	3.3	3.4	4.0	4.0	4.3
65	3.7	3.7	3.8	4.5	3.6	5.0
67	3.7	3.3	4.2	5.0	4.8	4.8
69	4.0	4.3	5.2	5.3	4.8	5.8
70	3.0	3.0	2.0	3.3	3.0	3.0
71	5.5	4.5	5.3	6.0	6.0	5.0
73	4.5	5.5	7.0	6.0	6.0	6.7
75	5.5	7.0	8.3	6.0	9.0	10.0
77	7.5	10.5	9.7	6.0	9.0	8.7
79	10.0	11.0	11.0	10.0	14.0	11.3
81	8.0	17.5	11.7	12.0	14.0	17.7
83	10.0	17.5	10.3	15.0	16.0	14.0
85	14.0	12.0	13.3	25.0	22.0	18.0
Initial Temp., °C.	8.0	7.8	6.8	6.3	6.5	7.0

1 For description of abbreviations used in this table see Appendix, pg. 84.

Table 10. Significance of mean squares showing differences attributable to muscles and animals for roasts from the adductor, rectus femoris, vastus lateralus, semimembranosus (posterior) and semimembranosus (anterior).

Factors	SOURCE OF VARIATION		
	Muscle	Animal	Muscle x Animal
D/F	4	5	20
Aroma scores	ns	***	**
Flavor scores	ns	**	ns
Tenderness scores	ns	*	ns
Tenderness pref.	ns	**	ns
Shear force values	ns	ns	ns
Juiciness scores	ns	ns	ns
Juiciness pref.	ns	ns	ns
Press fluid yields	ns	*	*
Total ckg. losses	ns	ns	ns
Volat. ckg. losses	ns	ns	ns
Drip. ckg. losses	ns	ns	ns
Cooking time	ns	ns	ns

ns - Non-significant.
* - Significant at the five percent level.
** - Significant at the one percent level.
*** - Significant at the one-tenth percent level.

Table 11. Summary of the t-test analyses for the psoas major, adductor and rectus femoris muscles cooked to two internal temperatures.

Factors	Psoas major	Adductor	Rectus femoris
Aroma scores	2.92 *	7.40 ***	8.28 ***
Flavor scores	2.76 *	1.35 ns	3.19 **
Tenderness scores	0.84 ns	1.73 ns	2.79 *
Tenderness pref.	2.33 *	1.65 ns	3.29 **
Shear force values	5.24 ***	2.93 *	0.56 ns
Juiciness scores	4.00 **	11.53 ***	9.69 ***
Juiciness pref.	3.18 **	9.59 ***	8.89 ***
Press fluid yields	2.03 ns	5.21 ***	4.58 ***
Total ckg. losses	16.09 ***	22.47 ***	12.68 ***
Volat. ckg. losses	17.62 ***	22.59 ***	12.70 ***
Drip. ckg. losses	2.48 *	4.44 **	0.98 ns
Cooking time	15.00 ***	11.64 ***	9.85 ***

ns - Non-significant.
* - Significant at the five percent level.
** - Significant at the one percent level.
*** - Significant at the one-tenth percent level.

Table 12. Summary of the t-test analyses for the vastus lateralus, semimembranosus (posterior) and semimembranosus (anterior) muscles cooked to two internal temperatures.

Factors	Vastus lateralus	Semimembranosus (post.)	Semimembranosus (ant.)
Aroma scores	8.53 ***	9.62 ***	8.87 ***
Flavor scores	1.31 ns	0.62 ns	1.35 ns
Tenderness scores	1.82 ns	0.10 ns	1.05 ns
Tenderness pref.	0.89 ns	0.28 ns	1.42 ns
Shear force values	0.08 ns	0.31 ns	1.59 ns
Juiciness scores	11.00 ***	14.23 ***	14.33 ***
Juiciness pref.	8.60 ***	18.80 ***	11.26 ***
Press fluid yields	4.53 ***	3.48 **	4.98 ***
Total ckg. losses	11.62 ***	9.78 ***	17.64 ***
Volat. ckg. losses	14.18 ***	9.90 ***	19.18 ***
Drip. ckg. losses	4.53 ***	5.04 ***	2.50 *
Cooking time	9.63 ***	13.32 ***	4.41 ***

ns - Non- significant.
* - Significant at the five percent level.
** - Significant at the one percent level.
*** - Significant at the one-tenth percent level.

Table 13. Summary of analyses of variance results of roasts from muscles cooked to three internal temperatures.

Factors	Semitendinosus	Longissimus dorsi (loin)	Longissimus dorsi (rib)
Aroma scores	***	***	***
Flavor scores	***	*	***
Tenderness scores	ns	**	*
Tenderness pref.	ns	*	**
Shear force values	***	ns	ns
Juiciness scores	***	***	***
Juiciness pref.	***	***	***
Press fluid yields	***	***	***
Total ckg. losses	***	***	***
Volat. ckg. losses	***	***	***
Drip. ckg. losses	**	ns	**
Cooking time	***	***	***

ns - Non-significant.
* - Significant at the five percent level.
** - Significant at the one percent level.
*** - Significant at the one-tenth percent level.

Table 14. Summary of mean squares and significance for aroma, flavor and tenderness factors for roasts cooked to three internal temperatures.

Source of Variation	D/F	Aroma scores	Flavor scores	Tenderness scores	Tenderness pref.	Shear force values
Semitendinosus						
Block, unadjusted	17	0.24 **	0.10 ns	0.12 ns	0.10 ns	66.67 *
Temp., adjusted	2	2.76 ***	0.87 ***	0.05 ns	0.76 ns	281.34 ***
Error	16	0.05	0.05	0.07	0.51	22.80
Total	35					
Longissimus dorsi (loin)						
Block, unadjusted	17	0.39 ***	0.16 ns	0.12 **	0.43 ns	11.58 *
Temp., adjusted	2	4.02 ***	0.50 *	0.20 **	2.32 *	11.99 ns
Error	16	0.04	0.09	0.03	0.48	3.96
Total	35					
Longissimus dorsi (rib)						
Block, unadjusted	17	0.33 ***	0.24 **	0.09 ns	0.46 ns	25.17 *
Temp., adjusted	2	3.55 ***	0.60 ***	0.39 *	3.54 **	11.30 ns
Error	16	0.05	0.05	0.08	0.48	10.45
Total	35					

ns - Non-significant.
* - Significant at the five percent level.
** - Significant at the one percent level.
*** - Significant at the one-tenth percent level.

Table 15. Summary of mean squares and significance for juiciness scores and preference and press fluid yields for roasts cooked to three internal temperatures.

Source of Variation	D/F	Juiciness scores	Juiciness pref.	Press fluid yields
Semitendinosus				
Block, unadjusted	17	0.58 **	0.63 ns	0.46 ns
Temp., adjusted	2	15.31 ***	22.44 ***	10.54 ***
Error	16	0.14	0.34	0.28
Total	35			
Longissimus dorsi (loin)				
Block, unadjusted	17	1.07 ***	0.71 **	1.55 *
Temp., adjusted	2	24.00 ***	16.66 ***	21.55 ***
Error	16	0.16	0.21	0.43
Total	35			
Longissimus dorsi (rib)				
Block, unadjusted	17	0.90 ***	0.74 **	1.70 ***
Temp., adjusted	2	18.22 ***	17.65 ***	19.64 ***
Error	16	0.16	0.17	0.32
Total	35			

ns - Non-significant
* - Significant at the five percent level.
** - Significant at the one percent level.
*** - Significant at the one-tenth percent level.

Table 16. Summary of mean squares and significance for cooking losses and cooking time for roasts cooked to three internal temperatures.

Source of Variation	D/F	Cooking losses percent	Volatile losses percent	Dripping losses percent	Cooking time min./lb.
Semitendinosus					
Block, unadjusted	17	48.87 ***	45.79 ***	0.47 ns	954.33 ***
Temp., adjusted	2	1177.58 ***	1138.03 ***	2.25 **	18198.66 ***
Error	16	2.38	1.71	0.33	93.04
Total	35				
Longissimus dorsi (loin)					
Block, unadjusted	17	65.75 ***	63.19 ***	0.29 ns	701.63 ***
Temp., adjusted	2	1565.67 ***	1570.48 ***	0.46 ns	19585.90 ***
Error	16	2.90	1.81	0.21	65.51
Total	35				
Longissimus dorsi (rib)					
Block, unadjusted	17	60.43 ***	58.68 ***	0.22 *	936.94 ***
Temp., adjusted	2	1451.67 ***	1396.65 ***	0.64 **	19410.49 ***
Error	16	3.10	3.59	0.08	88.34
Total	35				

ns - Non-significant.
* - Significant at the five percent level.
** - Significant at the one percent level.
*** - Significant at the one-tenth percent level.

