EFFECTS OF A MEAT TENDERIZER ON LESS TENDER CUTS OF BEEF COOKED BY FOUR METHODS

by

PATTIE PATRICE HAY

B. S., Kansas State College
of Agriculture and Applied Science, 1941

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

1952

TABLE OF CONTENTS

INTRODUCTION

Commercial meat tenderizers that contain the proteolytic enzyme, papain, are now on the market for consumer use, but few reports were found in the literature regarding the effectiveness of these tenderizers. According to Gottschall and Kies (1942), the greatest use of papain as a meat tenderizer has been empirical. The digestion of whole beef muscle have not been studied quantitatively.

Tauber (1942, p. 441) reported that commercial tenderizer preparations now available are usually spread on the surface of the meat a few minutes before the meat is cooked, but the best results are obtained when the enzyme is allowed to penetrate into the meat by applying deep cuts. Lowe (1943, p. 234) stated that if enzyme preparations are to give satisfactory results in tenderizing meat, they should be injected uniformly throughout all tissues.

The effect of tenderization is difficult to treat quantitatively, as pointed out by Gottschall and Kies (1942), because adequate criteria of what constitutes tenderness in meat are lacking. Tenderness is induced by the proteolytic enzyme as the result of protein breakdown. Although the exact relationship between the tenderizing effect and the protein digestion is not known, the more the meat is digested, the softer the structure of the meat. The purpose of this study was to determine the effects of a commercial meat tenderizer on the tenderness as well as on the flavor and juiciness of thick and thin round steaks, sirloin tip steaks, and rump roasts.

REVIEW OF LITERATURE

Composition and Structure of Beef

For the purpose of chemical review Smith (1942) divided meat into the anatomical elements, muscle and connective tissue, and subdivided the latter again into fatty and non-fatty tissue. Since the edible meat of a carcass consists of more or less intimate mixtures of these tissues in varying proportions, Smith (1942) reintegrated the anatomical differentiations when considering meat as it is eaten. He stated that meat that is ordinarily considered lean may contain more fat than protein.

The composition of muscle as reported by Smith (1942) was water 75, protein 18.5, soluble non-protein substances 3.5, and intracellular fat 3.0 percent. The intracellular fat represented the variable amount of fat that is contained in the muscle cell and did not take into account the abundant intercellular adipose tissue. The protein content of the muscle was reported as extracellular (collagen) and intracellular (myosin, myogen X, globulin X, and myoglobin).

According to Szent-Gyorgyi (1946) cross-striated muscle contains eight percent of myosin and about three percent of actin, which makes 11 percent of actomyosin. He explains that this actomyosin is contained in the fibril which occupies about one-third of the total volume of the muscle. The fibril thus contains no less than 33 percent of actomyosin, which is strongly hydrated. Szent-Gyorgyi (1946) defined "strongly hydrated" to mean that a relatively great part of the water present is bound to the protein. He stated that actomyosin binds approximately an amount of water equal to its dry weight, which would leave 66 percent of hydrated actomyosin and 34 percent of free water or free space. Thirty-four percent of free space means exceedingly close packing of actomyosin molecules within the fibrils.

Smith (1942) pointed out that the extracellular protein, consisting mainly of collagen, can be sharply differentiated from the remainder of the muscle protein by its complete insolubility in dilute mineral acid and this affords an easy method of determining the amount present in muscles. He also stated that the amount of extracellular tissue is one of the most important factors determining the physical properties of lean meat.

Skeletal muscle is an organ made up of fibers held together by connective tissue and surrounded by a sheath of heavier connective tissue. Each fiber is enclosed in a thin, colorless elastic membrane called the sarcolemma, and the fibers are then grouped parallel to each other in bundles called fasciculi. The perimysium is the connective tissue surrounding the fasciculus and the entire muscle is enclosed by connective tissue known as epimysium (Lowe, 1943, p. 205).

Lowe (1943, p. 212) described the fibers as being elongated, cylindrical, and multi-nucleated, the nuclei being elliptical in shape. The fibers vary in length and during growth increase in both length and diameter; the number of fibers does not increase after birth. A fiber may extend the full length of the muscle, or one end may terminate in the muscle. Generally it is the fasciculus and not the fiber that extends the length of the muscle.

Brady (1937) reported that the diameter of muscle fibers was larger for cows than for steers; that the diameter of the fibers of fresh meat was larger than the diameter of the fibers of aged meat; and the diameter of the fibers of aged meat was larger than the diameter of this same meat after cooking. Brady (1937) found no significant difference in the diameter of muscle fibers for different muscles and stated that the number of muscle fibers in a bundle may be taken as a measure of the size of the bundle and as a measure of texture.

The function of connective tissue is to support all the other tissues and organs in the body. Smith (1942) stated that in meat it is most evident in the form of tendon, or gristle, but it is also distributed in a finer state of subdivision throughout both muscle and fatty tissue. The extracellular protein (collagen) in finely divided connective tissue differs in no essential respect from that found in other parts of the body. According to Smith (1942) the solid constituents of the different forms of connective tissue are practically identical, but the diffuse connective tissue associated with muscles and fat differs from the compact form found in tendon in one respect, i.e., in the amount of water associated with it.

Lowe (1943, p. 209) gave the following description of connective tissue: "Connective tissue is characterized by a small number of cells and much intercellular substance. It has many variations and transitional forms. Some is loose, like that between organs; some is compact, as in heavy connective tissue visible to the eye and some is dense, like that in tendons. It always contains fibers."

Collagenous fibers are colorless and birefrigent, but when they appear in large masses, the tissue is white and is often referred to as white connective tissue (Lowe, 1943, p. 209). This author also stated that the main function of the collagenous fibers is to bind and support other tissues; and that when arranged in wavy rows, the fibers can be stretched until the waves are straightened, so they have flexibility but are not elastic.

According to Smith (1942) the properties of collagenous tissue which most concern us from the viewpoint of the properties of meat are the toughness and elasticity of the collagen fiber, its easy conversion to the tender soluble gelatin by boiling, and its inadequacy as a food protein. He pointed out that collagen is completely digested by trypsin and when, as is usual, it is accompanied by a considerable excess of protein of high biological value, it will itself be quite efficiently utilized.

A second protein in connective tissue is elastin. Elastin forms only a very small proportion of the diffuse connective tissue and ordinary white tendon, but it is concentrated in ligaments. Elastin, according to Smith (1942), differs from collagen in that it is practically indigestible and is softened little during cooking. Lowe (1943, p. 210) stated that the elastic fibers are thinner than the collagenous ones and that they branch readily and stretch like a fish net. The ends of the single fibers often appear curved. The fibers are extremely elastic and hence function when both elasticity and strength are required. The fibers forming ligaments are arranged parallel to each other and are bound together by collagenous fibers. Lowe (1943, p. 210) explained that when the fibers are massed together, as in ligaments, the color is yellow; hence, the name yellow connective tissue.

Factors that Affect the Tenderness of Beef

Collagenous and Elastic Tissue Content. According to Mitchell, Hamilton and Haines (1928) lean meat is essentially muscle tissue but also it contains considerable and variable amounts of connective tissue. They attributed the greater portion of the toughness of meat to the connective tissue fibers rather than the muscle fibers. Smith (1942) reported that there is a broad correlation between the toughness of meat and its extracellular (collagenous) tissue content.

Lowe (1943, p. 213) pointed out that toughness of meat may be due to the muscle fiber and/or the connective tissue composition of meat. Toughness of connective tissue, as explained by Lowe (1943, p. 213) depends upon its thickness and density, upon the proportion of elastin to collagen and possibly upon the age of the animal. Toughness of the muscle fiber depends upon the development and density of the fiber from activity and possibly upon the changes brought about by age.

Studies of Mackintosh, Hall and Vail (1936) and of Husaini et al. (1950) indicated that connective tissue is a major factor in tenderness. Harrison et al. (1949) found that the most tender roasts from four animals came from muscles and animals having the least connective tissue.

Much work has been done to determine the collagen content of raw meat; however, Bell, Morgan and Dorman (1941) were the first to report on a study of the determination of collagen in cooked meat. In 23 experiments on raw and cooked samples of beef shoulder, fillet, rump, and sirloin butt it was determined that 22 percent of the collagen nitrogen of the raw meat was lost during cooking. The meat was cooked for a fixed time or until an internal temperature of 85° C. (185° F.) was reached. They found no significant difference in the collagen content of the four cuts studied but noted that the loss of collagen, presumably through hydrolysis to gelatin during the cooking, was greater in the samples cooked for longer periods of time.

Prudent (1949) made a study of the collagen and elastin content of four beef muscles from a steer of good grade and a cow of cutter grade after storage for 1, 2, 5, 10, 20, and 30 days at 34° to 36° F. There was a significant difference in the collagen content of the different muscles studied. These findings correlated with the tenderness ratings of the same muscles as reported by Harrison et al. (1949). In Prudent's (1949) study it was found that the animal of Cutter grade contained more collagen but slightly less elastin than the steer of Good grade. The data indicated that the collagen and elastin content of beef muscles are not affected by storage at 34° to 36° F. for as long as 30 days.

No consistent difference between steer and heifer calves relative to the collagen and elastin content of the lean was reported by Mitchell, Hamilton and Haines (1928). In this same study consistent differences appeared between retail cuts. The lowest percentage of collagen for all calves was in the eye muscle of the rib, but the tenderloin contained only slightly higher amounts. Next in order in increasing collagen content were the round, porterhouse, and sirloin. The chuck-ribs and navel contained still larger percentages of collagen and the foreshank contained the highest percentage.

There was a different distribution of elastin among these cuts. The lowest percentage of elastin was found in the tenderloin, sirloin, and the longissimus dorsi muscle. The porterhouse and foreshank were next. The chuck-ribs and the round contained three times as much elastin as the porterhouse and foreshank, and the navel had the highest percentage of elastin.

Mitchell, Hamilton and Haines (1928) also found that the inner muscle of the round contained a smaller percent of collagen and elastin in most cases than the outer round. These data were based on a study of 12 animals which ranged in grade from Common to Choice minus. There were eight steers between one and four years of age, three cows from five to eight years of age, and one mature bull.

The Cut of Meat. Studies made on the comparative tenderness of 25 representative muscles from "U. S. Good" grade beef carcasses by Ramsbottom, Strandine, and Koonz (1945) indicated that the tenderness varied from muscle to muscle and in a few instances there were variations in tenderness within the muscle. It was found that the biceps femoris and latissimus dorsi were progressively more tender from the insertion to the origin lf the muscle. The longissimus dorsi and the multifidus dorsi were somewhat less tender at the anterior end of the muscle. Most of the 25 muscles studied decreased in tenderness upon cooking, and the decrease in tenderness was associated with factors such as the coagulation and denaturation of the muscle protein together with varying degrees of shrinkage and hardening of the muscle fibers. They also found that muscles with small amounts of connective tissue were tender and muscles with large amounts of connective tissue were tough.

In a later study on wholesale cuts of beef, Ramsbottom and Strandine (1948) found that the muscles varied greatly in weight, moisture, fat content, pH, and tenderness. The authors stated in this report that most of the muscles of the round of good quality beef were suitable for steaks.

Age of the Animal. Mackintosh, Hall, and Vail (1936) measured the palatability, shear values, and collagen nitrogen factors in beef from mature and yearling steers. The palatability factors indicated little difference in the meat from these animals. However, the shear values and the amount of collagenous connective tissue present in the meat showed that beef from mature steers was less tender than beef from yearling steers.

A study made by Hiner and Hankins (1950) indicated the tenderness of beef in relation to the different muscles and age of the animal. Samples used in the study were from 52 animals and the carcasses were aged from 12 to 15 days at 33° to 35° F. The 52 animals consisted of eight cows, approximately five and one-half years of age; eight barren heifers, three years old; 25 900-pound steers, 16 months old; eight 500-pound steer calves, seven months old; and three veal calves, two and one-half months old. The carcasses averaged in grade from Good to Commercial.

After aging, nine samples were cut from the following locations: neck, foreshank, third rib, round bone of chuck, eighth rib, third lumbar vertebra, tenderloin, loin end, and face of round. The sample of round was subdivided into semitendinosus, semimembranosus, and biceps femoris muscles, and each of the nine cuts was rated for tenderness. As the age of the animal increased, the tenderness decreased for each of the nine samples. The difference in tenderness between veal and cows was highly significant, whereas that between veal and beef from the 500-pound steers was not significant.

The samples in each of the five age groups classified themselves into four tenderness groups: (1) the least tender, neck and foreshank; (2) round; (3) chuck at the 3rd rib and across the humerus bone, 8th rib, short loin, and loin end; and (4) the tenderloin, the most tender. There was little difference in tenderness between the three muscles of the round within each age group. The semimembranosus muscle was slightly more tender than the other two muscles.

Length of Aging Period. Several studies have been made in regard to the increasing tenderness of beef stored at 35° F. from two hours to 31 days. Ramsbottom and Strandine (1949) reported on 10 beef carcasses which ranged in quality from Common to Good and were tested at 2, 5, 8, 11, and 14 hours, 1, 2, 3, 6, 9, and 12 days after slaughter. Beef was more tender at two hours following slaughter than at any time thereafter for the next two to six days. By the twelfth day beef which had been stored at 35° F. was considerably more tender than it was two hours after slaughter.

A similar study was carried out by Paul, Lowe, and McClurg (1944) in which a pair of rounds and a pair of psoas major muscles from a "good" grade yearling steer were used. The muscles utilized were the semitendinosus, semimembranosus, biceps femoris, the vastus group, gastrocnemius, adductor, and psoas major. The storage times were 0, 1, 2, 3, 9, and 18 days; the roasts with no storage time were cooked within 3 hours after slaughtering the animal. The other cuts were wrapped in Cellophane and stored at approximately 35° F. There was a decided increase in tenderness during storage as indicated by the scores and shear readings; the juiciness also increased, but the cooking losses and total cooking time did not change with storage.