Table 17. Mean values for factors related to aroma, flavor and tenderness.[1]

Muscle	Int. temp. °C.	Animal number	Code	Aroma scores	Flavor scores	Tenderness scores	Chews	Tenderness pref.	Shear force values
Psoas major	55	III	Al	7.7	8.0	9.0	20.8	2.6	14.3
			Br	7.7	7.8	9.3	18.5	2.3	12.6
		VI	Al	7.8	8.4	9.6	17.7	2.3	15.1
			Br	7.9	8.6	9.4	17.7	2.1	12.1
		VII	Ar	7.5	8.0	9.5	17.6	2.3	13.7
			Br	7.9	8.3	9.4	19.3	2.7	15.4
		VIII	Ar	7.0	7.9	9.5	18.8	2.6	15.9
			Br	7.0	7.9	9.5	17.4	1.8	13.5
		X	Al	7.0	8.1	9.1	21.6	2.3	15.6
			Br	7.3	8.3	9.0	22.5	2.5	20.7
		XII	Ar	7.4	8.1	9.5	18.5	2.6	14.4
			Br	7.3	8.1	9.6	18.1	2.4	14.1
Av.				7.46	8.12	9.37	19.04	2.38	14.78
	70	III	Ar	7.6	8.0	9.5	16.6	2.5	12.6
			Bl	7.9	8.0	9.3	20.4	2.6	11.3
		VI	Ar	8.3	9.0	9.3	18.9	2.7	13.2
			Bl	8.5	9.0	9.4	18.6	2.6	11.1
		VII	Al	7.8	8.6	9.3	20.4	2.6	12.1
			Bl	8.1	8.9	9.5	18.3	2.4	11.2
		VIII	Al	7.4	7.9	9.3	21.4	2.8	12.2
			Bl	7.1	8.4	9.4	19.6	2.8	12.3
		X	Ar	7.3	8.3	9.0	22.5	2.4	13.4
			Bl	7.1	8.0	9.0	23.0	2.9	13.9
		XII	Al	7.5	8.3	9.4	19.1	2.4	12.6
			Bl	7.3	8.0	9.4	19.5	2.6	10.2
Av.				7.66	8.37	9.32	19.86	2.61	12.18

Table 17. (cont.)

Muscle	Int. temp. °C.	Animal number	Code	Aroma scores	Flavor scores	Tenderness scores	Chews	Tenderness pref.	Shear force values
Adductor	70	III	Cl	7.7	8.8	8.7	22.8	2.3	16.5
			Dl	7.8	8.5	8.9	21.2	2.2	15.5
		VI	Cl	8.0	8.3	8.0	30.8	1.9	19.1
			Dl	7.6	7.8	7.8	32.4	2.8	33.9
		VII	Cr	7.9	7.7	7.9	29.8	2.4	18.8
			Dl	7.9	7.8	7.9	30.4	2.8	18.0
		VIII	Cl	7.3	7.3	7.3	37.6	2.2	22.2
			Dr	7.0	7.3	7.5	34.5	1.7	24.2
		X	Cl	7.7	7.7	8.7	24.7	2.3	18.7
			Dl	7.7	7.6	8.1	30.3	2.3	21.3
		XII	Cr	8.1	7.5	8.3	32.8	2.3	17.3
			Dr	8.0	7.6	7.9	37.3	2.9	19.7
Av.				7.73	7.82	8.08	30.38	2.34	20.43
	85	III	Cr	8.2	7.9	8.8	21.7	2.5	14.0
			Dr	8.2	7.5	8.4	26.1	3.1	19.4
		VI	Cr	8.4	8.8	8.3	27.8	1.9	25.1
			Dr	8.3	7.9	7.5	36.0	3.4	32.3
		VII	Cl	8.8	8.0	7.9	29.8	2.5	25.4
			Dr	8.7	7.7	8.0	29.2	2.3	21.0
		VIII	Cr	9.0	7.4	7.3	37.5	2.7	26.1
			Dl	8.6	7.8	6.5	38.5	3.2	41.2
		X	Cr	9.0	8.7	8.4	27.3	2.1	19.6
			Dr	8.9	8.4	7.7	31.9	3.3	23.4
		XII	Cl	8.9	8.5	8.1	33.8	2.7	23.9
			Dl	8.9	8.4	8.1	30.6	2.1	24.4
Av.				8.66	8.08	7.92	30.85	2.65	24.65

Table 17. (cont.)

Muscle	Int. temp. °C.	Animal number	Code	Aroma scores	Flavor scores	Tenderness scores	Chews	Tenderness pref.	Shear force values
Rectus femoris	70	III	Er	8.4	8.5	9.1	22.9	1.6	15.7
			Fl	8.1	8.4	8.4	27.3	2.6	19.1
		VI	El	8.1	8.1	8.4	28.2	2.6	18.7
			Fl	8.3	8.4	8.4	27.4	2.2	20.9
		VII	Er	7.6	8.3	8.8	25.3	2.7	10.1
			Fl	7.6	8.3	8.9	23.2	1.9	17.2
		VIII	El	7.5	7.6	8.1	32.0	2.4	27.7
			Fl	7.4	7.6	8.0	31.9	2.1	16.2
		X	El	7.3	7.3	9.0	23.0	1.4	12.8
			Fr	7.4	7.6	8.4	29.1	2.8	19.2
		XII	El	8.0	8.3	8.4	27.3	2.7	9.8
			Fr	7.7	7.9	8.3	30.3	2.1	19.4
Av.				7.78	8.02	8.52	27.32	2.26	17.23
	85	III	El	8.9	8.9	8.9	24.4	2.3	13.8
			Fr	8.9	8.5	7.9	28.5	3.5	12.8
		VI	Er	8.6	8.7	8.6	26.2	2.1	18.5
			Fr	8.8	8.8	8.2	29.0	3.2	20.3
		VII	El	9.0	8.6	8.7	22.8	2.5	10.5
			Fr	9.0	8.6	8.8	23.2	2.8	15.0
		VIII	Er	8.3	8.5	7.6	34.3	3.3	29.4
			Fr	8.8	7.9	8.0	31.9	2.2	14.2
		X	Er	8.4	8.3	8.8	27.0	2.8	17.5
			Fl	8.0	7.8	8.5	29.4	2.9	16.0
		XII	Er	8.5	7.7	7.7	34.7	3.1	23.0
			Fl	8.9	8.7	8.0	30.7	2.8	25.8
Av.				8.68	8.42	8.31	28.51	2.79	18.07

Table 17. (cont.)

Muscle	Int. temp. °C.	Animal number	Code	Aroma scores	Flavor scores	Tenderness scores	Chews	Tenderness pref.	Shear force values
Vastus lateralus	70	III	Gr	8.3	8.5	8.2	27.9	2.4	17.8
			Hl	8.2	8.2	8.1	26.0	2.4	14.9
		VI	Gr	7.3	8.1	7.4	36.9	2.4	19.6
			Hl	7.0	8.4	7.5	35.9	2.1	22.6
		VII	Gl	8.1	8.3	8.1	28.3	2.7	16.0
			Hl	7.9	8.2	8.0	28.8	2.9	16.9
		VIII	Gr	7.4	7.8	7.7	32.7	2.1	27.7
			Hr	7.0	7.8	7.7	34.9	2.4	24.6
		X	Gl	7.4	7.9	8.1	30.6	1.9	17.0
			Hl	7.3	7.5	8.0	32.9	2.3	20.0
		XII	Gl	7.3	7.9	7.5	37.4	2.5	16.9
			Hr	7.1	7.8	7.5	37.3	3.0	21.1
Av.				7.52	8.03	7.82	32.63	2.42	19.59
	35	III	Gl	8.4	8.4	8.2	27.7	2.8	17.8
			Hr	8.8	8.8	8.5	26.9	2.5	14.0
		VI	Gl	8.7	7.8	7.4	36.3	2.8	24.3
			Hr	8.3	8.3	7.6	34.9	2.6	23.6
		VII	Gr	8.7	8.3	8.6	25.0	2.4	14.9
			Hr	9.0	8.8	8.8	22.3	1.9	15.3
		VIII	Gl	8.1	7.6	7.9	34.9	2.6	28.9
			Hl	8.1	7.8	7.6	35.7	3.0	20.6
		X	Gr	8.5	8.5	8.1	28.5	2.2	18.1
			Hr	8.3	8.3	7.4	36.5	3.6	19.2
		XII	Gr	8.6	8.1	8.3	29.5	2.3	17.4
			Hl	8.5	7.5	7.9	33.4	2.3	20.4
Av.				8.50	8.18	8.02	30.97	2.58	19.54

Table 17. (cont.)