Deatherage and Harsham (1947) studied the relationship between the tenderness of beef and the post-mortem age of beef. Changes in the tenderness of 14 beef carcasses during aging at 33° to 35° F. were determined by estimating, after various intervals of time, the tenderness of the respective longissimus dorsi muscles by the subjective testing of broiled steaks.

One lot of 10 animals, graded U. S. Commercial and U. S. Good, were slaughtered and tested 2, 6, 10, 17, 24, 31, and 38 days after slaughter. A second lot of 4 animals, graded U. S. Good and U. S. Choice, were slaughtered and tested 3, 6, 10, 17, 24, 31, and 41 days after slaughter. After two or three days aging, 12 of the animals ranged in tenderness between very tough and tough to tough and slightly tough, whereas, two of the animals ranged from slightly tough to tender. As a whole, the tougher animals showed a break in tenderization at about 17 days, at which time there was a slight drop in tenderness from 17 to 24 days of aging. At 31 days there appeared to be some improvement beyond the 17 to 24 day levels. The results indicated that unless meat is going to be ripened for more than 4 weeks that two and a half weeks is the maximum aging time for increased tenderness.

The physical, organoleptic and histological changes in three grades of beef during aging was reported by Harrison et al. (1949). In this study four muscles, (the paired psoas major, longissimus dorsi, semitendinosus, and semimembranosus) varying in tenderness, were taken from carcasses of four animals representing three grades (Good, Commercial, and Cutter). The muscles were aged at 34° to 36° F. for 1, 2, 5, 10, 20, and 30 days. The greatest increase in the tenderness of the roasts occurred in the first 10 days of aging. When individual muscles were considered, tenderness was not always linearly related to aging. Tenderness varied among the muscles, among the carcass grades, and among animals within a given carcass grade. The most tender roasts came from the best grade and the least tender from the poorest grade carcasses.

Methods of Cooking. The preferred method of cooking depends somewhat on the cut of meat. The methods generally employed are dry heat for the tender cuts and moist heat for the less tender cuts. A number of studies have been made, however, in which methods of dry heat cookery have been applied to the less tender cuts of meat. The oven temperature and the length of cooking time have been of most concern in these studies.

Cover (1937) found that round bone chuck and rump roasts cooked to an internal temperature of 80° C. in an oven at 125° C. were preferred, as evaluated by the paired eating method, to roasts cooked to the same internal temperature when the oven temperature was 225° C. Observations made in this study indicated that the greater tenderness of the roasts cooked at the lower temperature was due to the longer cooking time rather than to the low oven temperature.

Later Cover (1941) reported that skewers decreased the cooking time and cooking losses but increased the toughness of paired round, arm bone chuck, and standing rib roasts of beef. The greatest difference in cooking time was 5.2 hours between the skewered and unskewered round roasts. The least difference in cooking time was 2.1 hours for the skewered and unskewered standing rib roasts. There was a greater difference in the palatability scores, by the paired eating method, for the round roasts where the difference in cooking time was greatest than for the standing rib roasts where the difference in cooking time was least. The judges preferred the roasts which were cooked the longest. The results of this experiment lend further support to the conclusions of the previous study and correlate with the results of a study made by Bell, Morgan, and Dorman (1941). They cooked four standing rib roasts, two of which were pierced by skewers, to an internal temperature of 87° C. in an oven maintained at 210° C. The skewered roasts reached the desired internal temperature in 17.3 minutes per pound of meat and the unskewered roasts took 21.3 minutes per pound of meat to reach the same internal temperature. The reduction in collagen produced by cooking the unskewered roasts was 26 percent, whereas the reduction of collagen in the skewered roasts was only 18 percent.

Another study by Cover (1943) showed that roasts were always tender when the rate of heat penetration was slow enough so that it required 30 hours or more for them to lose their pink color. In this study paired standing rib and arm bone chuck roasts were cooked well done at oven temperatures of 80° C. and 125° C. Paired bottom round roasts were cooked to both the well done and rare stages at the two oven temperatures. The larger amount of connective tissue in well done bottom round roasts cooked at

80° C. appeared to be completely changed from its hard and tough state to a moist, viscous mass which, while warm, was without resistance to either the knife or teeth. The moisture loss from these roasts was moderate in amount and the coagulation time was very long. Cover (1943) suggested that the water of hydration was released slowly enough from the meat protein so that it was used effectively for converting the collagen into gelatin.

Cline et al. (1930) stated that the palatability of the less tender cuts can be improved by cooking and that less tender cuts of beef from good grade heifer can be roasted and broiled to give palatable products if comparatively low temperatures are used. During a four year investigation on the effects of methods of cooking on the palatability and cooking losses of less tender cuts, Cline et al. (1930) obtained the following results: (1) low oven temperatures for roasting resulted in less cooking losses and greater palatability than did high oven temperatures, (2) high oven temperatures decreased juiciness and tenderness, (3) roasts cooked to the well-done stage had greater cooking losses than those cooked medium done, (4) there was little relation between the size of a roast and the percentage of cooking losses, (5) a low oven temperature of 125° C. produced a more tender medium-rare roast than a higher oven temperature of 165° C., and (6) a low internal temperature of a roast at the time it is put into the oven increased the cooking losses and the time of cooking.

Satorius and Child (1938) cooked the semitendinosus muscle to internal temperatures of 58° C., 67° C., and 75° C. and found an increase in total losses with each increment in internal temperature. The diameter of the muscle fibers decreased and tenderness increased with coagulation of the proteins up to 67° C. The diameter of the fiber was not changed between 67° and 75° C., but tenderness decreased from 67° to 75° C.

Methods of Increasing Tenderness

To be palatable, meat must be tender as well as flavorful. The less expensive cuts of beef have a good flavor; however, due to the large amounts of connective tissue, particularly in low grade beef, these cuts are much less tender than the more expensive cuts.

Lowe (1943, p. 233) gave these methods for increasing tenderness: (1) mechanical means, (2) freezing, (3) aging, (4) enzyme action, (5) cooking, (6) change in pH, (7) action of salts and sugars, and (8) injections of water and saline solutions.

According to McCoy et al. (1949) differences in the tenderness of all types of aged and unaged beef were not affected by freezing. However, they found that the differences in tenderness between aged and unaged beef became less with increased frozen storage time.

Hiner and Hankins (1951) studied the effects of freezing at -18° C. in still air on the tenderization of different muscles from beef animals of different ages. The five age groups of the 52 animals studied were as follows: cows, 67 months; heifers, 37 months; 900-pound steers, 14 months; 500-pound steers, eight months; and veal calves, two and one-half months. The three large muscles of the round were significantly tenderized by freezing, with the exception of the semitendinosus muscle of the 500-pound steers and all three muscles from the round of the veal calves. The semitendinosus muscle of the veal calves was slightly less tender after freezing. In no age group was the tenderizing of the foreshank significant. The tenderizing of the neck sample was significant or highly significant in all age groups with the exception of veal calves. Analysis of variance showed that tenderizing due to freezing was highly significant among age groups but not among samples from the same age group.

Tressler, Birdseye, and Murray (1932) compared the effects of storage at -20° F. on grade A and grade C sirloin steaks. The results showed that there was a gradual increase in the tenderness of both grades of meat for the period of the experiment, and that the tenderness was more pronounced in the case of the tougher steak than in the grade A sirloin. After five weeks storage the grade C steak was as tender as the grade A steak prior to freezing. In a later study Tressler and Murray (1932) aged sirloin steaks four days at 1° to 3° C. and then cut, packaged, froze and stored them at -18° C. for a month or longer. When thawed, these steaks were as tender and of better flavor than adjacent steaks aged six or seven days at 1° to 3° C. and then tested immediately without freezing.

According to Lowe (1943, p. 233) the cathepsin found in muscle tissue induces autolysis of the protein, thus increasing the tenderness of meat. Beef required 14 to 20 days storage at 1.7° C. (35° F.) to bring about a desirable degree of tenderness by this method.

Tauber (1949, p. 440) stated that "after death, animal tissues undergo a gradual self-digestion affected by autolytic enzymes such as cathepsin, lipase, nuclease, and others present in tissues. It is generally known that tissues frozen and then thawed decompose much faster than tissues that have not been frozen at all. Disruption of cells brings the substrate and the enzyme closer together." Balls and Lineweaver (1939) found that lipase action is considerable at low temperatures, whereas other enzyme action is slight. According to Tauber (1949, p. 440) even this slight action is important, owing to the fact that the first phase of enzyme attack, which has taken place during freezing, considerably hastens enzyme action when the materials are brought to ordinary room temperature.

The hydrolysis of meat by tissue-bound enzymes is a desirable process and is greatly accelerated by treating meat with various enzyme preparations (Tauber, 1949, p. 440). Lowe (1943, p. 234) found that when papain, a proteolytic enzyme, was applied to the surface of meat, as a liquid, dried powdered papain leaves, or bruised fresh papain leaves, time was required for the enzyme to act and then only a thin, powdery surface layer was formed due to the breakdown of the surface protein.

Papain is the name of the powdered latex of the green fruit of Carica papaya. The fresh latex contains a very powerful proteolytic enzyme system; however, due to its sensitivity to oxidation, half of the proteolytic power is soon lost. Prolonged oxidation renders the proteinases permanently inert. The inactivation at first may be reversed by treatment with reducing agents such as hydrogen sulfide and other sulfides, hydrogen cyanide, and sulfites. The chemical nature of the groupings of the proteinases has not been definitely established. Some fractions contain sulfhydryl groups and for this reason commercial papain cannot be kept too long. In normal times papain is the cheapest source of the commercial proteolytic enzyme. Another desirable property of papain is its relative resistence to heat (Tauber, 1949, p. 160).

Papain has been crystallized by Balls and Lineweaver (1939). They state that the enzyme is activated by cyanide, sulfhydryl compounds and the like, and will digest hemoglobin with a velocity comparable to the pancreatic proteinases. It also clots milk and hydrolyzes hippurylamide. It is quite stable in dilute alkali (up to a pH of 10.5) but is unstable in dilute acid (below pH 4.5). The isolated proteinase is but slightly soluble in dilute salt solutions, particularly at low temperatures, and behaves like prolamine to the extent that it is soluble in 70 percent alcohol. It is isoelectric at about pH 9.0 and has a molecular weight of about 27,000 measured by osmotic pressure. The proteinase contains 15.5 percent nitrogen, 1.2 percent total sulfur, 1.0 percent cystine sulfur, and 0.0 percent phosphorus.

Experiments by Gottschall (1944) showed that when inactive or nearly inactive papain is used in the digestion of beef muscles, the enzyme becomes progressively more active as the proteolysis proceeds. He attributes this activation to the fixed sulfhydryl groups of the muscle protein. Gottschall (1944) found that more papain was activated in ono hour at 70° C. than in 24 hours at 23° C. He stated that the more rapid activation at 70° C. is probably caused by the uncovering of a greater number of sulfhydryl groups as the beef is digested.

The National Cooperative Meat Investigations Committee on Preparation Factors (1942) stated that if the tenderness of meat is increased by the cooking process, it is brought about by two reactions: (1) the coagulation of soluble protein, which may be a toughening process under certain conditions and (2) the hydrolysis of collagen to gelatin, which is usually a tenderizing process. The total effect of these two processes depends upon the composition of meat, its acidity, and the temperature and rate at which it is cooked. If the protein coagulation predominates, as may occur in a cut low in collagen, the meat may become tougher upon cooking. If hydrolysis of the collagen predominates, the tenderness of the meat may be increased by cooking. They stated that tenderness of meat is increased with a low cooking temperature.

A U. S. Patent was issued in 1950 for a new aging process which speeds the tenderizing of beef by delaying the chilling of freshly slaughtered meat until after the period of rigor mortis has elapsed. According to this new process a freshly slaughtered carcass is immediately placed in a chamber maintained at 90 percent relative humidity and a temperature of 98.6° F. for four to five hours at the end of which time rigor mortis is complete. The carcass is then transferred to a cooler where the temperature is approximately 34° F. Processing the meat in this manner accelerates the transition period and toughening substantially is avoided.

A tenderizing device which has been patented, Science News Letter (1947), is an apparatus called a jet tenderizer. The jet tenderizer is electrically driven and equipped with a needle fine jet which sprays liquid at a very high pressure and drives droplets of tenderizing fluid into the meat. The fluids may be liquid fats, fiber softening enzymes, mild acid or anything else that will accomplish the purpose.

The "Tenderay" process, described by McCarthy and King (1942), consists of holding freshly slaughtered meat in a process room for 48 hours at 15.6° C., (60° F.) with a relative humidity of 85 to 90 percent in the presence of ultraviolet lamps. Tenderization by the Tenderay process takes place by a natural breakdown and softening of the meat's stringy connective tissue and muscle fibers by enzymatic action (Science Digest, 1949). By this process beef is tenderized in 44 hours which is 11.5 times faster than under the customary refrigeration. The ultraviolet radiation protects the meat from decomposition by bacteria and molds.

Some of the chemical changes that characterize the tenderization of beef by this process compared with standard low temperature (30 days at 35° F.) tenderization, reported by McCarthy and King (1942) were: (1) a more rapid rise in sulfhydryl content, (2) a more rapid increase in soluble nitrogen compounds, (3) a comparable rate of disappearance of vitamin C, and (4) a more rapid rise in hematin, a type of pigment in the press fluid. McCarthy and King (1942) quoted work done by Oppenheimer and Stern, in which they stated that the quick rise in sulfhydryl groups probably serves both to increase proteolytic activity and to inhibit oxidation of ascorbic acid.

The tenderness of U. S. Commercial grade animals was compared to the tenderness of U. S. Good grade animals in a study using the Tenderay process (Deatherage and Reiman, 1946). Tenderness values were obtained by duplicate testing of broiled short-loin steaks by a palatability panel consisting of six tasters. The U. S. Commercial grade carcasses showed somewhat greater improvement in tenderness when treated by the Tenderay process than the U. S. Good grade carcasses.