Muscle	Int. temp. °C.	Animal number	Code	Aroma scores	Flavor scores	Tenderness scores	Chews	Tenderness pref.	Shear force values
Semimembranosus (posterior)	70	III	Pr	7.9	8.0	8.4	26.6	2.1	11.9
			Qr	7.6	8.0	7.5	34.5	2.5	30.7
		VI	Pl	7.9	8.3	7.4	35.8	2.7	20.9
			Ql	8.0	8.6	7.4	35.6	2.9	31.4
		VII	Pr	8.1	8.0	7.9	31.9	2.6	16.9
			Qr	8.1	8.1	7.9	31.4	2.6	28.0
		VIII	Pl	7.6	8.0	7.1	33.3	2.3	21.0
			Ql	7.4	7.9	7.8	33.3	2.1	38.0
		X	Pl	7.9	7.9	8.1	30.8	2.2	20.2
			Qr	7.6	8.0	7.9	33.3	2.1	22.1
		XII	Pl	7.5	7.9	8.4	29.8	2.9	18.1
			Ql	7.4	7.6	8.0	32.0	2.8	32.7
Av.				7.75	8.02	7.82	32.36	2.48	24.32
	85	III	Pl	8.3	7.5	8.4	27.3	2.0	16.0
			Ql	8.7	8.1	7.5	33.6	3.4	24.8
		VI	Pr	9.0	8.7	7.9	31.8	1.6	21.0
			Qr	8.6	7.9	7.4	35.7	2.8	26.4
		VII	Pl	8.6	7.9	7.7	32.6	3.1	27.7
			Ql	8.9	7.9	8.2	28.6	1.8	17.4
		VIII	Pr	8.5	7.9	7.4	32.7	2.6	17.7
			Qr	8.9	8.1	7.0	38.0	3.1	31.6
		X	Pr	8.5	7.9	7.8	33.7	2.7	28.2
			Ql	8.4	8.1	7.6	35.3	3.1	26.9
		XII	Pr	8.4	7.9	8.4	28.5	2.2	17.7
			Qr	8.4	8.1	8.4	29.9	2.1	29.7
Av.				8.60	8.00	7.81	32.31	2.54	23.76

Table 17. (cont.)

Muscle	Int. temp. °C.	Animal number	Code	Aroma scores	Flavor scores	Tenderness scores	Chews	Tenderness pref.	Shear force values
Semimembranosus (anterior)	70	III	Rl	7.5	7.7	8.1	30.1	1.7	17.7
			Sr	7.5	7.6	7.7	33.8	2.8	22.7
		VI	Rr	8.1	7.7	7.4	34.8	2.2	24.0
			Sl	8.0	8.0	7.8	33.7	2.3	34.4
		VII	Rr	7.7	7.6	7.9	32.4	2.9	21.3
			Sl	7.9	8.0	8.1	31.3	2.8	23.2
		VIII	Rl	7.8	7.8	8.0	30.3	2.9	23.5
			Sr	7.5	7.5	8.5	27.0	1.9	29.5
		X	Rl	7.9	7.5	7.9	33.1	1.6	20.7
			Sl	8.1	7.4	7.8	33.6	1.9	29.3
		XII	Rr	7.7	7.7	7.7	34.7	2.4	18.2
			Sl	7.9	7.7	7.7	36.7	2.4	24.3
Av.				7.80	7.68	7.88	32.62	2.32	24.07
	85	III	Rr	8.0	7.2	7.8	32.7	2.7	16.4
			Sl	8.3	7.6	7.4	35.9	2.8	25.7
		VI	Rl	8.8	7.7	7.6	34.1	2.4	28.0
			Sr	8.4	7.3	7.3	37.3	3.2	34.5
		VII	Rl	8.6	8.0	8.0	31.1	2.3	23.1
			Sr	8.6	8.0	8.3	29.3	2.0	25.9
		VIII	Rr	9.1	8.0	8.8	25.9	1.8	29.2
			Sl	8.8	8.3	7.4	34.8	3.4	39.3
		X	Rr	8.9	7.9	6.9	42.0	3.0	27.3
			Sr	8.6	7.9	7.1	37.0	3.5	20.6
		XII	Rl	9.1	8.0	8.3	30.7	2.3	15.5
			Sr	9.1	8.3	7.6	35.0	2.9	30.7
Av.				8.69	7.85	7.71	33.82	2.69	26.35

Table 17. (cont.)

Muscle	Int. temp. °C.	Animal number	Code	Aroma scores	Flavor scores	Tender-ness scores	Chews	Tender-ness pref.	Shear force values
Semitendinosus	55	III	Jr	7.5	7.8	8.5	27.3	3.3	18.2
			Kr	7.8	7.7	8.5	28.0	2.7	18.2
		VI	Jl	6.9	7.8	8.3	27.3	2.8	34.3
			Ll	6.9	7.8	8.5	26.8	3.1	29.1
		VII	Jr	7.6	7.6	8.4	25.7	3.6	33.9
			Kl	7.4	8.0	8.6	25.4	3.6	17.9
		VIII	Jl	7.7	7.3	8.3	28.8	3.7	27.5
			Lr	7.4	7.6	8.2	29.1	3.7	33.6
		X	Jr	7.8	8.0	8.6	27.4	3.4	49.6
			Kl	8.0	8.0	8.4	28.3	3.3	39.8
		XII	Jr	7.2	8.2	9.0	23.2	3.3	36.0
			Kl	7.8	8.4	8.8	23.8	3.4	31.7
Av.				7.50	7.85	8.51	26.76	3.32	30.82
	70	III	Kl	8.3	8.0	8.0	30.8	4.8	17.2
			Ll	7.8	7.8	8.7	27.0	2.2	20.7
		VI	Jr	6.9	8.3	7.9	28.9	4.3	24.9
			Kl	7.4	7.9	8.3	28.1	3.8	21.1
		VII	Jl	7.8	8.2	8.3	27.1	4.2	22.3
			Ll	7.8	8.2	8.3	27.2	4.2	17.1
		VIII	Kl	7.8	8.2	8.6	28.8	2.9	18.8
			Ll	7.9	8.1	8.6	28.1	3.1	24.2
		X	Kr	8.2	8.1	8.3	27.2	3.3	23.8
			Ll	8.0	7.9	8.2	28.6	3.6	18.4
		XII	Kr	8.0	8.4	8.8	24.8	3.8	17.6
			Ll	8.0	8.2	9.2	22.2	2.8	17.7
Av.				7.82	8.11	8.43	27.40	3.58	20.32

Table 17. (cont.)

Muscle	Int. temp. °C.	Animal number	Code	Aroma scores	Flavor scores	Tenderness scores	Chews	Tenderness pref.	Shear force values
Semitendinosus	85	III	Jl	8.8	8.7	8.2	29.8	4.1	16.6
			Lr	8.7	8.8	8.3	29.0	4.1	18.5
		VI	Kr	8.5	8.3	8.4	27.4	3.3	20.8
			Lr	8.3	8.5	8.3	28.9	3.8	23.6
		VII	Kr	8.4	8.9	8.9	23.0	2.7	17.4
			Lr	8.2	8.7	9.0	22.1	2.8	16.8
		VIII	Jr	8.6	8.1	8.4	28.6	3.6	23.9
			Kr	8.3	8.2	8.0	30.1	4.0	22.2
		X	Jl	8.2	8.0	8.1	30.6	4.4	21.4
			Lr	8.6	8.0	8.4	27.6	2.9	19.1
		XII	Jl	8.8	8.4	8.8	23.4	3.8	20.9
			Lr	9.0	8.4	8.8	23.6	3.9	18.9
Av.				8.53	8.42	8.47	27.01	3.62	20.01
Longissimus dorsi (loin)	55	III	Nl	7.9	8.1	9.3	20.1	1.9	10.6
			Or	7.9	7.9	9.1	22.4	3.2	10.9
		VI	Nl	7.3	8.0	8.9	23.6	2.8	18.3
			Ol	7.3	7.9	8.8	23.8	2.9	12.1
		VII	Ml	7.5	7.9	9.0	21.9	2.8	15.0
			Nr	7.6	7.8	9.0	21.8	2.7	13.4
		VIII	Nl	7.0	7.8	8.6	25.5	1.7	18.4
			Ol	6.5	7.8	8.6	27.8	3.4	14.2
		X	Mr	7.5	7.4	8.6	28.4	3.5	12.2
			Nr	7.6	8.0	8.6	28.6	3.3	18.5
		XII	Nl	7.5	7.8	8.8	23.7	3.9	15.6
			Or	7.5	8.0	9.0	20.7	2.6	12.8
Av.				7.42	7.87	8.86	24.02	2.89	14.33

Table 17. (cont.)

Muscle	Int. temp. °C.	Animal number	Code	Aroma scores	Flavor scores	Tenderness scores	Chews	Tenderness pref.	Shear force values
Longissimus dorsi (loin)	70	III	Mr	8.6	8.9	8.7	25.6	4.4	12.4
			Nr	8.7	8.9	8.9	22.7	4.3	11.4
		VI	Mr	7.7	8.3	8.8	24.8	3.1	13.1
			Nr	7.7	8.3	8.7	25.0	3.4	16.1
		VII	Mr	8.4	8.4	9.0	23.1	3.2	12.1
			Ol	8.1	8.3	8.6	25.9	4.4	16.4
		VIII	Mr	7.1	8.0	8.5	27.8	2.7	21.7
			Nr	7.4	7.1	8.0	32.4	4.1	10.3
		X	Nl	7.8	8.0	8.5	28.8	3.9	13.5
			Ol	7.9	8.3	8.6	26.8	2.7	13.4
		XII	Ml	7.8	8.2	8.7	24.5	4.1	14.7
			Nr	8.0	8.2	8.5	24.7	4.3	13.1
Av.				7.93	8.24	8.62	26.01	3.72	14.02
	85	III	Ml	9.0	8.4	9.0	22.0	3.7	11.7
			Ol	8.9	8.7	9.0	22.0	3.6	11.2
		VI	Ml	8.7	8.3	8.6	26.1	4.2	12.7
			Or	8.4	8.2	8.3	28.9	4.2	14.2
		VII	Nl	9.4	8.6	8.8	24.3	3.5	16.6
			Or	9.1	8.3	8.6	26.3	4.5	17.9
		VIII	Ml	7.9	7.5	8.0	32.1	5.0	20.2
			Or	8.3	8.0	8.1	32.1	4.1	17.1
		X	Ml	8.8	8.4	8.6	28.8	3.7	16.4
			Or	8.4	8.3	8.5	29.3	3.9	17.6
		XII	Mr	8.8	8.5	8.8	21.7	3.3	15.0
			Ol	8.5	8.5	8.8	22.5	2.8	13.3
Av.				8.68	8.31	8.59	26.34	3.88	15.32

Table 17. (cont.)