EXPERIMENTAL PROCEDURE

Meat Used

Paired rounds from three carcasses, graded U. S. Commercial, were used in this study. The untrimmed rounds were purchased from a Kansas City packing house and cut in the animal husbandry meats laboratory at Kansas State College. The thin covering of fat noticeable in Plate I is indicative of the low quality meat. One of the rounds from animal three was marked with tape to illustrate where the cuts were taken and is shown in Plates II and III. Plate IV shows the face of the round and the division into top and bottom round steaks.

The rounds were cut into top and bottom round steaks, sirloin tip steaks and rump roasts as follows:

	4	1.5-inch steaks per pound
Top round	8	1.5-inch steaks per pair of rounds
	24	1.5-inch steaks, total
Bottom	2	2.0-inch steaks per pound
round	4	2.0-inch steaks per pair of rounds
	12	2.0-inch steaks, total
	4	0.5-inch steaks per round
	8	0.5-inch steaks per pair of rounds
	24	0.5-inch steaks, total
Sirloin	4	1.0-inch steaks per round
tip	8	1.0-inch steaks per pair of rounds
	24	1.0-inch steaks, total
	3	3.0-inch roasts per pound
Rump roast	6	3.0-inch roasts per pair of rounds
	18	3.0-inch roasts, total

The three pairs of rounds were cut the same day. Each cut of meat was wrapped in Cellophane and waxed locker paper, and labeled. The meat was then frozen in a blast freezer at -10° F. and stored at 0° F. until it was used. The thaw loss of each cut was calculated from the weight of the frozen meat and the weight of the thawed meat. All the cuts from animal I were cooked first; the cuts from animal III were cooked next, and the cuts from animal II were cooked last. This order of cooking was determined by randomization.

EXPLANATION OF PLATE I

Top row, paired rounds from animal I.

Bottom row, left, paired rounds from animal II.

Bottom row, right, paired rounds from animal III.

PLATE I

EXPLANATION OF PLATE II

Top Round

The location of the one and one-half-inch top round steaks is indicated by strips of tape on the right of the round.

The location of the one-inch sirloin tip steaks is indicated by strips of tape on the left of the round.

EXPLANATION OF PLATE III

Bottom Round

The location of the two-inch bottom round steaks and the one-half-inch steaks is indicated by strips of tape on the left of the round.

The location of the one-inch sirloin tip steaks is indicated by strips of tape on the right of the round.

EXPLANATION OF PLATE IV

The Face of the Round with the Rump Removed

The horizontal tape separates the top and bottom round. The portion to the right of the vertical tape was used for round steaks. The portion to the lower left was used for sirloin tip steaks.

PLATE IV

Statistical Design

The steaks and roasts were cut as pairs. One steak from each pair was treated with a commercially prepared meat tenderizer* containing the proteolytic enzyme, papain, and the other steak was untreated. The steak from each pair that was treated was chosen at random. The following design was used for applying the treatment to the rump roasts:

Latin Square:

Left

	Animal Roast	I	II	III
Proximal End (Rump)	A'	T2	T1	T3
	B'	T1	T3	T2
Distal End (Shank)	C'	T3	T2	T1

Right

Animal Roast	I	II	III
A	T3	T1	T2
B	T1	T2	T3
C	T2	T3	T1

Treatments:
- T1 Untreated or control
- T2 The tenderizer was allowed to act on the meat for one hour at room temperature for each inch of thickness
- T3 The tenderizer was allowed to act on the meat for eighteen hours, total time, at refrigerator temperature.

* Adolph's Meat Tenderizer
Non-seasoned tenderizer contains salt, dextrose, hydrolyzed vegetable protein, calcium stearate and vitazyme brand vegetable enzyme made by a secret process from the tropical papaya melon.

Seasoned tenderizer contains salt, pure spices, dextrose and vitazyme.

Application of the Tenderizer

The seasoned tenderizer was used on the sirloin tip steaks and the non-seasoned tenderizer was used on the top and bottom round steaks and rump roasts. Six grams of tenderizer per pound of meat were used for all treated cuts. This amount was determined by preliminary experimental work.

A salt shaker was used to sprinkle a weighed amount of the tenderizer on the treated cuts. The meat was forked before and after applying the tenderizer. The tenderizer was applied to two sides of the steaks and to the entire surface of the roasts. The steaks were allowed to stand at room temperature for one hour for each inch of thickness. One-third of the roasts were untreated; one-third were treated with the tenderizer and allowed to remain in the refrigerator at approximately 35° F. for eighteen hours; and one-third were treated with the tenderizer and allowed to stand at room temperature for one hour for each inch of thickness. The thickness of the steaks and roasts was determined by measuring the height of the steaks and roasts in four places and taking the average.

Methods of Cooking

The methods of cooking used for the various cuts were: (1) broiling, top round steaks; (2) braising, two-inch bottom round steaks; (3) pan-frying, one-half inch bottom round steaks and the one-inch sirloin tip steaks; and (4) roasting, rolled rump roasts.

The steaks that were broiled were placed on a wire rack eight inches in height set in a shallow pan. The roasting pan was then placed in a rotary gas oven (Plate V), maintained at 400° F. The steaks were cooked to an internal temperature of 150° F. It was unnecessary to turn the steaks because the heat reached the steaks uniformly from all sides.

The braised steaks were slowly browned for seven and one-half minutes on each side in 20 grams of suet, then placed on a rack in covered enamel roasters with 30 grams of water. The steaks were then placed in a rotary gas oven heated to 300° F. and cooked to an internal temperature of 176° F.

The one-half-inch bottom round steaks and the sirloin tip steaks were pan-fried in 20 grams of suet for three minutes on each side for each one-half-inch of thickness. The skillet was heated to 400° F. and the gas flame was adjusted to maintain a temperature between 375° F. and 425° F. while the meat was frying. A griddle thermometer was used to check the temperature of the skillet.

The roasts were placed on a wire rack one inch in height which was set in a shallow roasting pan. They were then roasted in a rotary gas oven maintained at 300° F. to an internal temperature of 150° F.

The internal temperature of 150° F. for the broiled steaks and rump roasts and the cooking time for the pan-fried steaks was determined by preliminary experiments. At this internal tempera-

EXPLANATION OF PLATE V

Top round steaks ready to broil in a rotary gas oven.

PLATE V

ture or after the given frying time, the meat was medium-well-done.

Two pair or a total of four broiled, braised or one-inch pan-fried steaks, or three roasts were cooked and tested for palatability, shear value, and press fluid yields, at one time. Three pair or a total of six one-half-inch pan-fried steaks were cooked and tested for palatability, depth of penetration, and press fluid yields in one period.

Data Obtained

Palatability Scores. A panel of eight judges tasted and scored the meat for aroma, flavor of the lean, tenderness, and juiciness. The tasting was done in a tasting laboratory especially designed for this purpose, Plate VI. Scores were given within the range of 10, extremely good, to one, extremely poor, for each palatability factor, Form 1, Appendix. Each judge also rated the samples according to his first, second, third, etc. choice, depending on the number of samples being tasted. Tenderness scores were given on the basis of the number of chews it took to completely masticate a bite of meat of a certain size. The thickness of the samples, one-eighth of an inch, was regulated by cutting the meat on a General home slicer, Plate VII, and the sample for each judge was taken from approximately the same location in the cut every time. The scores of the judges were averaged for each factor and for each cut of meat.

Cooking Losses and Change in the Shape of the Meat. Total

EXPLANATION OF PLATE VI

Tasting Laboratory

Five of the eight judges who served on the palatability committee.

PLATE VI

EXPLANATION OF PLATE VII

Home Slicer

Slices cut from a cooked roast.

One inch core of cooked roast used in the shear test.

One inch metal cylinder used for removing core of meat used in the shear test.

PLATE VII

cooking losses were calculated for all cuts from the weight of the meat just before and immediately after cooking. In addition, volatile losses and dripping losses were determined for the rump roasts and broiled steaks. A record of the change in the shape of the steaks was made by tracing one surface of each cut before and after cooking and measuring, in centimeters, the length, width, and thickness of the cut before and after cooking. The thickness of each steak was measured in four places and the average measurements were used to designate the thickness of the meat. The measurements for length were taken as nearly as possible between the same points on each steak; the measurements for width were done in the same manner. The dimensions of the steaks were marked on the tracings and for permanent record the original tracings were copied on to clean paper. Plates VIII through XI give examples of the drawings made of the cooked steaks and indicate the areas from which samples for palatability were taken for each steak, and samples for press fluid yields, shear values,and penetrometer values when they were used.

Shear Values. Samples of cooked meat, one inch in diameter and parallel to the fiber axis, were removed from the meat with a sharp edged, metal cylinder, Plate XII. These samples were used to measure tenderness by mechanical means. One sample from each roast (Plate VII), and two samples from the broiled (Plate XIII), braised, and one-inch pan-fried steaks were cut on the Warner-Bratzler shear apparatus, Plate XIV. This apparatus measures the number of pounds of force required for a dull blade to