Muscle	Int. temp. °C.	Animal number	Code	Aroma scores	Flavor scores	Tenderness scores	Chews	Tenderness pref.	Shear force values
Longissimus dorsi (rib)	55	III	Tl	7.4	8.0	9.0	22.0	3.4	15.4
			Ur	7.5	8.3	9.1	20.0	2.6	7.6
		VI	Tr	7.6	7.6	9.0	23.4	2.6	17.8
			Vl	7.6	8.0	9.0	19.7	2.5	13.7
		VII	Tl	8.4	8.6	9.1	22.1	3.3	14.8
			Ul	8.1	8.5	9.3	21.0	2.7	14.2
		VIII	Tr	7.8	7.9	9.3	21.2	1.9	13.1
			Ul	7.7	7.8	9.2	23.3	2.5	14.6
		X	Tl	7.1	8.1	9.0	23.5	2.6	18.0
			Vl	7.3	8.0	9.0	23.8	3.3	20.1
		XII	Tr	7.4	7.6	8.7	25.7	3.8	17.0
			Vr	7.4	7.7	8.9	23.9	3.1	14.1
Av.				7.61	8.01	9.05	22.47	2.86	15.03
	70	III	Ul	8.2	8.9	9.1	19.7	2.7	9.8
			Vr	7.8	8.6	8.7	23.1	4.5	11.8
		VI	Ul	8.3	8.3	8.9	24.3	2.7	14.8
			Vr	7.9	8.4	8.4	27.3	4.6	13.2
		VII	Ur	8.3	8.8	8.9	24.6	4.3	11.0
			Vr	8.3	8.9	9.1	21.5	3.6	11.5
		VIII	Tl	7.9	8.1	8.9	24.4	3.6	18.5
			Vr	8.0	8.1	8.9	24.9	3.2	19.8
		X	Tr	7.5	7.9	8.5	27.0	3.2	21.1
			Ur	7.5	8.4	8.8	24.9	4.1	15.7
		XII	Ul	8.4	8.6	9.0	23.3	2.7	13.9
			Vl	7.9	8.2	9.0	24.0	3.3	11.3
Av.				8.00	8.43	8.85	24.08	3.54	14.37

Table 17. (concl.)

Muscle	Int. temp. °C.	Animal number	Code	Aroma scores	Flavor scores	Tender-ness scores	Chews	Tender-ness pref.	Shear force values
Longissimus dorsi (rib)	85	III	Tr	9.0	8.6	8.8	22.2	4.1	12.1
			Vl	9.1	8.6	8.8	22.8	3.7	9.9
		VI	Tl	8.9	8.6	8.4	29.4	4.3	23.8
			Ur	9.0	8.4	8.4	28.1	4.4	20.5
		VII	Tr	9.1	9.0	8.8	23.3	4.3	15.4
			Vl	9.4	9.3	9.4	20.3	2.9	11.3
		VIII	Ur	8.6	7.9	8.1	28.1	4.7	26.0
			Vl	8.3	8.1	8.0	30.4	5.2	19.8
		X	Ul	8.8	8.5	8.5	27.6	4.6	19.2
			Vr	8.8	8.1	8.9	25.5	3.3	12.8
		XII	Tl	8.7	8.7	8.9	23.9	4.2	20.1
			Ur	8.9	8.7	8.8	25.8	3.9	19.3
Av.				8.88	8.54	8.65	25.62	4.13	17.52

1 For description of abbreviations used in this table see Appendix, pg. 84.

Table 18. Mean values for factors related to juiciness and cooking losses.[1]

Muscle	Int. temp. °C.	Animal number	Code	Juiciness scores	Juiciness pref.	Press fluid ml/25g.	Ckg. losses pct	Volat. losses pct	Drip. losses pct
Psoas major	55	III	Al	9.1	2.5	8.6	8.8	7.5	0.9
			Br	9.1	2.5	8.7	7.7	6.7	0.7
		VI	Al	9.2	2.1	8.8	6.3	5.9	0.8
			Br	9.2	2.1	7.8	6.9	6.7	0.3
		VII	Ar	9.3	2.1	10.0	8.7	8.0	1.5
			Br	9.6	1.9	9.5	8.0	7.1	0.7
		VIII	Ar	9.4	2.7	9.6	8.6	7.6	0.8
			Br	9.6	2.4	9.5	8.0	7.7	0.3
		X	Al	9.5	2.1	9.3	10.4	9.2	1.2
			Br	9.6	1.9	8.9	9.8	8.5	1.0
		XII	Ar	8.5	2.5	9.9	9.2	8.3	0.9
			Br	8.8	2.3	8.6	8.6	8.1	0.5
Av.				9.24	2.26	9.10	8.42	7.61	0.80
	70	III	Ar	8.9	2.6	8.0	13.6	12.3	1.1
			Bl	9.1	2.4	9.3	14.8	13.2	1.1
		VI	Ar	8.9	2.8	9.0	13.5	12.4	0.7
			Bl	8.9	2.9	7.6	14.0	12.7	0.9
		VII	Al	9.0	3.1	10.5	15.3	14.6	1.0
			Bl	9.3	2.9	10.4	14.0	13.3	0.8
		VIII	Al	9.4	2.2	10.9	15.0	13.6	1.2
			Bl	9.1	2.7	9.7	13.3	12.3	0.8
		X	Ar	9.1	2.9	10.1	19.2	17.2	2.0
			Bl	8.9	3.1	8.4	15.6	13.7	1.8
		XII	Al	8.6	2.7	10.0	14.0	13.1	0.9
			Bl	8.6	2.5	9.4	12.6	12.0	0.6
Av.				8.98	2.73	9.44	14.58	13.37	1.08

Table 18. (cont.)

Muscle	Int. temp. °C.	Animal number	Code	Juiciness scores	Juiciness pref.	Press fluid ml/25g.	Ckg. losses pct	Volat. losses pct	Drip. losses pct
Adductor	70	III	Cl	8.0	1.7	8.3	18.4	16.1	2.2
			Dl	8.1	1.6	8.6	18.8	15.5	2.6
		VI	Cl	8.9	1.6	7.2	22.1	20.0	2.1
			Dl	8.6	1.6	8.7	19.9	17.5	2.1
		VII	Cr	7.9	1.6	8.0	20.6	17.2	3.5
			Dl	8.0	1.5	9.1	19.5	17.3	1.7
		VIII	Cl	8.6	1.8	8.2	23.7	19.6	4.2
			Dr	8.4	1.9	8.3	23.6	20.4	2.9
		X	Cl	8.1	2.1	8.4	22.4	19.2	3.1
			Dl	8.3	2.1	7.1	23.2	20.8	2.2
		XII	Cr	8.0	1.5	10.0	22.5	19.5	3.0
			Dr	7.5	2.1	8.7	23.9	20.2	3.7
Av.				8.20	1.76	8.38	21.55	18.61	2.78
	85	III	Cr	5.9	3.3	7.5	30.9	28.5	2.0
			Dr	5.9	3.5	6.1	36.5	34.1	2.1
		VI	Cr	6.6	2.9	6.7	32.8	31.1	1.8
			Dr	4.9	3.9	5.7	37.6	35.4	1.8
		VII	Cl	5.7	3.2	5.8	35.8	33.2	2.6
			Dr	5.2	3.8	6.5	35.5	34.3	1.0
		VIII	Cr	5.8	3.4	6.8	39.0	35.1	3.8
			Dl	6.6	2.6	7.8	36.4	34.0	2.4
		X	Cr	6.6	2.9	7.7	37.1	34.9	2.2
			Dr	6.7	2.9	7.1	37.1	35.2	1.9
		XII	Cl	6.4	2.9	7.5	34.1	32.5	1.4
			Dl	5.9	3.5	7.0	39.2	37.4	1.7
Av.				6.02	3.23	6.85	36.00	33.81	2.06

Table 18. (cont.)