EXPLANATION OF PLATE VIII

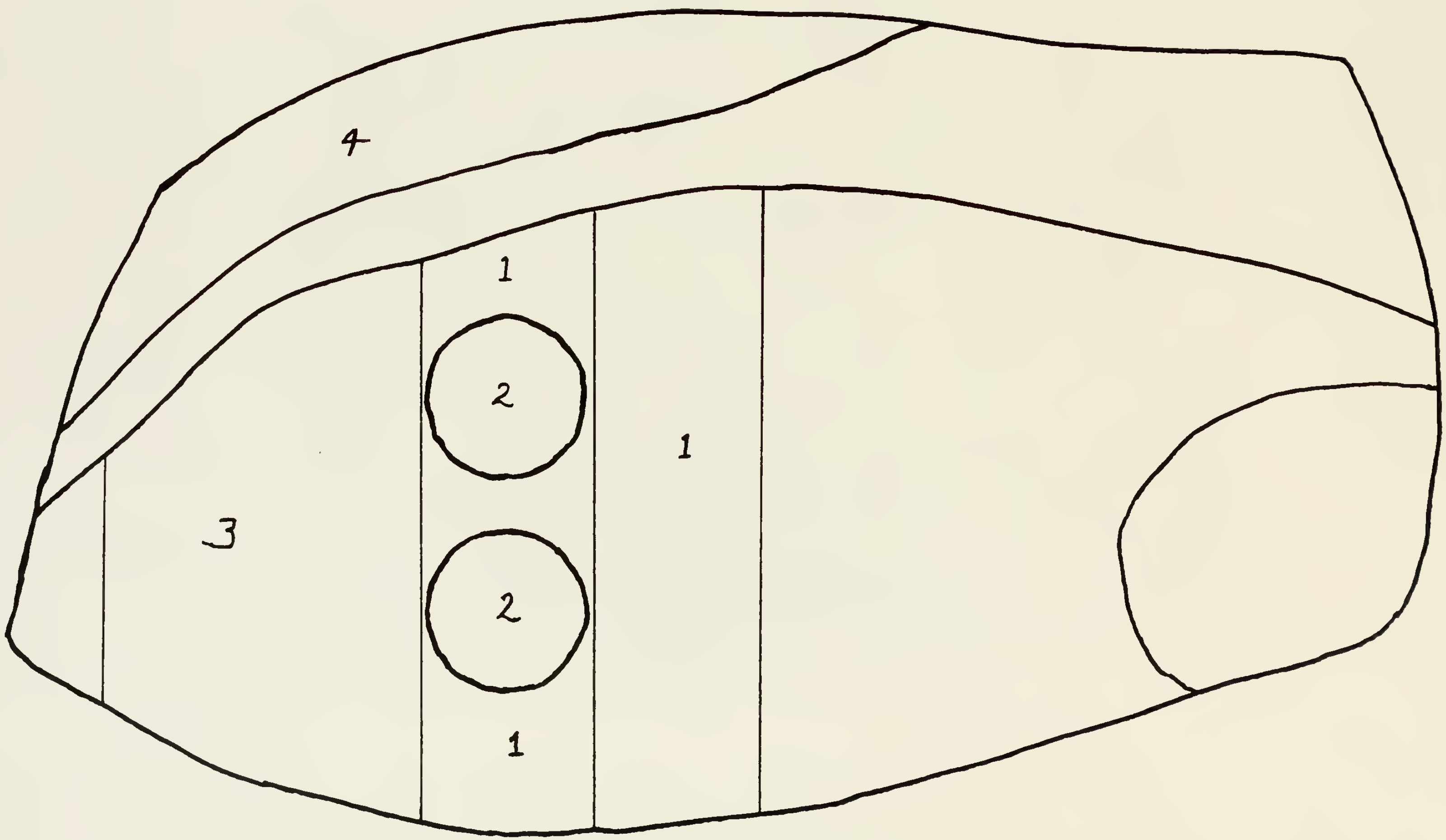
One and One-half-inch Top Round Steak

Semimembranosus Muscle

1. Press fluid
2. Shear
3. Palatability

4. Fat

PLATE VIII



EXPLANATION OF PLATE IX

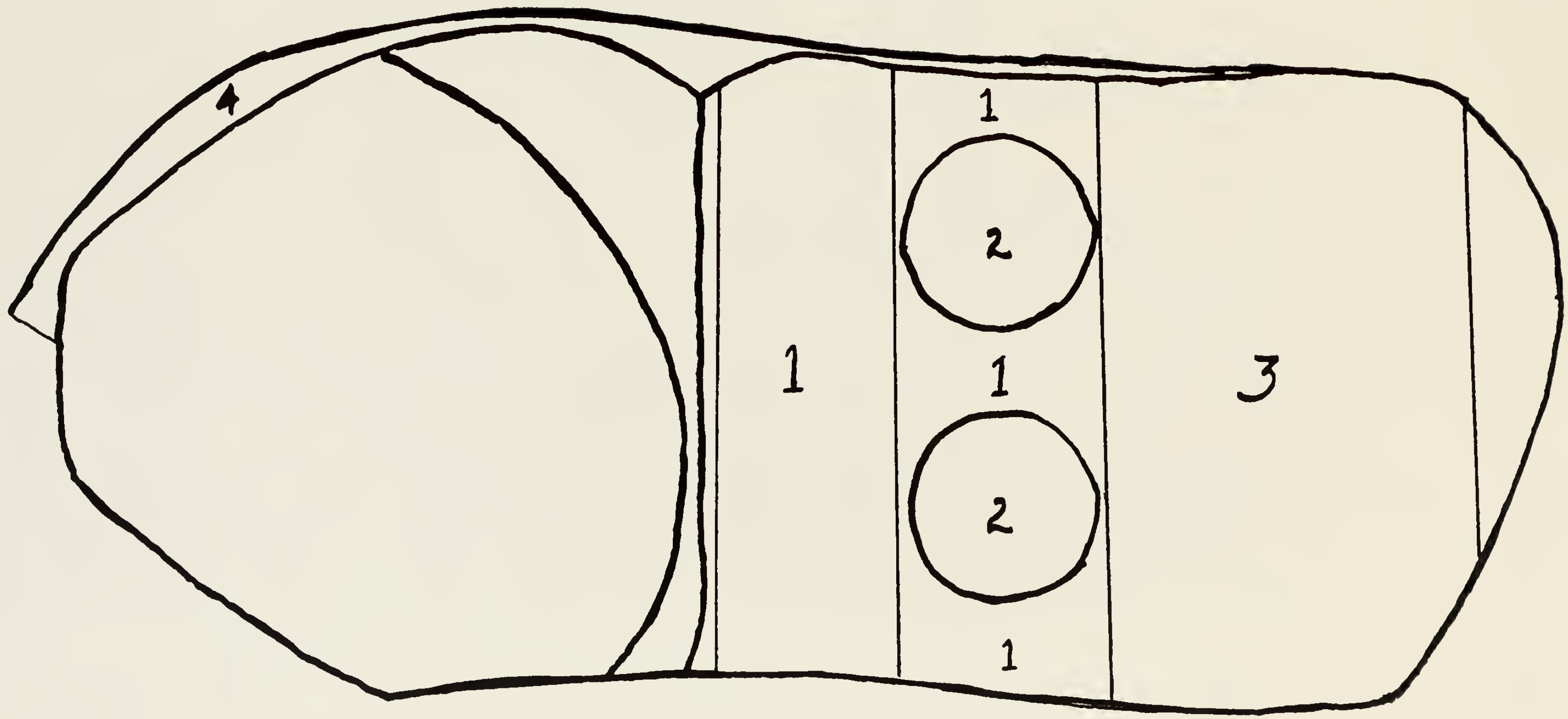
Two-inch Bottom Round Steak

Biceps Femoris Muscle

1. Press fluid
2. Shear
3. Palatability

4. Fat

PLATE IX



EXPLANATION OF PLATE X

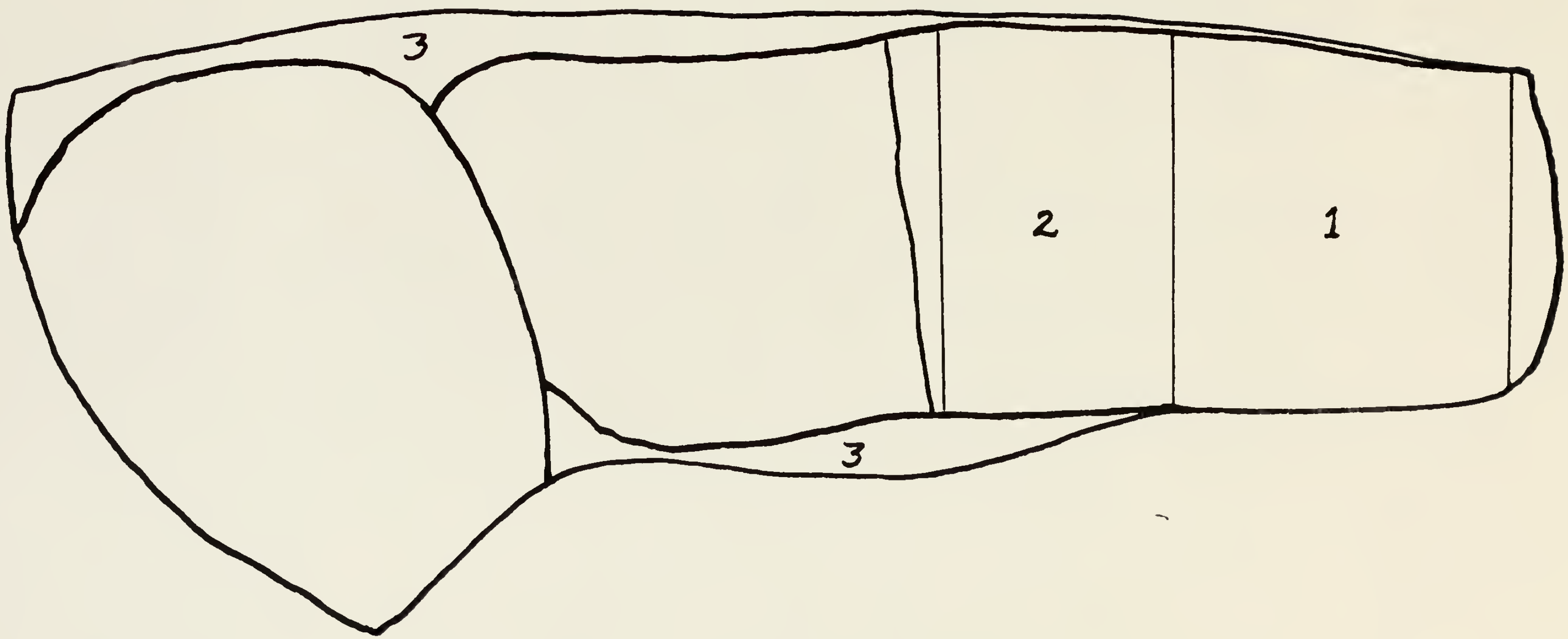
One-half-inch Bottom Round Steak

Biceps Femoris Muscle

1. Palatability
2. Penetrometer

3. Fat

PLATE X

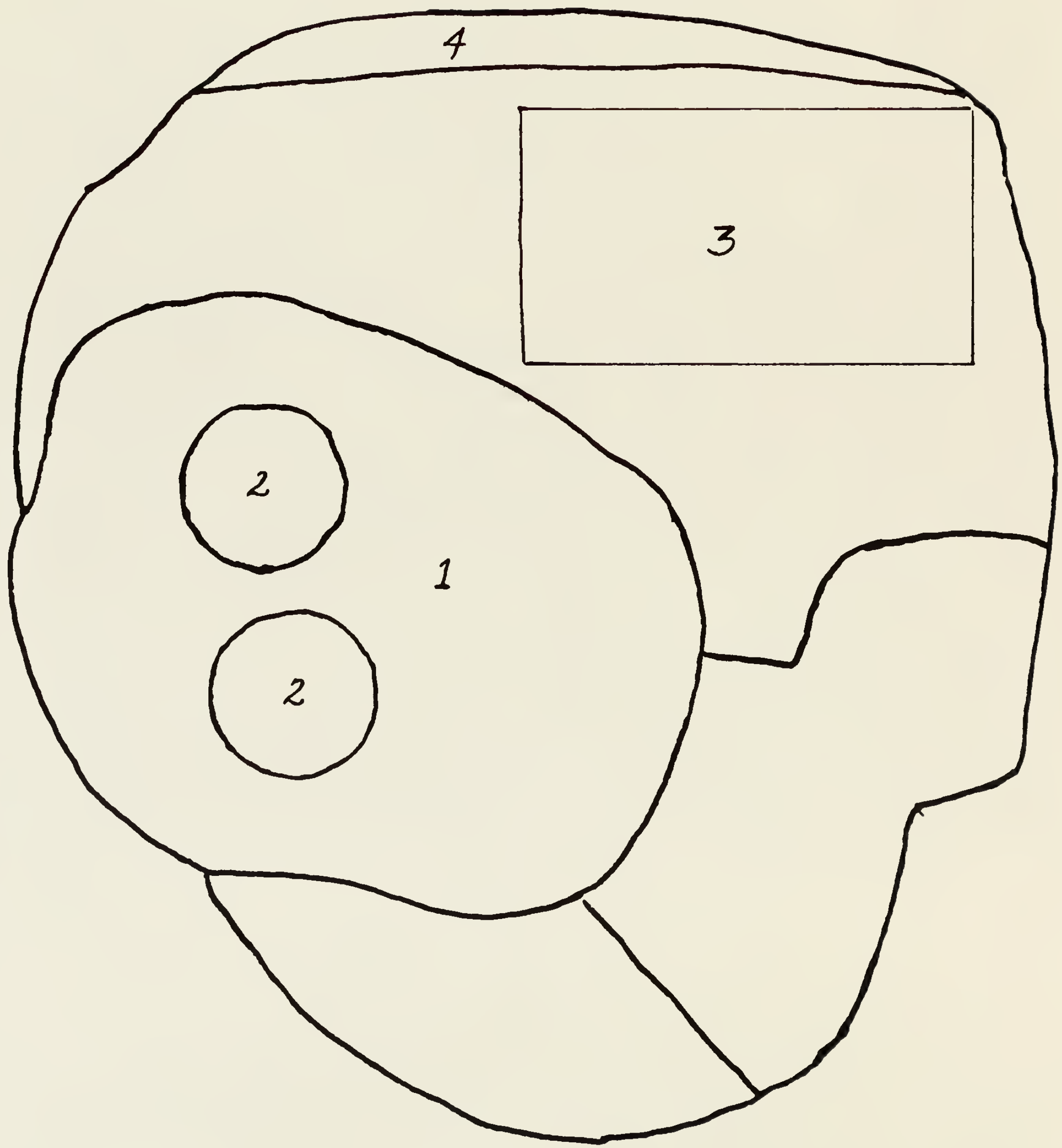


EXPLANATION OF PLATE XI

One-inch Sirloin Tip Steak

1. Press fluid
2. Shear
3. Palatability
4. Fat

PLATE XI



EXPLANATION OF PLATE XII

Removing a one-inch sample from a rump roast to be used for the shear test.

PLATE XII

EXPLANATION OF PLATE XIII

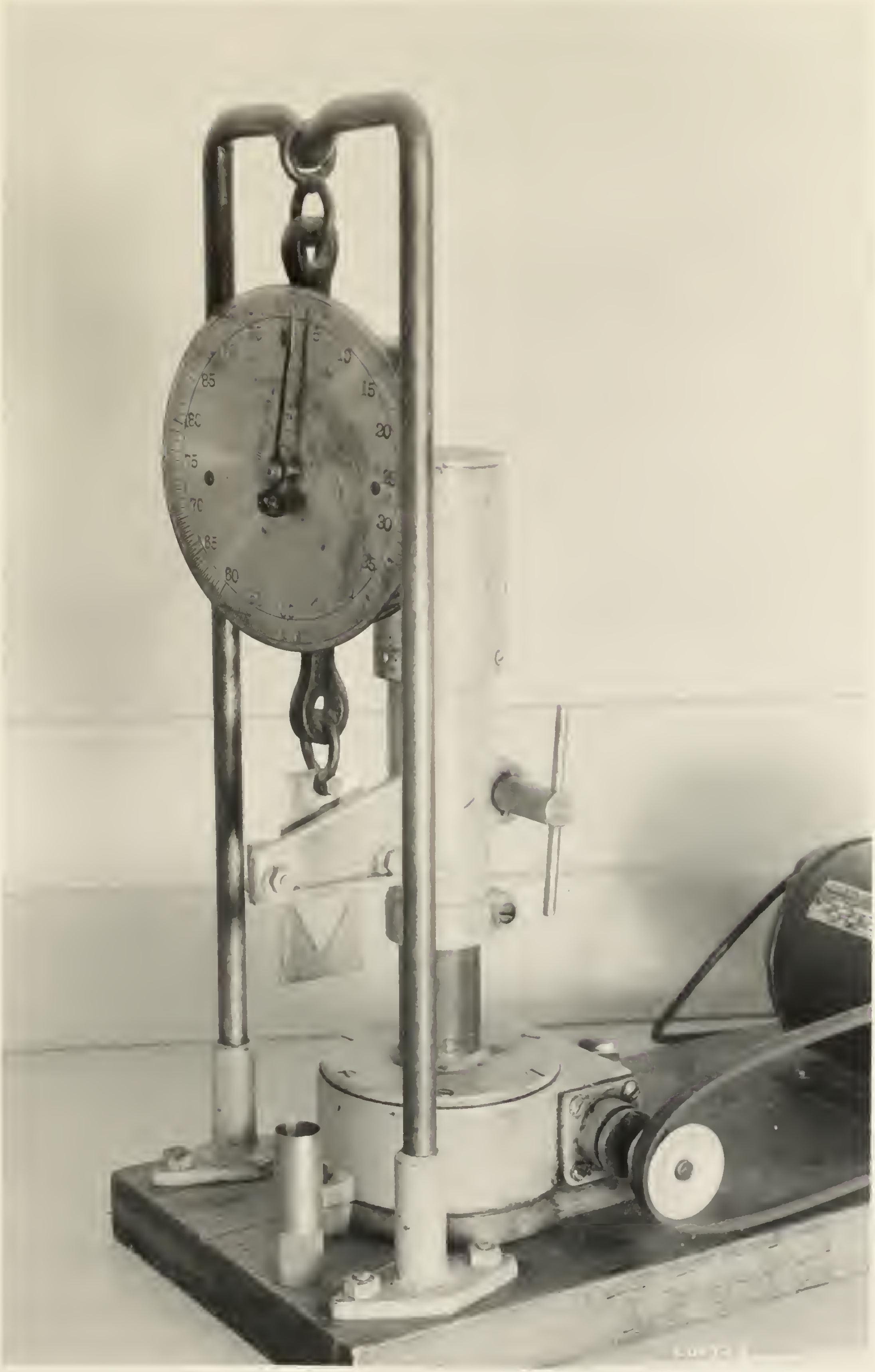
Broiled Top Round Steaks

The steak at the left is cut to show the palatability slices (lower portion, minus the tip), cores used for the shearing test, and the center portion used for press fluid yields.

PLATE XIII

EXPLANATION OF PLATE XIV

Warner-Bratzler Shear Apparatus



cut through a cylinder of meat one inch in diameter. The values obtained from four shears on the sample or samples taken from the cut were averaged and called the shear value for the cut.

Press Fluid Yields. Press fluid yields were obtained on the roasts, broiled, braised, and one-inch pan fried steaks. The visible fat and muscle sheath were trimmed from the cooked meat used for press fluid determinations and the meat was ground in a Universal No. 3 food grinder. The fluid was pressed from 25 gram samples of the ground meat in a Carver Laboratory Press, Plate XV. A 2.25-inch metal cylinder was lined with two thicknesses of cheese cloth and a piece of 5.5 centimeter filter paper was placed on top of the cheese cloth in the bottom of the cylinder. The ground meat was added to the cylinder in three layers with a piece of filter paper between each layer. A piece of filter paper and a leather disc were placed on top of the last layer of meat, then a heavy metal plunger was placed in the cylinder. The packed cylinder was placed in a shallow stainless steel pan and the entire assembly was placed in the hydraulic press. Pressure was gradually applied over a period of 15 minutes 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

* 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.

EXPLANATION OF PLATE XV

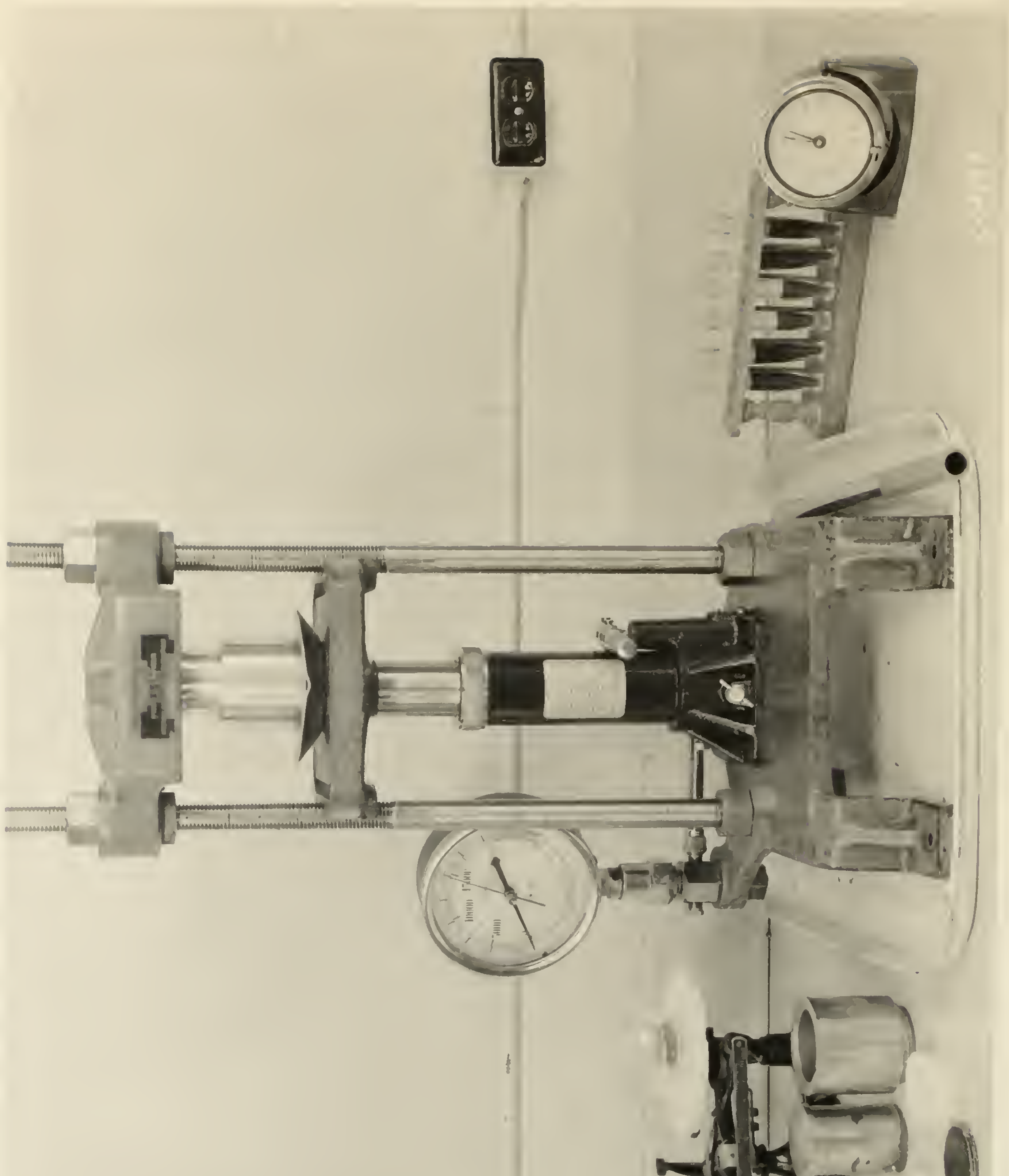
Carver Laboratory Press and Accessories

Right of press. Time clock and rack with centrifuge tubes containing press fluid.

Left of press. Scales with a tare equivalent to 25 grams, test cylinder, metal plunger, filter paper, cheese cloth, and leather disc.

A packed test cylinder is in the press ready for operation.

PLATE XV



When the pressure was released, the pan and cylinder were removed from the press. The cylinder was removed from the pan and any fluid or fat still clinging to the bottom of the cylinder was scraped into the pan with a rubber policeman. The fluid in the pan was poured into centrifuge tubes that were graduated to 0.1 milliliter and any fluid or fat remaining in the pan was scraped into the tube with a rubber policeman. The tubes were placed in the refrigerator and allowed to stand overnight. The next day the tubes were read and the total volume of press fluid, the volume of fat, and the volume of serum were recorded. Duplicate determinations were made on each sample.

Penetrometer Test. The "Precision" Universal Penetrometer was used to measure by mechanical means, the tenderness of the one-half-inch pan-fried steaks, Plate XVI. This apparatus measures in tenths of millimeters the depth of penetration into a sample of meat. A 100-gram and a 50-gram weight were used to force the test rod into the meat. A sample, varying from one to one and one-half inches in length (Plate XVI), was taken from the cooked steak and used for this test. The average of six penetration readings for each sample was considered an index as to the tenderness of the steaks.

Consumer Preference Test. A consumer preference test was made to determine if a group of 100 people had a preference for meat treated with the commercially prepared seasoned and non-seasoned tenderizers or for meat that was not treated. Three one-inch sirloin tip steaks were used for this test. One steak

EXPLANATION OF PLATE XVI

"Precision" Universal Penetrometer

Samples of one-half-inch steak ready to be tested.

was not treated, one steak was treated with the seasoned tenderizer, and one steak was treated with the nonseasoned tenderizer. The three steaks were broiled to an internal temperature of 150° F. in an electric broiler. The steaks were cut into bite size samples and each sample pierced with a toothpick. A white toothpick was used for the untreated steak, a toothpick dipped in red food coloring was used for the seasoned, and a toothpick dipped in green food coloring was used for the nonseasoned sample. One hundred judges, selected at random during the first day of Hospitality Days at Kansas State College, tasted the three samples offered them and listed their preference according to the color of the toothpick.

Analysis of Variance

A separate analysis of variance was run on the total cooking losses, tenderness, flavor, and juiciness scores for each cut of meat used in the study. Also a separate analysis of variance was run on the shear values, penetrometer readings, and press fluid yields, when they were used.

RESULTS AND DISCUSSION

Thaw Losses

The average thaw losses for the different cuts of meat from three animals are shown in Table 1. The one-inch pan-fried steaks lost the most weight during thawing and the roasts lost the least weight during thawing. The average thaw losses for the broiled, braised, and one-half-inch steaks varied only 0.4 percent. The percentage thaw loss for the top and bottom round steaks from the right and left sides of the animals varied only 0.1 percent. There were greater variations in the thaw loss between the right and left sides for the sirloin tip steaks (0.6 percent) and the rump roasts (1.0 percent).

Table 1. The average thaw losses for steaks and roasts from three animals.

Cut	Loss Pct.
Broiled steaks	2.5
Braised steaks	2.2
Pan-fried steaks (0.5 in.)	2.1
Pan-fried steaks (1.0 in.)	3.3
Rump roasts	0.7

Cooking Time and Cooking Losses

Broiled Steaks. The average cooking time per pound of meat for each treatment is given in Table 2. The treated broiled steaks required 1.3 minutes per pound less cooking time than the untreated steaks. The treated steaks cooked in 26.3 minutes per pound and the untreated in 27.6 minutes per pound of meat.

The following plan was used for statistical analyses of the data obtained from the steaks:

Source of variation	D/F Broiled	D/F Braised	D/F Pan-fried
Treatment	1	1	1
Animal	2	2	2
T X A	2	2	2
Position	3	1	3
Remainder	15	5	15
Total	23	11	23

Table 2. Average cooking time, volatile, dripping, and total cooking losses of broiled steaks.

Animal	Cooking time Min./lb.		Volatile loss %		Dripping loss %		Total loss %	
	T	Unt	T	Unt	T	Unt	T	Unt
I	22.9	29.0	16.0	18.6	4.4	3.5	20.8	23.5
II	32.2	28.9	19.2	21.0	4.0	3.0	23.3	24.0
III	23.7	25.6	19.6	22.9	4.8	3.8	24.9	26.8
Average	26.3	27.6	18.3	20.8	4.3	3.4	23.0	24.8

T Treated.
Unt Untreated.

The differences were considered statistically significant if the F value reached the five percent level of significance and highly significant if it exceeded the one percent level. The terms significant and highly significant will be used in this manner throughout the discussion of the statistical analyses.

The total cooking losses, Table 2, were less for the treated than for the untreated steaks. This result is in line with the shorter cooking time for the treated steaks. The total cooking losses for the treated steaks was 23 percent and for the untreated steaks 24.8 percent, a difference of 1.8 percent. Analysis of variance showed that this difference between treatments was not great enough to be significant, however, the difference in total cooking losses among animals was significant. The volatile loss was less for the treated than for the untreated steaks but the dripping loss was less for the untreated than for the treated steaks.

Braised Steaks. The length of cooking time per pound of meat, Table 3, was considerably less for the treated than for the untreated steaks. The average cooking time was 22.5 minutes per pound for the treated steaks and 28.3 minutes per pound for the untreated; a difference of 5.8 minutes per pound.

The total cooking losses, Table 3, were 33.4 percent for the treated steaks and 30.4 percent for the untreated. Analysis of variance showed no significant difference between the treatments for the total cooking losses. Volatile and dripping losses were not calculated as such for the braised steaks.

Table 3. Average cooking time and total cooking losses of braised steaks.

Animal	Cooking time Min./lb. Treated	Cooking time Min./lb. Untreated	Cooking losses Pct. Treated	Cooking losses Pct. Untreated
I	21.0	31.3	31.9	29.8
II	23.7	25.4	36.5	30.3
III	22.9	28.2	31.8	31.0
Average	22.5	28.3	33.4	30.4

One-half-inch Pan-fried Steaks. The one-half-inch steaks were fried in 20 grams of suet for three minutes on each side, or a total time of six minutes, and the cooking time per pound was not calculated. The total cooking losses, Table 4, were 17.7 percent for the treated and 19.0 percent for the untreated steaks, a difference of 1.3 percent. Analysis of variance showed that this difference between treatments was not great enough to be significant. The volatile and dripping losses were not calculated for the one-half-inch pan-fried steaks.

One-inch Pan-fried Steaks. The one-inch steaks were fried in 20 grams of suet for six minutes on each side, a total cooking time of 12 minutes, and as in the case of the one-half-inch steaks, the cooking time per pound of meat was not calculated.

Table 4 gives the total cooking losses for each treatment. The total cooking losses were 16.5 percent for the treated and 15.9 percent for the untreated steaks, a difference of only 0.6 percent. This difference between treatments was not great enough to be significant when analyzed statistically.

Table 4. Average total cooking losses of one-half-inch and one-inch pan-fried steaks.

Animal	One-half-inch %		One-inch %	
	Treated	Untreated	Treated	Untreated
I	19.7	16.8	16.3	16.1
II	16.8	20.9	15.5	15.1
III	16.6	19.4	17.6	16.6
Average	17.7	19.0	16.5	15.9

Rump Roasts. Table 5 shows the average cooking time per pound of meat and the percentage of volatile, dripping, and total cooking losses for the untreated roasts, the roasts treated with the tenderizer at room temperature, and the roasts treated with tenderizer at refrigerator temperature. Both of the groups that were treated with the tenderizer cooked in slightly less than 45 minutes per pound. The roasts that were not treated, cooked in 52.3 minutes per pound; thus, the treatment with the tenderizer decreased the cooking time by approximately seven minutes per pound when the meat was roasted at 300° F.

It is interesting that there was not any difference in the cooking time required for the roasts in which the tenderizer remained on the meat for three hours at room temperature and for those in which the tenderizer remained on the roasts for 18 hours at refrigerator temperature before cooking. The internal temperature of the roasts at the time they were placed in the oven was lower for the roasts treated at refrigerator temperature than

Table 5. Average cooking time, volatile, dripping, and total cooking losses of rump roasts.