Muscle	Int. temp. °C.	Animal number	Code	Juiciness scores	Juiciness pref.	Press fluid ml/25g.	Ckg. losses pct	Volat. losses pct	Drip. losses pct
Rectus femoris	70	III	Fr	8.8	2.2	8.7	21.1	17.3	4.1
			Fl	9.1	1.8	9.9	14.6	13.5	0.6
		VI	El	8.4	1.9	5.7	20.8	18.8	2.0
			Fl	8.4	1.9	7.2	16.2	14.8	1.6
		VII	Er	8.6	1.5	8.0	22.9	20.4	2.5
			Fl	8.8	1.5	8.6	16.6	15.4	1.2
		VIII	El	8.6	1.9	9.0	22.3	18.5	3.3
			Fl	8.9	1.8	8.6	21.7	18.6	3.2
		X	El	8.8	2.0	8.3	24.0	21.0	3.2
			Fr	8.6	2.1	9.6	17.5	16.0	1.1
		XII	El	8.0	2.1	8.6	25.9	24.1	1.8
			Fr	8.4	1.6	8.3	23.2	21.2	1.8
Av.				8.62	1.86	8.38	20.57	18.30	2.20
	85	III	El	6.6	3.6	5.2	40.4	39.3	1.4
			Fr	7.5	2.5	7.0	35.2	32.5	2.6
		VI	Er	7.3	3.2	5.0	35.3	33.4	1.8
			Fr	7.1	3.0	7.8	35.6	34.1	1.5
		VII	El	6.4	3.5	5.5	38.1	36.9	1.3
			Fr	5.7	3.5	6.4	37.6	36.3	1.3
		VIII	Er	7.1	2.9	7.1	37.9	35.9	2.1
			Fr	7.0	3.4	6.2	35.3	33.0	2.1
		X	Er	6.9	3.3	5.2	39.2	36.5	2.8
			Fl	7.5	2.6	7.5	33.1	30.9	2.3
		XII	Er	7.1	2.9	8.5	31.8	29.8	1.8
			Fl	6.7	3.5	8.1	34.5	33.2	1.3
Av.				6.91	3.16	6.62	36.18	34.32	1.86

Table 18. (cont.)

Muscle	Int. temp. °C.	Animal number	Code	Juiciness scores	Juiciness pref.	Press fluid ml/25g.	Ckg. losses pct	Volat. losses pct	Drip. losses pct
Vastus lateralus	70	III	Gr	8.9	1.5	8.0	17.8	15.2	2.6
			Hl	8.9	1.9	8.1	18.2	15.6	2.6
		VI	Gr	8.6	1.6	7.5	17.1	14.5	2.5
			Hl	8.9	1.8	7.4	15.8	14.0	2.0
		VII	Gl	8.7	1.9	8.0	19.4	16.6	2.7
			Hl	9.1	1.3	8.9	16.3	14.2	2.3
		VIII	Gr	7.7	2.1	7.9	26.1	20.5	5.5
			Hr	8.3	2.1	8.7	22.0	16.2	5.6
		X	Gl	8.6	2.0	8.4	22.9	19.5	3.5
			Hl	8.6	1.9	9.0	21.6	17.1	4.3
		XII	Gl	8.3	1.9	7.7	23.4	20.2	3.2
			Hr	8.9	1.9	9.5	18.1	15.3	2.8
Av.				8.62	1.82	8.26	19.89	16.58	3.30
	85	III	Gl	7.4	3.5	6.6	33.9	32.0	1.8
			Hr	7.5	3.3	7.1	34.0	31.8	2.1
		VI	Gl	5.9	3.6	7.6	35.5	33.7	1.9
			Hr	6.9	2.9	7.0	32.9	31.4	1.7
		VII	Gr	7.3	3.2	6.3	37.3	35.9	1.4
			Hr	6.3	3.6	6.4	37.6	36.3	1.5
		VIII	Gl	5.9	3.5	7.0	34.1	31.8	2.3
			Hl	6.4	2.4	6.1	37.7	35.0	2.4
		X	Gr	6.8	3.3	7.4	33.9	31.8	2.0
			Hr	7.5	2.8	7.9	32.8	30.6	2.2
		XII	Gr	6.8	2.8	7.9	33.3	31.2	2.1
			Hl	6.0	3.4	7.3	41.1	38.8	2.3
Av.				6.72	3.19	7.05	35.34	33.36	1.98

Table 18. (cont.)

Muscle	Int. temp. °C.	Animal number	Code	Juiciness scores	Juiciness pref.	Press fluid ml/25g.	Ckg. losses pct	Volat. losses pct	Drip. losses pct
Semimembranosus (posterior)	70	III	Pr	8.1	1.8	6.7	18.7	15.5	2.9
			Qr	8.4	1.9	8.1	20.3	16.7	3.2
		VI	Pl	8.6	1.8	8.3	15.9	14.2	1.6
			Ql	8.9	1.5	8.4	16.2	14.8	1.3
		VII	Pr	8.7	1.7	8.9	15.6	13.7	2.0
			Qr	8.8	1.7	8.5	17.9	15.8	2.3
		VIII	Pl	8.2	1.9	8.9	22.1	19.8	2.2
			Ql	8.6	1.7	9.1	23.4	21.0	2.2
		X	Pl	8.4	1.9	9.0	19.0	16.8	2.2
			Qr	8.6	1.7	9.0	17.8	15.3	2.6
		XII	Pl	8.5	1.6	8.9	17.3	15.3	1.9
			Ql	8.3	1.9	8.7	18.4	16.2	2.2
Av.				8.51	1.76	8.54	18.55	16.26	2.22
	85	III	Pl	5.8	3.6	8.7	33.0	30.5	2.4
			Ql	6.8	2.8	8.0	32.7	30.9	1.8
		VI	Pr	7.6	3.4	6.9	27.5	25.7	1.4
			Qr	7.6	3.3	7.2	31.6	30.0	1.4
		VII	Pl	6.2	3.6	6.3	37.2	35.8	1.2
			Ql	6.7	3.1	7.2	31.1	29.7	1.7
		VIII	Pr	6.1	3.2	7.7	22.9	20.7	1.9
			Qr	6.7	3.1	7.0	39.1	37.4	1.6
		X	Pr	6.7	3.2	7.6	34.1	32.3	1.6
			Ql	6.8	3.2	6.7	36.2	34.8	1.5
		XII	Pr	6.1	3.2	7.3	34.2	32.5	1.6
			Qr	5.9	3.3	7.5	36.2	34.6	1.4
Av.				6.58	3.25	7.34	32.98	31.24	1.62

Table 18. (cont.)

Muscle	Int. temp. °C.	Animal number	Code	Juiciness scores	Juiciness pref.	Press fluid ml/25g.	Ckg. losses pct	Volat. losses pct	Drip. losses pct
Semimembranosus (anterior)	70	III	Rl	8.8	1.6	7.2	20.0	17.4	2.6
			Sr	8.7	1.7	8.9	22.1	18.5	3.7
		VI	Rr	7.8	2.1	8.3	21.2	19.9	1.4
			Sl	7.9	1.6	7.5	19.4	18.4	1.2
		VII	Rr	7.9	2.2	9.1	19.0	17.9	1.4
			Sl	8.4	1.5	8.4	17.3	16.4	0.9
		VIII	Rl	7.8	1.8	9.6	21.3	18.8	2.5
			Sr	8.1	1.5	9.3	23.3	21.3	2.1
		X	Rl	7.9	1.8	8.5	22.0	18.7	3.2
			Sl	7.8	1.8	8.1	22.8	19.5	3.2
		XII	Rr	7.7	2.1	8.5	21.9	20.1	1.7
			Sl	8.1	1.7	9.2	22.9	19.4	3.4
Av.				8.08	1.78	8.55	21.10	18.86	2.28
	85	III	Rr	5.9	3.7	6.8	34.6	32.0	2.5
			Sl	6.6	3.1	9.0	38.4	36.4	2.1
		VI	Rl	6.7	2.7	7.4	32.0	30.7	1.5
			Sr	5.8	3.6	6.7	37.2	36.2	1.0
		VII	Rl	5.9	3.1	6.7	39.0	38.1	0.9
			Sr	6.7	3.1	6.8	35.4	33.8	1.7
		VIII	Rr	5.9	3.7	6.6	36.0	34.4	1.6
			Sl	6.4	3.1	8.1	45.0	42.9	1.8
		X	Rr	6.4	3.1	5.8	37.2	34.9	2.3
			Sr	6.1	3.4	7.7	34.2	32.3	1.7
		XII	Rl	5.3	3.4	6.7	37.4	35.6	1.8
			Sr	5.7	2.8	7.5	39.2	37.4	1.8
Av.				6.12	3.23	7.15	37.13	35.39	1.72

Table 18. (cont.)

Muscle	Int. temp. °C.	Animal number	Code	Juiciness scores	Juiciness pref.	Press fluid ml/25g.	Ckg. losses pct	Volat. losses pct.	Drip. losses pct
Semitendinosus	55	III	Jr	9.0	1.6	9.2	10.7	9.4	1.1
			Kr	9.2	2.2	9.4	11.1	9.5	1.1
		VI	Jl	9.0	2.1	9.9	9.5	8.9	0.8
			Ll	9.4	1.5	9.9	8.8	7.9	0.9
		VII	Jr	8.8	2.4	8.8	10.1	9.2	1.0
			Kl	9.0	2.0	9.5	10.6	9.8	0.8
		VIII	Jl	9.3	2.7	9.3	10.4	9.3	0.9
			Lr	9.3	2.5	9.2	9.5	8.6	0.7
		X	Jr	8.9	2.3	9.7	11.0	9.9	0.9
			Kl	8.9	2.3	8.9	13.3	11.3	1.9
		XII	Jr	9.2	2.6	9.4	12.5	11.0	1.5
			Kl	8.8	3.4	9.0	13.2	11.8	1.6
Av.				9.07	2.30	9.35	10.89	9.72	1.10
	70	III	Kl	8.7	2.8	9.8	20.6	17.9	2.4
			Ll	8.3	3.8	8.2	17.9	15.5	2.2
		VI	Jr	7.4	4.1	8.1	16.5	15.1	1.8
			Kl	8.3	2.8	8.5	15.8	14.8	1.0
		VII	Jl	8.6	2.9	9.0	14.8	13.5	1.3
			Ll	8.6	2.9	9.7	17.6	16.7	1.2
		VIII	Kl	8.2	3.2	9.3	20.6	17.9	2.7
			Ll	8.2	3.1	8.3	20.8	17.3	3.4
		X	Kr	7.9	3.6	8.9	19.5	18.0	1.3
			Ll	8.6	2.4	9.2	20.4	16.6	3.6
		XII	Kr	8.8	2.5	9.1	20.9	19.1	1.8
			Ll	8.8	2.3	9.2	20.0	17.7	2.0
Av.				8.37	3.03	8.94	18.78	16.68	2.06

Table 18. (cont.)