Animal	Cooking time Min./lb.			Volatile loss %			Dripping loss %			Total loss %		
	T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3
I	54.2	43.8	47.3	16.1	14.6	12.1	5.2	7.2	7.6	21.4	21.8	19.7
II	46.5	45.8	43.2	18.0	16.9	15.7	4.2	6.1	6.7	22.4	23.3	22.5
III	56.3	44.8	44.5	15.8	15.6	15.6	3.6	7.2	7.2	19.5	23.3	23.0
Average	52.3	44.8	44.9	16.6	15.7	14.5	4.3	6.8	7.2	21.1	22.8	21.7

T1 Untreated.
T2 Treated three hours at room temperature.
T3 Treated eighteen hours at refrigerator temperature.

for the roasts treated at room temperature or the untreated roasts. The last two groups of roasts remained at room temperature for three hours before cooking time.

The following plan was used for statistical analyses of the data obtained from the roasts:

Source of Variation	D/F
Side (left and right)	1
Treatment	2
Animal	2
Position	2
Error	10
Total	17

Analysis of variance showed no significant difference among the treatments in the total cooking losses. However, the average total cooking losses, Table 5, were least for the untreated group and highest for the group treated at room temperature. The difference was 1.7 percent between the untreated roasts and the roasts treated at room temperature and 1.1 percent between the roasts treated at refrigerator temperature and those treated at room temperature.

The volatile loss, Table 5, was least for the roasts treated at refrigerator temperature and greatest for the untreated roasts. The dripping loss was the least for the untreated roasts and the greatest for the roasts treated at refrigerator temperature.

Plate XVII shows three roasts before cooking and Plate XVIII shows the same three roasts after cooking. These roasts were representative of the roasts used in this study. The tenderizer can be seen on top of the roast at the right in Plate XVII.

EXPLANATION OF PLATE XVII

Rump Roasts Before Cooking

Left, untreated.

Center, treated 18 hours at refrigerator temperature.

Right, treated 3 hours at room temperature.

PLATE XVII

EXPLANATION OF PLATE XVIII

Rump Roasts After Cooking

Left, untreated.

Center, treated 18 hours at refrigerator temperature.

Right, treated 3 hours at room temperature.

PLATE XVIII

This was the roast on which the tenderizer was allowed to act at room temperature for three hours before cooking. The roast in the center was treated with the tenderizer and allowed to stand at refrigerator temperature for 18 hours. Note that the tenderizer is not noticeable on the surface of this roast. Also, the surface of the roast treated at refrigerator temperature was slimy before cooking which was not the case for the roast treated at room temperature. The roast on the left was untreated.

Comparison of the Treated and Untreated Cuts. The cooking time per pound of the broiled and braised steaks and the roasts treated with tenderizer was less than for the untreated steaks or roasts. The cooking time per pound was not calculated for the pan-fried steaks, as these steaks were cooked a certain length of time based on the thickness rather than the weight of the steak. The treated pan-fried steaks appeared to be more well done than the untreated steaks when cooked for the same length of time. Also the treated broiled, braised, and roasted cuts cooked to a given internal temperature had the appearance of being well done while the untreated cuts cooked to the same internal temperature had the appearance of medium doneness. The breakdown of the muscle of the cuts treated with the tenderizer probably allowed for a faster rate of heat penetration and may account for the shorter cooking time.

A comparison of the total cooking time and the total cooking losses of the broiled steaks show that both were less for the treated than for the untreated steaks. For the braised steaks and the roasts, the cooking losses were less for the untreated cuts, whereas the cooking time was less for the treated cuts. The cooking losses were less for the treated one-half-inch pan-fried steaks than for the untreated steaks, but the cooking losses were less for the one-inch untreated pan-fried steaks than for the treated steaks.

Change in Shape

Table 20, Appendix, represents the percentage increase or decrease in thickness, length, and width of the broiled steaks. The figures were not averaged because there was a wide variation in the percentage changes within each dimension measured and the treatment did not seem to have any effect on the direction in which the meat shrank. All the treated steaks decreased in thickness; six decreased and six increased in length, whereas, five decreased, five increased, and two did not change in width. Eleven of the untreated steaks decreased in thickness and one increased; ten steaks decreased and two increased in length; five decreased and seven increased in width.

The percentage increase or decrease in thickness, length and width of the braised steaks is shown in Table 21, Appendix. All of the treated steaks decreased in thickness and length; four treated steaks decreased in width, one steak increased, and one steak did not change in width. All of the untreated steaks decreased in thickness and length; four steaks decreased in width and two steaks did not change in width.

Table 22, Appendix, represents the percentage of increase or decrease in thickness, length, and width of the one-half-inch pan-fried steaks. Seven of the treated steaks decreased, one increased, and four did not change in thickness; all treated steaks decreased in length, seven decreased in width, four increased, and one did not change in width. Nine of the untreated steaks decreased, two increased, and one did not change in thickness; ten untreated steaks decreased, one increased, and one steak did not change in length; eight steaks decreased, two steaks increased, and two steaks did not change in width.

Table 23, Appendix, represents the percentage decrease or increase in thickness, length, and width of the one-inch pan-fried steaks. Seven treated steaks decreased, four increased, and one did not change in thickness; seven treated steaks decreased and five increased in length; three steaks decreased, seven increased, and two did not change in width. Seven of the untreated steaks decreased, two increased, and three did not change in thickness; seven untreated steaks decreased and five increased in length; six steaks decreased and six increased in width.

When meat is cooked it usually shrinks in the direction of the fibers. However, both the fibers and connective tissue tend to contract and large amounts of connective tissue may cause the meat to shrink in directions other than with the length of the fibers. The steaks in this study were cut across the fibers so that the fibers ran parallel to the dimension called thickness. Most of the broiled and braised steaks, both those treated with tenderizer and the untreated steaks, decreased in thickness or shrank in the direction of the fibers. However, there was some variation in the direction of shrinkage of the pan-fried steaks. This variation in the sirloin tip pan-fried steaks was perhaps due to the fact that more muscles were present in these steaks than in the top or bottom round steaks. With a greater number of muscles, there would be more heavy connective tissue because of the sheath around each muscle. Although the one-half-inch pan-fried steaks contained the same two muscles as the two-inch braised steaks, they may have had more connective tissue than the two-inch steaks because they were cut closer to the distal end of the bottom round. Also the thickness of the steaks and the method of cooking may have attributed to the differences in the change in the shape of the thick and thin steaks from the bottom round.

Flavor and Aroma

Broiled Steaks. The palatability scores, Table 6, indicated little difference in either the flavor or aroma of the treated and untreated broiled steaks. The average flavor score was 8.1 for the treated steaks and 7.9 for the untreated steaks. Aroma scores averaged 7.4 for the treated and 7.3 for the untreated steaks. Analysis of variance showed no significant difference in flavor due to treatment.

Braised Steaks. The average flavor score was 7.3 for the treated braised steaks, Table 6, and 7.0 for the untreated.

Table 6. Judges' average scores* for aroma, flavor of lean, tenderness and juiciness, and average shear values and press fluid yields for broiled, braised, and the one-inch pan-fried steaks.

Cut	Factor	Animal I		Animal II		Animal III		Av. for three animals	
		T	Unt	T	Unt	T	Unt	T	Unt
Brl.	Aroma	8.1	8.0	7.9	7.9	6.2	6.1	7.4	7.3
	Flavor of lean	8.5	8.0	7.9	7.9	8.0	7.8	8.1	7.9
	Tenderness	8.5	6.8	8.8	7.5	8.0	6.9	8.4	7.1
	Shear value, lbs.	17.6	24.9	15.3	23.3	21.4	29.5	18.1	25.9
	Juiciness	7.2	7.6	6.9	7.8	7.0	7.1	7.0	7.5
	Press fluid, ml	9.2	9.2	9.0	9.2	8.9	8.5	9.0	8.9
Brs.	Aroma	7.7	8.0	7.7	7.5	8.0	7.2	7.8	7.6
	Flavor of lean	8.0	7.0	7.3	7.2	6.7	6.8	7.3	7.0
	Tenderness	8.0	5.8	7.7	6.7	6.4	6.0	7.4	6.2
	Shear value, lbs.	12.8	20.5	20.3	27.7	20.5	32.6	17.9	26.9
	Juiciness	5.7	5.5	4.7	5.1	4.9	4.9	5.1	5.1
	Press fluid, ml	7.6	7.9	6.8	7.8	7.0	7.6	7.1	7.8
P.-fried (1.0 in.)	Aroma	7.6	7.9	8.4	8.5	7.9	8.1	7.9	8.2
	Flavor of lean	7.8	7.9	8.4	7.8	8.1	7.8	8.1	7.9
	Tenderness	8.5	7.4	8.3	7.2	8.3	6.9	8.4	7.2
	Shear value, lbs.	18.4	24.5	23.6	28.2	19.7	31.2	20.6	27.9
	Juiciness	7.9	8.6	7.9	8.6	7.6	8.5	7.8	8.6
	Press fluid, ml	8.9	9.2	8.4	9.3	9.0	9.6	8.8	9.4

* Highest possible score, 10.
T Treated.
Unt Untreated.

The aroma of the treated steaks was also preferred by a small margin. The judges' aroma scores averaged 7.8 for the treated and 7.6 for the untreated steaks. Analysis of variance showed no significant difference in flavor due to treatment, but the difference in flavor among animals was significant.

One-half-inch Pan-fried Steaks. The flavor and aroma scores of the one-half-inch pan-fried steaks are given in Table 7. According to the terminology on the score card (Form I, Appendix) the judges scored the flavor of the treated steaks slightly above "good" (8.2 points) and the flavor of the untreated steaks between "medium plus to good" (7.5 points). When analyzed statistically, this difference was not significant. The judges' average scores for aroma were 7.4 points for the untreated and 7.1 points for the treated steaks.

One-inch Pan-fried Steaks. The sirloin tip steaks were treated with the seasoned tenderizer. The judges' scores for flavor are given in Table 6. The treated steaks were scored slightly above "good" (8.1 points) and the untreated were scored slightly below "good" (7.9 points), a difference of 0.2 point. Analysis of variance showed that this difference was not great enough to be significant. The one-inch pan-fried or sirloin tip steaks were treated with the seasoned tenderizer. All other treated cuts were treated with the non-seasoned. For the first few tasting periods, at least half of the judges preferred the flavor of the untreated steak to that of the steak treated with the seasoned tenderizer, but by the last of the tasting periods

Table 7. Judges' average scores* for aroma, flavor of lean, tenderness, and juiciness, and average of the penetrometer readings in millimeters for the one-half-inch pan-fried steaks.

Factor	Animal I		Animal II		Animal III		Av. for three animals	
	T	Unt	T	Unt	T	Unt	T	Unt
Aroma	6.1	7.2	7.8	7.6	7.4	7.5	7.1	7.4
Flavor of lean	7.9	7.3	8.2	7.8	8.4	7.3	8.2	7.5
Tenderness	7.6	6.6	8.2	7.8	8.8	6.9	8.2	7.1
Penetrometer, mm	6.6	6.6	6.4	5.8	8.2	7.8	7.1	6.7
Juiciness	7.2	6.8	7.3	7.7	7.0	8.0	7.2	7.5

* Highest possible score, 10.
T Treated.
Unt Untreated.

for these steaks, more of the judges preferred the steaks treated with the seasoned tenderizer than the untreated. This trend is indicated by the flavor scores for each animal, Table 6. The steaks from animal I were cooked and tested first and the judges' scores show that the untreated steaks were preferred for flavor; animal III was cooked and tested next and the steaks treated with the seasoned tenderizer were preferred to the untreated, but not by as large a margin as for treated steaks from animal II which were cooked last. The most frequent comment made by the judges regarding the seasoned tenderizer concerned the pronounced garlic flavor. Some of the judges liked this flavor and some did not; no doubt this was a deciding factor concerning the flavor score for the steak treated with the seasoned tenderizer. The judges' average scores, Table 6, for aroma were higher by 0.3 point for the untreated than for the treated steaks.

Rump Roasts. Analysis of variance showed no significant difference in the flavor of the roasts attributable to treatments. However, the average score, Table 8, was 0.2 point higher for the untreated roasts than for the roasts that were treated at room temperature, and the roasts treated at room temperature were scored 0.1 of a point higher than the roasts treated at refrigerator temperature.

The aroma scores were the same for the untreated roasts and those treated at room temperature, but the roasts treated at refrigerator temperature were scored 0.1 of a point lower. The range of the aroma scores was 7.7 to 7.8.

Table 8. Judges' average scores* for aroma, flavor of lean, tenderness, and juiciness, and average shear values and press fluid yields for rump roasts.

Factor	Animal I			Animal II			Animal III			Av. for three animals		
	T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3
Aroma	8.1	8.2	7.6	7.6	7.3	7.5	7.8	7.8	7.9	7.8	7.8	7.7
Flavor of lean	8.2	7.8	7.3	8.3	7.5	8.0	7.4	7.7	7.6	7.9	7.7	7.6
Tenderness	8.0	7.9	7.7	7.7	8.0	7.5	7.4	7.4	7.4	7.7	7.8	7.5
Shear value, lbs.	24.0	14.6	10.8	15.6	16.4	23.3	15.3	13.9	24.0	18.3	13.9	19.3
Juiciness	7.4	6.9	7.1	8.0	5.6	7.4	7.5	6.5	7.0	7.6	6.7	7.1
Press fluid, ml	7.7	8.0	8.2	8.0	7.2	8.4	8.4	8.3	8.7	8.0	7.8	8.5

* Highest possible score, 10.
T1 Untreated.
T2 Treated one hour at room temperature for each inch of thickness.
T3 Treated eighteen hours at refrigerator temperature.

<u>Comparison of the Flavor of the Treated and Untreated Cuts</u>. Average scores for flavor of the treated broiled, braised, and pan-fried steaks were slightly higher than for the untreated steaks; however, the average scores were higher for the untreated roasts than for the treated roasts. Table 9 gives the average scores for each treatment and method of cooking.

Table 9. Average flavor scores for each method of cooking.