Muscle	Int. temp. °C.	Animal number	Code	Juiciness scores	Juiciness pref.	Press fluid ml/25g.	Ckg. losses pct	Volat. losses pct	Drip. losses pct
Semitendinosus	85	III	Jl	6.5	5.8	7.6	33.0	31.4	1.8
			Lr	7.5	4.9	7.5	31.6	29.8	1.9
		VI	Kr	6.4	5.3	7.1	33.3	32.1	1.2
			Lr	6.9	5.2	8.4	30.8	29.8	1.0
		VII	Kr	7.0	5.1	7.2	32.5	31.2	1.5
			Lr	6.6	5.7	6.5	35.2	34.2	1.0
		VIII	Jr	6.1	4.7	7.2	36.8	34.8	1.8
			Kr	6.0	4.8	6.8	34.3	32.1	2.2
		X	Jl	6.7	4.9	7.2	33.6	31.1	2.5
			Lr	6.0	5.5	7.4	34.7	32.6	1.8
		XII	Jl	6.6	5.2	7.7	31.9	29.5	2.4
			Lr	7.2	5.0	8.2	32.6	30.9	1.6
Av.				6.62	5.18	7.40	33.36	31.62	1.72
Longissimus dorsi (loin)	55	III	Nl	9.4	1.8	9.9	9.4	8.1	1.2
			Or	9.0	1.6	10.2	8.3	6.6	1.6
		VI	Nl	9.6	1.8	8.8	7.6	6.7	1.1
			Ol	9.4	2.2	8.7	8.6	7.2	1.2
		VII	Ml	9.3	2.1	7.7	7.3	6.3	1.0
			Nr	9.1	2.7	9.5	9.4	8.0	1.5
		VIII	Nl	9.8	2.8	7.7	10.0	8.6	1.1
			Ol	9.8	2.6	9.2	12.5	9.9	2.2
		X	Mr	9.8	2.4	8.2	12.4	11.2	1.0
			Nr	9.6	2.9	8.3	12.5	9.2	2.8
		XII	Nl	9.2	2.9	9.0	10.1	8.8	1.4
			Or	9.3	2.8	9.1	12.0	10.1	1.7
Av.				9.44	2.38	8.86	10.01	8.39	1.48

Table 18. (cont.)

Muscle	Int. temp. °C.	Animal number	Code	Juiciness scores	Juiciness pref.	Press fluid ml/25g.	Ckg. losses pct	Volat. losses pct	Drip. losses pct
Longissimus dorsi (loin)	70	III	Mr	8.7	3.6	10.0	16.9	15.1	1.6
			Nr	8.6	3.4	9.6	17.8	16.0	1.7
		VI	Mr	9.1	3.3	9.2	17.0	15.2	1.8
			Nr	9.1	3.3	7.9	17.3	15.6	1.7
		VII	Mr	8.6	2.9	8.7	14.5	13.9	0.9
			Ol	8.9	2.6	7.8	18.2	15.7	2.6
		VIII	Mr	9.3	2.8	9.2	17.3	14.5	2.7
			Nr	8.5	3.7	7.8	19.0	16.3	2.7
		X	Nl	9.0	3.1	8.5	19.3	17.0	2.1
			Ol	9.1	3.4	8.3	18.2	16.6	1.6
		XII	Ml	8.2	2.8	9.0	17.4	15.8	1.5
			Nr	8.0	3.0	9.4	21.0	18.7	2.1
Av.				8.76	3.16	8.78	17.82	15.87	1.92
	85	III	Ml	6.3	5.4	8.0	35.1	33.7	1.3
			Ol	7.1	5.1	5.7	39.3	37.1	2.0
		VI	Ml	7.0	5.1	7.0	33.0	31.6	1.4
			Or	6.4	5.4	6.4	33.2	32.1	1.1
		VII	Nl	5.6	5.2	6.1	33.1	31.9	1.2
			Or	5.1	5.6	4.9	35.2	33.6	1.5
		VIII	Ml	6.6	4.7	7.0	32.1	30.5	1.6
			Or	6.9	4.4	4.9	33.8	31.9	1.9
		X	Ml	6.1	4.9	5.0	41.1	38.9	1.8
			Or	6.5	4.6	5.7	38.6	36.1	2.4
		XII	Mr	6.0	5.1	8.2	35.6	33.9	1.6
			Ol	6.7	4.5	7.5	37.4	35.6	1.6
Av.				6.38	5.00	6.37	35.62	33.91	1.62

Table 18. (cont.)

Muscle	Int. temp. °C.	Animal number	Code	Juiciness scores	Juiciness pref.	Press fluid ml/25g.	Ckg. losses pct	Volat. losses pct	Drip. losses pct
Longissimus dorsi (rib)	55	III	Tl	9.8	1.8	9.2	7.0	6.3	0.7
			Ur	9.6	2.3	10.0	8.5	7.6	0.9
		VI	Tr	9.4	2.5	7.7	8.3	7.8	0.5
			Vl	9.7	1.4	7.6	8.2	7.4	0.6
		VII	Tl	9.5	2.4	8.4	9.5	8.6	0.9
			Ul	9.5	2.1	9.5	9.3	8.4	0.9
		VIII	Tr	9.1	2.3	8.9	8.4	7.3	1.1
			Ul	9.6	2.0	8.5	9.1	8.1	1.0
		X	Tl	9.6	2.5	8.5	11.4	9.4	1.8
			Vl	9.8	2.4	9.0	8.5	7.6	0.9
		XII	Tr	9.6	2.7	8.3	10.1	8.6	1.4
			Vr	9.3	3.1	8.9	10.9	9.7	1.2
Av.				9.54	2.29	8.71	9.10	8.07	0.99
	70	III	Ul	8.9	3.1	8.8	15.2	14.2	1.3
			Vr	8.7	3.4	10.1	14.2	13.3	1.1
		VI	Ul	9.0	2.8	8.9	16.4	15.3	1.0
			Vr	8.4	3.9	7.2	16.0	14.8	1.0
		VII	Ur	9.1	3.2	9.7	14.5	13.5	1.0
			Vr	9.3	3.2	9.9	14.3	13.3	1.0
		VIII	Tl	9.0	3.2	9.2	16.9	14.7	2.0
			Vr	8.3	3.4	8.9	14.7	13.1	1.6
		X	Tr	8.8	3.5	7.6	18.9	16.6	2.2
			Ur	8.9	2.9	8.8	17.5	15.6	1.7
		XII	Ul	8.7	3.1	8.8	19.0	16.8	2.2
			Vl	8.7	2.9	8.9	16.9	15.0	1.6
Av.				8.82	3.22	8.90	16.21	14.68	1.48

Table 18. (concl.)

Muscle	Int. temp. °C.	Animal number	Code	Juiciness scores	Juiciness pref.	Press fluid ml/25g.	Ckg. losses pct	Volat. losses pct	Drip. losses pct
Longissimus dorsi (rib)	85	III	Tr	7.5	4.8	7.7	29.6	27.8	1.6
			Vl	6.7	5.8	6.2	33.8	32.3	1.3
		VI	Tl	7.1	5.2	4.0	33.8	33.1	1.0
			Ur	6.6	5.2	6.4	33.0	31.8	1.0
		VII	Tr	7.8	5.2	7.2	30.4	29.1	1.3
			Vl	8.0	4.9	7.4	29.4	27.6	1.7
		VIII	Ur	6.2	4.7	6.7	29.3	27.2	1.9
			Vl	5.9	5.4	5.4	36.2	34.9	1.2
		X	Ul	6.5	4.7	6.1	36.3	34.4	1.4
			Vr	5.9	5.0	6.2	37.3	35.9	1.2
		XII	Tl	6.9	4.6	6.0	37.8	36.3	1.3
			Ur	6.7	4.7	6.5	36.4	34.7	1.4
Av.				6.82	5.02	6.32	33.61	32.09	1.36

[1] For description of abbreviations used in this table see Appendix, pg. 84.

Table 19. Weights and cooking times for roasts from beef muscles.[1]

Muscle	Int. temp. °C.	Animal number	Code	Weights Gms.	Weights Lbs.	Cooking time min./lb.
Psoas major	55	III	Al	455.0	1.0	43.0
			Br	534.0	1.2	37.5
		VI	Al	477.0	1.1	34.5
			Br	578.0	1.3	34.6
		VII	Ar	413.0	0.9	40.0
			Br	563.0	1.2	38.3
		VIII	Ar	512.0	1.1	39.1
			Br	585.0	1.3	35.4
		X	Al	491.0	1.1	37.3
			Br	520.0	1.1	35.5
		XII	Ar	338.0	0.7	47.1
			Br	383.0	0.8	45.0
Av.				487.4	1.1	38.94
	70	III	Ar	537.0	1.2	55.0
			Bl	522.0	1.1	65.5
		VI	Ar	534.0	1.2	51.7
			Bl	542.0	1.2	58.8
		VII	Al	412.0	0.9	72.2
			Bl	528.0	1.2	60.8
		VIII	Al	493.0	1.1	60.0
			Bl	489.0	1.1	60.9
		X	Ar	407.0	0.9	66.7
			Bl	597.0	1.3	58.5
		XII	Al	328.0	0.7	71.4
			Bl	349.0	0.8	66.3
Av.				478.2	1.1	62.32

Table 19. (cont.)

Muscle	Int. temp. °C.	Animal number	Code	Weights Gms.	Weights Lbs.	Cooking time min./lb.
Adductor	70	III	Cl	603.0	1.3	70.8
			Dl	457.0	1.0	78.0
		VI	Cl	661.0	1.5	74.7
			Dl	532.0	1.2	70.8
		VII	Cr	739.0	1.6	61.3
			Dl	462.0	1.0	74.0
		VIII	Cl	598.0	1.3	80.8
			Dr	555.0	1.2	78.3
		X	Cl	769.0	1.7	61.8
			Dl	500.0	1.1	71.8
		XII	Cr	435.0	1.0	80.0
			Dr	456.0	1.0	73.0
Av.				563.9	1.2	72.94
	85	III	Cr	550.0	1.2	117.5
			Dr	425.0	0.9	156.7
		VI	Cr	671.0	1.5	118.0
			Dr	455.0	1.0	153.0
		VII	Cl	762.0	1.7	109.4
			Dr	574.0	1.3	138.5
		VIII	Cr	664.0	1.5	114.7
			Dl	500.0	1.1	129.1
		X	Cr	812.0	1.8	104.4
			Dr	528.0	1.2	125.0
		XII	Cl	501.0	1.1	122.7
			Dl	401.0	0.9	152.2
Av.				570.3	1.3	128.43

Table 19. (cont.)

Muscle	Int. temp. °C.	Animal number	Code	Weights Gms.	Weights Lbs.	Cooking time min./lb.
Rectus femoris	70	III	Er	711.0	1.6	61.9
			Fl	658.0	1.4	70.7
		VI	El	607.0	1.3	72.3
			Fl	728.0	1.6	58.1
		VII	Er	750.0	1.7	63.5
			Fl	739.0	1.6	61.9
		VIII	El	600.0	1.3	76.2
			Fl	695.0	1.5	70.0
		X	El	728.0	1.6	73.1
			Fr	799.0	1.8	62.8
		XII	El	617.0	1.4	80.0
			Fr	617.0	1.4	67.1
Av.				687.4	1.5	68.13
	85	III	El	715.0	1.6	150.0
			Fr	653.0	1.4	117.1
		VI	Er	703.0	1.6	125.0
			Fr	744.0	1.6	134.4
		VII	El	700.0	1.5	138.0
			Fr	683.0	1.5	137.3
		VIII	Er	633.0	1.4	128.6
			Fr	700.0	1.5	120.0
		X	Er	715.0	1.6	111.3
			Fl	789.0	1.7	104.7
		XII	Er	560.0	1.2	102.5
			Fl	705.0	1.6	109.4
Av.				691.7	1.5	123.19

Table 19. (cont.)

Muscle	Int. temp. °C.	Animal number	Code	Weights		Cooking time min./lb.
				Gms.	Lbs.	
Vastus lateralus	70	III	Gr	606.0	1.3	64.6
			Hl	770.0	1.7	58.2
		VI	Gr	650.0	1.4	57.9
			Hl	695.0	1.5	53.3
		VII	Gl	813.0	1.8	56.1
			Hl	692.0	1.5	53.3
		VIII	Gr	813.0	1.8	62.2
			Hr	677.0	1.5	53.7
		X	Gl	874.0	1.9	54.2
			Hl	842.0	1.9	48.9
		XII	Gl	751.0	1.7	54.7
			Hr	708.0	1.6	48.1
Av.				740.9	1.6	55.43
	85	III	Gl	779.0	1.7	97.6
			Hr	714.0	1.6	102.5
		VI	Gl	837.0	1.8	105.0
			Hr	893.0	2.0	97.5
		VII	Gr	879.0	1.9	112.6
			Hr	612.0	1.3	143.8
		VIII	Gl	710.0	1.6	102.5
			Hl	618.0	1.4	112.1
		X	Gr	880.0	1.9	82.1
			Hr	744.0	1.6	84.4
		XII	Gr	756.0	1.7	90.6
			Hl	654.0	1.4	113.6
Av.				756.3	1.7	103.69

Table 19. (cont.)

Muscle	Int. temp. °C.	Animal number	Code	Weights Gms.	Weights Lbs.	Cooking time min./lb.
Semimembranosus (posterior)	70	III	Pr	1050.0	2.3	50.9
			Qr	981.0	2.2	49.5
		VI	Pl	508.0	1.1	74.5
			Ql	532.0	1.2	67.5
		VII	Pr	700.0	1.5	56.0
			Qr	647.0	1.4	60.7
		VIII	Pl	734.0	1.6	68.8
			Ql	781.0	1.7	70.6
		X	Pl	716.0	1.6	60.0
			Qr	642.0	1.4	59.3
		XII	Pl	808.0	1.8	55.0
			Ql	717.0	1.6	51.9
Av.				734.7	1.6	60.39
	85	III	Pl	764.0	1.7	93.5
			Ql	709.0	1.6	93.1
		VI	Pr	637.0	1.4	102.1
			Qr	516.0	1.1	127.3
		VII	Pl	581.0	1.3	132.3
			Ql	829.0	1.8	105.0
		VIII	Pr	782.0	1.7	112.9
			Qr	617.0	1.4	125.0
		X	Pr	637.0	1.4	112.9
			Ql	604.0	1.3	125.4
		XII	Pr	808.0	1.8	102.2
			Qr	641.0	1.4	120.7
Av.				677.1	1.5	112.70

Table 19. (cont.)

Muscle	Int. temp. °C.	Animal number	Code	Weights Gms.	Weights Lbs.	Cooking time min./lb.
Semimembranosus (anterior)	70	III	Rl	909.0	2.0	58.0
			Sr	813.0	1.8	55.6
		VI	Rr	962.0	2.1	67.6
			Sl	952.0	2.1	61.9
		VII	Rr	738.0	1.6	60.8
			Sl	883.0	1.9	62.1
		VIII	Rl	750.0	1.7	61.8
			Sr	748.0	1.6	71.3
		X	Rl	840.0	1.9	58.4
			Sl	883.0	1.9	56.3
		XII	Rr	932.0	2.1	60.0
			Sl	855.0	1.9	53.2
Av.				855.4	1.9	61.25
	85	III	Rr	682.0	1.5	100.0
			Sl	968.0	2.1	99.5
		VI	Rl	926.0	2.0	96.5
			Sr	798.0	1.8	120.6
		VII	Rl	685.0	1.5	140.0
			Sr	998.0	2.2	92.3
		VIII	Rr	794.0	1.7	117.1
			Sl	665.0	1.5	95.3
		X	Rr	1084.0	2.4	84.2
			Sr	1118.0	2.5	87.2
		XII	Rl	878.0	1.9	109.5
			Sr	882.0	1.9	108.9
Av.				873.2	1.9	104.26

Table 19. (cont.)

Muscle	Int. temp. °C.	Animal number	Code	Weights Gms.	Weights Lbs.	Cooking time min./lb.
Semitendinosus	55	III	Jr	531.0	1.2	53.3
			Kr	630.0	1.4	49.3
		VI	Jl	504.0	1.1	49.1
			Ll	456.0	1.0	50.0
		VII	Jr	513.0	1.1	53.6
			Kl	625.0	1.4	47.9
		VIII	Jl	450.0	1.0	52.0
			Lr	547.0	1.2	42.5
		X	Jr	544.0	1.2	44.2
			Kl	573.0	1.3	46.2
		XII	Jr	456.0	1.0	47.0
			Kl	642.0	1.4	42.9
Av.				539.3	1.2	48.17
	70	III	Kl	627.0	1.4	73.6
			Ll	464.0	1.0	78.0
		VI	Jr	611.0	1.3	66.9
			Kl	613.0	1.4	65.7
		VII	Jl	602.0	1.3	64.6
			Ll	432.0	1.0	80.0
		VIII	Kl	637.0	1.4	70.0
			Ll	624.0	1.4	64.3
		X	Kr	611.0	1.3	73.1
			Ll	608.0	1.3	69.2
		XII	Kr	597.0	1.3	69.2
			Ll	446.0	1.0	72.0
Av.				572.7	1.3	70.55

Table 19. (cont.)