Method of cooking	Treated	Untreated
Broiled	8.1	7.9
Braised	7.3	7.0
Pan-fried (0.5 in.)	8.2	7.5
Pan-fried (1.0 in.)	8.1	7.9
Roast	7.7 T2 7.6 T3	7.9

T2 Treated three hours at room temperature.
T3 Treated eighteen hours at refrigerator temperature.

The average flavor scores, Table 9, and the preference ratings, Table 10, for each treatment, were in agreement in that they both indicate a preference for the treated steaks. Each judge rated the samples according to her first, second, third, etc. choice, depending upon the number of samples being tasted.

Table 10. Preference ratings for broiled, braised, and pan-fried steaks.

Cut	Choice	Treated %	Untreated %
Broiled steak	1st	63	37
	2nd	58	42
	3rd	45	55
	4th	29	71
Braised steak	1st	67	33
	2nd	67	33
	3rd	50	50
	4th	25	75
Pan-fried steak (0.5 inch thick)	1st	71	29
	2nd	63	37
	3rd	46	54
	4th	20	80
	5th	21	79
	6th	33	67
Pan-fried steak (1.0 inch thick)	1st	76	24
	2nd	62	38
	3rd	25	75
	4th	13	87

The average flavor scores, Table 9, and the preference ratings for the roasts, Table 11, are in agreement in that they both indicate a preference for the untreated roasts. In a number of cases the judges commented that the flavor of the treated roasts was too strong and also the texture was "mushy" or "mealy". The surface area for the roasts was much less than for the other cuts, thus the concentration of tenderizer in contact with the surface of the meat was greater. Also the tenderizer remained on the roasts for a considerably longer time than for the other cuts of meat.

Table 11. Preference ratings for rump roasts.

Choice	Treatment T1 %	T2 %	T3 %
First	76	12	12
Second	16	38	46
Third	30	40	30

T1 Untreated.
T2 Treated three hours at room temperature.
T3 Treated eighteen hours at refrigerator temperature.

Tenderness

Broiled Steaks. The judges scored, Table 6, the treated broiled steaks between tender and very tender (8.4 points), and the untreated steaks just slightly above medium plus (7.1 points). Analysis of variance showed that this difference was highly significant.

The average shear force values for the treated steaks, Table 6, was 18.1 pounds and 25.9 pounds for the untreated; a difference of 7.8 pounds. Analysis of variance showed that this difference also was highly significant. Since a high score and a low shear force indicate tender meat, these two methods of measuring tenderness were in agreement that the tenderizer was effective in making these steaks more tender.

Braised Steaks. The range in the tenderness scores of the braised steaks, Table 6, was from 7.4 for the treated to 6.2 for the untreated steaks. When analyzed statistically, this difference between treatments was not significant.

The shear value, in pounds, Table 6, was 17.9 for the treated steaks and 26.9 for the untreated. Analysis of variance showed this difference between treatments was great enough to be highly significant. Also the variation in the shear values among animals was very highly significant.

<u>One-half-inch Pan-fried Steaks</u>. The treated steaks were more tender than the untreated steaks as shown by the scores given in Table 7. The average scores give a tenderness rating of 8.2 for the treated and 7.1 for the untreated steaks. Analysis of variance showed no significant difference between the treatments.

The treated pan-fried steaks were more tender than the untreated as determined by the penetrometer. The average depth of penetration into the samples of the treated steaks was 7.1 millimeters and 6.7 millimeters into the samples of the untreated steaks. This difference was not significant,but the interaction between treatment X animals was highly significant.

<u>One-inch Pan-fried Steaks</u>. The average scores for the one-inch pan-fried steaks, Table 6, were between tender and very tender (8.4 points) and between tender and medium plus (7.2 points) for the untreated. Analysis of variance showed this difference to be highly significant.

The average shear force value, Table 6, was 20.6 pounds for the treated and 27.9 pounds for the untreated steaks, a difference of 7.3 pounds. Analysis of variance showed this difference was great enough to be significant.

Rump Roasts. The average tenderness scores and the average shear force values, in pounds, of the rump roasts are given in Table 8. Analysis of variance showed no significant differences between treatments when measured by either of these methods.

The judges' scores and the shear force readings were in agreement in that the roasts treated at room temperature were the most tender, and those treated at refrigerator temperature were the least tender. However, the difference in tenderness among the three groups as determined by the palatability committee was slight; the range in scores was 7.5 to 7.8. The average shear force for the roasts treated at room temperature was 13.9 pounds whereas, the average shear force for the untreated roasts was 18.3 pounds and 19.3 pounds for the roasts treated at refrigerator temperature.

A possible explanation for the difference in the tenderness of the roasts treated with the tenderizer might be that more of the papain in the tenderizer was activated at room temperature in three hours than at refrigerator temperature in eighteen hours. Gottschall (1944) reported that more papain was activated in one hour at 70° C. than in twenty-four hours at 23° C., this might also apply to the difference between room temperature and refrigerator temperature. There is no explanation for the untreated roasts being more tender than the roasts treated at refrigerator temperature.

Table 12. Average tenderness scores, shear values, and penetrometer readings for each cut.

Cut	Score (points)				Shear value (lbs)				Penetrometer (mm)	
	T	Unt	T2	T3	T	Unt	T2	T3	T	Unt
Broiled	8.4	7.1			18.1	25.9				
Braised	7.4	6.2			17.9	26.9				
Pan-fried (1.0 in.)	8.4	7.2			20.6	27.9				
Pan-fried (0.5 in.)	8.2	7.1							7.1	6.7
Roast		7.7	7.8	7.5		18.3	13.9	19.3		

T2 Treated one hour at room temperature for each inch of thickness.
T3 Treated eighteen hours at refrigerator temperature.

Comparison of the Tenderness of the Treated and Untreated Cuts. Table 12 gives a summary of the average scores and the values obtained by mechanical means for testing tenderness of all cuts. This table shows quite clearly that for each method of testing, the treated steaks were decidedly more tender than the untreated steaks. The scores for the treated broiled and pan-fried steaks ranged between tender and very tender, while the scores for the untreated steaks ranged between medium plus to tender. The shear values for the broiled and one-inch pan-fried steaks were over seven pounds less for the treated than for the untreated steaks. The tenderness scores for the braised steaks were less for each treatment than for the other methods of cooking. However, the tenderness scores for the treated braised steaks averaged 1.2 points higher than for the untreated, and the average shear value shows the treated steaks to have required nine pounds less shearing force than the untreated. In general, according to the shear values, the rump roasts were more tender than the steaks.

Juiciness

Broiled Steaks. The average juiciness scores and press fluid yields for the broiled steaks are given in Table 6. The juiciness scores show that the untreated steaks were slightly more juicy (0.5 of a point) than the treated steaks. This difference was highly significant.

The press fluid yields indicated very little difference in the juiciness of the two treatments; however, they showed the treated steaks to be more juicy by 0.1 of a milliliter. When analyzed statistically the difference was not significant.

Braised Steaks. The judges' scores for juiciness, Table 6, averaged 5.1 points for both the treated and untreated steaks. This score was the lowest score for juiciness given any cut of the meat used in this study. It should be pointed out that the braised meat was cooked well done, whereas all other cuts were cooked medium done. This accounts for the difference in juiciness as the more well done a piece of meat, the less juicy it is.

The average press fluid yield was 7.1 milliliters for the treated and 7.8 milliliters for the untreated steaks. Analysis of variance showed no significant difference in juiciness between treatments for either of the methods of testing.

<u>One-half-inch Pan-fried Steaks</u>. The juiciness of the one-half-inch steaks was measured only by the judges' scores. The average scores, Table 7, ranged from 7.2 for the treated to 7.5 for the untreated steaks. This difference was not great enough to be significant when analyzed statistically.

<u>One-inch Pan-fried Steaks</u>. The juiciness scores for the one-inch steaks, Table 6, averaged 7.8 points for the treated steaks and 8.6 points for the untreated steaks. The difference of 0.8 point was great enough to be highly significant.

The press fluid yields were also higher for the untreated steaks. Measured in milliliters the average yield of the treated steaks was 8.8 and the untreated steaks 9.4. Analysis of variance showed that this difference was not great enough to be significant.

<u>Rump Roasts</u>. The average juiciness scores and the average press fluid yields, expressed in milliliters, are given in Table 8. The press fluid yields indicated the roasts treated at refrigerator temperature were only slightly juicier than the other roasts (0.5 point). Analysis of variance showed no significant difference in juiciness among treatments. However, there was greater variation in treatment as measured by juiciness scores. The scores were as follows: untreated 7.6, treated at refrigerator temperature 7.1, and treated at room temperature 6.7. Analysis of variance of the scores showed a significant difference in the juiciness of the roasts given the three treatments.

<u>Comparison of the Juiciness of the Treated and Untreated Cuts</u>. Table 13 summarizes the juiciness scores and the press fluid yields of each cut studied. The scores were higher for all the untreated than for the treated cuts, the difference was great enough to be highly significant for the broiled and one-inch pan-fried steaks and significant for the rump roasts. The differences in juiciness between the treated and untreated cuts as determined by the press fluid were not great enough for any one cut to be significant. In two instances, the broiled steaks and the roasts treated at refrigerator temperature, the press fluids were slightly higher for the treated than for the untreated cuts.

Table 13. Summary of the average juiciness scores and press fluid yields for each cut.

Cut	Score (points)				Press fluid yields (ml)			
	T	Unt	T2	T3	T	Unt	T2	T3
Broiled	7.0	7.5			9.0	8.9		
Braised	5.1	5.1			7.1	7.8		
Pan-fried (1.0 in.)	7.8	8.6			8.3	9.4		
Pan-fried (0.5 in.)	7.2	7.5						
Roast	7.6		6.7	7.1		8.0	7.8	8.5

There was a considerable difference in juiciness as measured by the scores and the Carver Laboratory press. The juiciness scores showed a greater difference between treatments than the press fluid yields. The treated cuts may have seemed to be less juicy to the judges because they appeared more well done.

The color of the juice pressed from untreated samples was a bright red, whereas the juice from the treated cuts was a dull dark red color. This dark red color was more pronounced in the juice from the roasts than from the steaks. McCarthy and King (1942) found a more rapid rise in the hematin type pigment in the press fluids of samples of meat tenderized by the Tenderay process.

Consumer Preference Test

The results of the consumer preference test for broiled untreated sirloin tip steaks and broiled sirloin tip steaks treated with the seasoned or the nonseasoned tenderizer are given in Table 14.

Table 14. Consumer preference for untreated sirloin tip steaks and sirloin tip steaks treated with seasoned or nonseasoned tenderizer.

Choice	Treatment	Percent
1st	Seasoned tenderizer	40
	Nonseasoned tenderizer	53
	Untreated	7
2nd	Seasoned tenderizer	38
	Nonseasoned tenderizer	41
	Untreated	18

Ninety-three percent of the consumers indicated a preference for the meat treated with the tenderizer; 40 percent chose that treated with the seasoned tenderizer and 53 percent that treated with the nonseasoned tenderizer. According to the comments of the consumers, flavor alone seemed to be the contributing factor for the difference between the seasoned and nonseasoned samples, and tenderness was the contributing factor for the preference of the treated to the untreated steak.

SUMMARY

The purpose of this study was to determine the effects of a commercial meat tenderizer on the palatability, especially the tenderness, of thick and thin round steaks, sirloin tip steaks, and rump roasts.

The meat used for this study was three pair of rounds from Commercial grade beef. The steaks were cut as pairs and one steak from each pair was treated with the tenderizer for one hour for each inch of thickness and the other steak was untreated. The top round steaks were cut one and one-half inches thick and were broiled. The bottom round was cut into two-inch and into one-half-inch steaks; the thick steaks were braised and the thin steaks were pan-fried. The sirloin tip was cut into one-inch steaks which were pan-fried.

The rump was boned and rolled and three three-inch roasts were cut from each rump; one-third of the roasts were untreated, one-third were treated with the tenderizer and allowed to stand at room temperature one hour for each inch of thickness, and one-third were treated with the tenderizer and allowed to stand in the refrigerator eighteen hours. The method of cooking was roasting.

Total cooking losses were determined for each cut of meat, and volatile and dripping losses were calculated on the broiled steaks and the roasts. The cooking time per pound was determined for the thick steaks and rump roasts. Changes in the shape of the steaks were recorded by tracings made before and after cooking.

A palatability committee scored the cooked meat for aroma, flavor of the lean, tenderness, and juiciness. Objective tests for tenderness and press fluid yield were carried out on the cooked meat by means of the Warner-Bratzler shear apparatus, the Precision penetrometer, and the Carver Laboratory press.

A consumer preference test was made to determine if a group of 100 people had a preference for meat treated with the commercially prepared seasoned and nonseasoned tenderizers or for meat that was not treated.

Statistical analyses, showed no significant difference in the total cooking losses due to the action of the tenderizer for any of the cuts of meat. The average total cooking losses were less for the broiled and one-half-inch pan-fried treated steaks than for the untreated, but the cooking losses were less for the untreated braised steaks, the one-inch pan-fried steaks, and the rump roasts.

The cooking time per pound of the broiled and braised steaks and rump roasts treated with the tenderizer was less than for the untreated steaks or roasts. The treated cuts appeared more well-done than the untreated when cooked the same length of time (pan-fried steaks), or to the same internal temperature (broiled and braised steaks and rump roasts).

Most of the broiled and braised steaks, both those treated with the tenderizer and the untreated steaks, decreased in thickness or shrank in the direction of the fibers. There was some variation in the direction of the shrinkage of the pan-fried steaks.

Average scores for the flavor of the treated broiled, braised, and pan-fried steaks were slightly higher than for the untreated steaks. The average scores for flavor were higher for the untreated than for the treated roasts. The average flavor scores were in agreement with the preference ratings of the judges for the treated and untreated samples. The difference in the scores for the treated or untreated samples was not significant according to statistical analysis of the data.