Muscle	Int. temp. °C.	Animal number	Code	Weights Gms.	Weights Lbs.	Cooking time min./lb.
Semitendinosus	85	III	Jl	566.0	1.2	147.5
			Lr	534.0	1.2	124.2
		VI	Kr	574.0	1.3	140.8
			Lr	386.0	0.9	142.2
		VII	Kr	679.0	1.5	130.0
			Lr	480.0	1.1	159.1
		VIII	Jr	448.0	1.0	170.0
			Kr	586.0	1.3	130.8
		X	Jl	527.0	1.2	114.2
			Lr	487.0	1.1	142.7
		XII	Jl	508.0	1.1	114.5
			Lr	564.0	1.2	119.2
Av.				528.3	1.2	136.27
Longissimus dorsi (loin)	55	III	Nl	652.0	1.4	42.1
			Or	578.0	1.3	32.3
		VI	Nl	655.0	1.4	34.3
			Ol	596.0	1.3	33.8
		VII	Ml	729.0	1.6	30.6
			Nr	671.0	1.5	31.3
		VIII	Nl	441.0	1.0	40.0
			Ol	506.0	1.1	36.4
		X	Mr	872.0	1.9	40.0
			Nr	760.0	1.7	31.2
		XII	Nl	577.0	1.3	33.1
			Or	534.0	1.2	35.8
Av.				630.9	1.4	35.08

Table 19. (cont.)

Muscle	Int. temp. °C.	Animal number	Code	Weights		Cooking time min./lb.
				Gms.	Lbs.	
Longissimus dorsi (loin)	70	III	Mr	629.0	1.4	63.6
			Nr	589.0	1.3	70.8
		VI	Mr	552.0	1.2	57.5
			Nr	583.0	1.3	60.0
		VII	Mr	765.0	1.7	52.4
			Ol	725.0	1.6	49.4
		VIII	Mr	752.0	1.7	50.0
			Nr	710.0	1.6	54.4
		X	Nl	701.0	1.5	60.0
			Ol	757.0	1.7	57.6
		XII	Ml	657.0	1.4	63.6
			Nr	561.0	1.2	69.2
Av.				665.1	1.5	59.04
	85	III	Ml	712.0	1.6	128.1
			Ol	595.0	1.3	138.5
		VI	Ml	572.0	1.3	132.3
			Or	554.0	1.2	143.3
		VII	Nl	722.0	1.6	116.3
			Or	736.0	1.6	103.1
		VIII	Ml	573.0	1.3	109.2
			Or	571.0	1.3	123.1
		X	Ml	665.0	1.5	118.7
			Or	715.0	1.6	96.9
		XII	Mr	629.0	1.4	120.0
			Ol	441.0	1.0	141.0
Av.				623.8	1.4	122.54

Table 19. (cont.)

Muscle	Int. temp. °C.	Animal number	Code	Weights		Cooking time min./lb.
				Gms.	Lbs.	
Longissimus dorsi (rib)	55	III	Tl	741.0	1.6	33.8
			Ur	739.0	1.6	41.3
		VI	Tr	424.0	0.9	47.8
			Vl	527.0	1.2	40.0
		VII	Tl	464.0	1.0	47.0
			Ul	536.0	1.2	40.0
		VIII	Tr	455.0	1.0	45.0
			Ul	627.0	1.4	38.6
		X	Tl	542.0	1.2	35.8
			Vl	766.0	1.7	27.1
		XII	Tr	662.0	1.5	31.3
			Vr	857.0	1.9	33.7
Av.				611.7	1.4	38.45
	70	III	Ul	709.0	1.6	60.0
			Vr	758.0	1.7	56.5
		VI	Ul	477.0	1.1	72.7
			Vr	601.0	1.3	64.5
		VII	Ur	498.0	1.1	63.6
			Vr	498.0	1.1	63.6
		VIII	Tl	497.0	1.1	66.4
			Vr	695.0	1.5	60.0
		X	Tr	650.0	1.4	57.9
			Ur	582.0	1.3	56.2
		XII	Ul	672.0	1.5	57.3
			Vl	800.0	1.8	48.9
Av.				619.8	1.4	60.63

Table 19. (concl.)

Muscle	Int. temp. °C.	Animal number	Code	Weights Gms.	Weights Lbs.	Cooking time min./lb.
Longissimus dorsi (rib)	85	III	Tr	571.0	1.3	100.8
			Vl	595.0	1.3	138.5
		VI	Tl	399.0	0.9	166.7
			Ur	509.0	1.1	150.0
		VII	Tr	540.0	1.2	120.8
			Vl	586.0	1.3	116.9
		VIII	Ur	526.0	1.2	110.8
			Vl	733.0	1.6	126.9
		X	Ul	639.0	1.4	115.7
			Vr	585.0	1.3	132.3
		XII	Tl	535.0	1.2	126.7
			Ur	649.0	1.4	126.4
Av.				572.3	1.3	127.71

[1] For description of abbreviations used in this table see Appendix, pg. 84.

COMPARISON OF RARE, MEDIUM- AND WELL-DONE ROASTS FROM CERTAIN BEEF MUSCLES

by

MARILYN STAYTON BUNYAN

B. A., Southwestern College,
Winfield, Kansas, 1954

AN ABSTRACT OF A THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Foods and Nutrition

KANSAS STATE COLLEGE
OF AGRICULTURE AND APPLIED SCIENCE

1958

A better understanding is needed of the effect that the degree of cooking has on the tenderness of meat. Generally it is believed that during heating, the muscle fibers become less tender when the protoplasmic proteins coagulate; whereas, simultaneously tenderness may be increased as the connective tissue is softened and partially hydrolyzed. At times these changes in connective tissue may increase the tenderness of cooked meat more than the coagulation of the protoplasmic proteins decrease tenderness.

The purpose of this study was to investigate the acceptability of oven-roasted beef muscles cooked to end-point temperatures of 55°, 70° and 85°C. representing rare, medium- and well-done, respectively. Differences in tenderness as well as other palatability factors were measured subjectively and objectively to determine any changes that might occur which could be attributed to the degree to which the meat was cooked.

Roasts from certain muscles of six U. S. Good long hindquarters of beef were used. A randomized incomplete block design was used for cooking roasts from the semitendinosus, longissimus dorsi (loin) and longissimus dorsi (rib) muscles. Three roasts were cut from each of the previously mentioned muscles and cooked to end-point temperatures of 55°, 70° and 85°C. Two roasts were cut from the psoas major, adductor, rectus femoris, vastus lateralus, semimembranosus (posterior) and semimembranosus (anterior). A randomized complete block design was used for cooking of the roasts either to end-point temperatures of 55° and 70°C. or 70° and 85°C. from the last muscles mentioned.

The defrosted roasts were cooked in a pre-heated rotary hearth oven maintained at 300°F. The rate of rise in internal temperature was noted during cooking. After removing the roasts from the oven, weights were taken from which data for total, volatile and dripping cooking losses were obtained. Shear force values for one-inch cores of meat, press fluid yields and palatability scores were obtained. These data were analyzed statistically; the analyses of variance were run on data from the roasts cooked to three end-point temperatures and t-tests were done on data from those roasted to two end-point temperatures.

No particular difference was noted in the rate of heat penetration between the roasts from the right and left muscles. Most of the curves tended to rise rather sharply until the internal temperature in the meat was 40°C., after that, the curves flattened out gradually until the end-point temperatures were reached. For some of the muscles, the roasts from the proximal or anterior end had the slower rate of heat penetration; whereas, in the remaining muscles the distal or posterior end roasts had the slower rates. The center cuts showed no consistent pattern for rate of heat penetration. The average weight of the roasts ranged from 1.1 to 1.9 pounds but the largest roasts did not require the longest cooking time.

Aroma and flavor scores for roasts increased with an increase in end-point temperatures. Significant and very highly significant increases for aroma scores were found with each increase in in end-point temperature. Approximately one-half of the muscles had significant differences in flavor scores that could be attributed to an increase in end-point temperature. In most cases, the tenderness scores for roasts decreased with an increase in end-point temperature, but an increase in end-point temperature had little real effect on the tenderness scores of the roasts, because significant differences in tenderness attributable to degree of cooking were noted in only a few cases. Tenderness preference decreased with an increase in end-point temperature. An increase in end-point temperature had no consistent effect on the shear force values, since they increased for some of the roasts but decreased for others. Significant negative correlation coefficients for tenderness scores and shear force values were found for the majority of the roasts cooked to 85°C.

Juiciness scores and preference for juiciness decreased with an increase in end-point temperature; whereas, the total cooking losses and cooking times increased with an increase in the degree of cooking. Significant to very highly significant differences for each of these factors were found as the degree of cooking increased. The dripping cooking losses tended to decrease with an increase in end-point temperature and differences were significant for roasts from most muscles. Generally, the average press fluid yields decreased significantly with each increase in end-point temperature. The majority of the correlation coefficients between juiciness scores and press fluid yields were positive, however, only two coefficients were significant. Slightly more than half of the correlation coefficients for juiciness scores and cooking losses (total and volatile) were negative and only a few of these were significant. Most of the correlation coefficients for press fluid yields and cooking losses (total and volatile) were negative and only a few of these were significant. No consistent trend for significant correlation coefficients was found for dripping losses and juiciness scores or dripping losses and press fluid yields.