The tenderizer used in this study was effective in increasing the tenderness of the broiled, braised, and pan-fried steaks, and the rump roasts treated at room temperature. Statistical analysis of the tenderness scores indicated that the increase in tenderness was highly significant for the broiled and one-inch pan-fried steaks. When the shear values were analyzed statistically, the increase in tenderness due to treatment was highly significant for the broiled and braised steaks and significant for the one-inch pan-fried steaks. The tenderizer was not effective in increasing the tenderness of the rump roast treated at refrigerator temperature.

The juiciness scores were higher for the untreated cuts than for the treated cuts. Statistical analysis showed that this difference was highly significant for the broiled and one-inch pan-fried steaks and significant for the rump roasts. The difference in juiciness between the treated and untreated cuts as measured by press fluid yields was not great enough to be significant. However, in two instances, the broiled steaks and the roasts treated at refrigerator temperature, the press fluid yields were slightly higher for the treated than for the untreated cuts.

In the consumer preference test 93 percent of the consumers indicated a preference for the meat treated with the tenderizer; 40 percent chose that treated with the seasoned tenderizer and 53 percent that treated with the nonseasoned.

ACKNOWLEDGMENTS

Sincere appreciation is expressed to Dr. Dorothy L. Harrison of the Department of Foods and Nutrition for her interest in and guidance of the laboratory work and the preparation of the manuscript; also to Dr. Gladys E. Vail, Head of the Department of Foods and Nutrition, for her suggestion of the study and for making the necessary arrangements with Adolph's Food Products. The writer is grateful to Adolph's Food Products for financial support; to Professor D. L. Mackintosh of the Animal Husbandry Department for procuring and aiding in processing the meat; to Dr. H. C. Fryer, Experiment Station Statistician, for suggestions on the statistical design; and to the members of the faculty and graduate students who scored the meat for palatability.

LITERATURE CITED

Anonymous. How beef is tenderized. Science Digest. 26:83, 1949.

Anonymous. Jet tenderizer cures and softens tough beef steak. Science News Letter. 51:265, 1947.

Balls, A. K., and H. Lineweaver. Isolation and properties of crystalline papain. Jour. Biol. Chem. 130:669-685, 1939.

Bell, Edith F., Agnes Fay Morgan, and Adamae Dorman. Collagen determination in cooked meat. Food Res. 6:245-263, 1941.

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

Cline, Jessie Alice, E. A. Trowbridge, M. T. Foster, and Hazel Elinor Fry. How certain methods of cooking affect the quality and palatability of beef. Mo. Agr. Expt. Sta. Bul. 293, 1930.

Cover, Sylvia. The effect of temperature and time of cooking on the tenderness of roasts. Tex. Agr. Expt. Sta. Bul. 542, 1937.

Cover, Sylvia. Effect of metal skewers on cooking time and tenderness of beef. Food Res. 6:233-238, 1941.

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

Deatherage, F. E., and Walter Reiman. Measurement of meat tenderness and tenderization of beef by Tenderay process. Food Res. 11:525-534, 1946.

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

Gottschall, G. Y. Activation of papain during digestion of meat. Food Res. 9:6, 1944.

Gottschall, G. Y., and M. W. Kies.
Digestion of beef by papain. Food Res. 7:373-381, 1942.

Harrison, Dorothy L., Belle Lowe, Buford R. McClurg, and P. S. Shearer.
Physical, organoleptic and histological changes in three grades of beef during aging. Food Tech. 3:284-288, 1949.

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

Hiner, R. L., and O. G. Hankins.
Effects of freezing on tenderness of beef from different muscles and from animals of different age. Food Tech. 5:374-376, 1951.

Husaini, S. A., F. E. Deatherage, L. E. Kunkle, and H. N. Draudt.
The biochemistry of beef as related to tenderness. Food Technol. 4:313-316, 1950.

Lowe, Belle.
Experimental cookery from the chemical and physical standpoint, 3rd ed. Chapter 8. New York: John Wiley and Sons, 1943.

Mackintosh, D. L., J. L. Hall, and G. E. Vail.
Some observations pertaining to tenderness of meat. Amer. Soc. Animal Prod. Proc. 29:285-289, 1936.

McCarthy, James F., and C. G. King.
Some chemical changes accompanying tenderization of beef. Food Res. 7:295-299, 1942.

McCoy, D. C., G. A. Hayner, Walter Reiman, and Robert Hockman.
Effect of aging before freezing on beef palatability. Refrig. Engg. 57:971-974, 1949.

Mitchell, H. H., T. S. Hamilton, and W. T. Haines.
Some factors affecting the connective tissue content of beef muscles. Jour. Nutr. 1:165, 1928.

National Cooperative Meat Investigations, Committee on Preparation Factors. Meat and meat cookery. p. 76. Chicago, Nat. Live Stock and Meat Board, 1942.

Paul, P., L. J. Bratzler, and E. D. Farwell.
The effects of methods of cooking on tenderness of beef at different intervals after slaughter. Jour. Animal Sci. 7:519, 1948.

Paul, P., Belle Lowe, and Buford R. McClurg.
Changes in histological structure and palatability of beef during storage. Food Res. 9:221-233, 1944.

Prudent, I.
Collagen and elastic content of four beef muscles aged varying periods of time. Jour. Home Econ. 41:571, 1949.

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

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

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

Satorius, M. J., and A. M. Child.
Effect of coagulation on press fluid, shear force, muscle-cell diameter, and composition of beef muscle. Food Res. 3:619-626, 1938.

Smith, E. C. B.
The nation's food. V Meat as a food. 2. Chemical composition of mammalian and avian meat. Soc. Chem. Indus. Jour. 61:373-377, 1942.

Szent-Gyorgyi, A.
Contraction and the chemical structure of the muscle fibril. Jour. Colloid Sci. 1:1-19, 1946.

Tauber, Henry.
The chemistry and technology of enzymes. New York: John Wiley and Sons, 1949.

Tressler, Donald K., Clarence Birdseye, and William T. Murray.
Tenderness of meat I. Determination of relative tenderness of chilled and quick frozen beef. Indus. and Engg. Chem. 24:242-245, 1932.

Tressler, Donald K., and William T. Murray.
II. Determination of period of aging grade A beef required to produce a tender quick-frozen product. Indus. and Engg. Chem. 24:890-892, 1932.

U. S. Patent 2,519,931 issued Aug. 22, 1950 to H. L. Roschen, Maywood, B. J. Ortscheid, and J. M. Ramsbottom assigned to Swift and Co., Chicago. Meat tenderizing speeded by new aging process. Abst. in Food Engg. 23:160, 1951.

APPENDIX

Table 15. Cooking data for broiled steaks.

Animal	*	Weight gms	Weight lbs.	Cooking time min.	Cooking time /lb. T	Cooking time /lb. Unt	Volatile loss %	Drip loss %	Total loss %
I	1	1119.0	2.5	74	29.6		19.5	3.8	23.5
	1'	1275.0	2.8	83		29.6	20.8	3.4	23.4
	2	1047.0	2.3	55		23.9	20.0	2.4	22.7
	2'	990.0	2.1	29	13.8		12.0	4.4	17.0
	3	872.5	1.9	40	21.1		17.1	3.2	20.8
	3'	1133.0	2.5	48		19.2	17.0	3.8	21.3
	4	685.5	1.5	65		43.3	16.6	4.5	26.4
	4'	900.7	2.0	54	27.0		15.5	6.1	22.0
II	5	1187.5	2.6	84	32.3		20.8	2.9	23.8
	5'	1156.0	2.5	66		26.4	20.5	2.3	22.9
	6	1278.5	2.8	71	25.4		21.5	3.0	24.8
	6'	1212.0	2.7	81		30.0	23.2	2.3	25.8
	7	925.0	2.0	83	41.5		20.0	4.8	24.8
	7'	1031.5	2.3	60		26.1	19.1	3.9	23.1
	8	711.0	1.6	47	29.4		14.5	5.4	20.5
	8'	750.0	1.7	56		32.9	20.3	3.4	24.0
III	9	1283.4	2.8	80		28.6	26.7	3.3	30.3
	9'	1326.5	2.9	60	20.7		18.2	4.1	22.5
	10	1173.0	2.6	53	20.4		17.8	4.8	23.0
	10'	1452.4	3.2	50		15.6	21.0	2.5	23.9
	11	1248.5	2.7	78		28.9	22.5	4.3	26.6
	11'	1537.0	3.4	75	22.1		20.2	4.5	25.2
	12	959.3	2.1	66	31.4		22.0	5.7	28.8
	12'	1263.3	2.8	82		29.3	21.5	4.8	26.2

* Position of the steak in the round.

Table 16. Cooking data for braised steaks.

Animal	*	Weight gms	Weight lbs.	Cooking time min.	Cooking time /lb. T	Cooking time /lb. Unt	Total loss %
I	B1	967.5	2.1	64		30.5	29.9
	B1'	866.0	1.9	33	17.4		32.9
	B2	946.0	2.0	64		32.0	29.7
	B2'	819.0	1.8	44	24.5		30.9
II	B3	1044.5	2.3	56	24.4		32.5
	B3'	812.0	1.8	50		27.8	30.5
	B4	971.0	2.1	48	22.9		40.5
	B4'	1046.0	2.3	53		23.0	30.0
III	B5	1138.0	2.5	65		26.0	32.5
	B5'	917.6	2.0	50	25.0		31.6
	B6	1071.0	2.4	50	20.8		34.9
	B6'	1084.0	2.4	73		30.4	29.4

* Position of the steak in the round.

Table 17. Cooking data for one-half-inch thick pan-fried steaks.

Animal	*	Weight gms	Weight lbs.	Total cooking time min.	Total loss %	Treated
I	C1	320.5	0.70	6	12.5	no
	C1'	289.2	0.63	6	20.1	yes
	C2	222.3	0.49	6	23.1	yes
	C2'	282.2	0.62	6	17.2	no
	C3	274.5	0.60	6	19.6	no
	C3'	292.5	0.64	6	13.3	yes
	C4	201.5	0.44	5	22.4	yes
	C4'	259.0	0.57	6	17.8	no
II	C5	370.5	0.82	8	27.9	no
	C5'	326.5	0.72	6	13.9	yes
	C6	272.0	0.60	6	19.6	yes
	C6'	317.2	0.70	6	18.8	no
	C7	260.0	0.57	6	14.8	no
	C7'	288.5	0.64	6	15.1	yes
	C8	233.0	0.51	6	18.5	yes
	C8'	237.0	0.52	6	22.2	no
III	C9	392.0	0.87	7	19.6	yes
	C9'	469.5	1.00	7	16.2	no
	C10	326.7	0.72	7	21.7	no
	C10'	344.0	0.76	6	14.8	yes
	C11	319.0	0.70	6	21.4	no
	C11'	412.5	0.91	6	12.0	yes
	C12	253.5	0.56	6	19.8	yes
	C12'	377.5	0.83	7	18.3	no

* Position of the steak in the round.

Table 18. Cooking data for one-inch pan-fried steaks.

Animal	*	Weight gms	Weight lbs.	Total cooking time min.	Total loss %	Treated
I	D1	456.5	1.0	12	13.5	no
	D1'	557.0	1.2	10	15.8	yes
	D2	638.0	1.4	12	17.5	no
	D2'	608.0	1.3	12	13.7	yes
	D3	686.0	1.5	12	12.1	yes
	D3'	632.0	1.4	12	12.7	no
	D4	652.0	1.4	12	15.5	yes
	D4'	398.5	0.9	12	13.8	no
II	D5	418.5	0.9	12	18.4	yes
	D5'	597.5	1.3	13	18.3	no
	D6	621.5	1.4	12	17.2	yes
	D6'	620.0	1.4	12	14.6	no
	D7	477.0	1.1	13	15.6	no
	D7'	509.5	1.1	12	15.3	yes
	D8	419.5	0.9	12	11.8	no
	D8'	481.0	1.1	12	11.1	yes
III	D9	469.6	1.0	12	18.6	yes
	D9'	668.2	1.5	13	13.0	no
	D10	600.5	1.3	12	14.4	no
	D10'	737.0	1.6	12	14.3	yes
	D11	711.0	1.6	11	17.1	yes
	D11'	801.0	1.8	12	14.9	no
	D12	721.0	1.6	12	19.5	yes
	D12'	842.2	1.9	15	15.2	no

* Position of the steak in the round.

Table 19. Cooking data for rump roasts.

Animal	*	Weight gms	Weight lbs.	Cooking time min.	Cooking time per lb.	Volatile loss %	Drip loss %	Total loss %	Treatment
	B'	1012.0	2.2	130	59.0	16.5	5.3	21.9	T1
	B	1553.0	3.4	167	49.1	15.6	5.1	20.8	T1
I	A'	1621.0	3.6	130	36.1	12.6	10.1	22.8	T2
	C	1188.0	2.6	134	51.5	16.6	4.2	20.8	T2
	C'	1025.0	2.3	128	55.7	15.7	5.7	21.4	T3
	A	1121.5	2.5	97	38.8	8.4	9.4	17.9	T3
	A'	1663.3	3.7	170	45.9	18.7	4.9	23.7	T1
	A	1504.5	3.3	155	47.0	17.3	3.5	21.0	T1
II	C'	1304.0	2.9	140	48.3	16.9	5.0	22.2	T2
	B	1557.2	3.4	147	43.2	17.0	7.2	24.4	T2
	C	1716.2	3.8	161	42.4	15.3	7.2	22.6	T3
	B'	1507.3	3.3	145	43.9	16.0	6.1	22.4	T3
	C'	1199.5	2.6	140	53.8	14.2	3.8	18.1	T1
	C	1061.3	2.3	135	58.7	17.4	3.4	20.9	T1
III	B'	1003.7	2.2	111	50.5	14.1	5.2	19.9	T2
	A	1854.3	4.1	160	39.0	17.1	9.2	26.6	T2
	A'	1403.0	3.1	153	49.4	16.1	8.5	24.8	T3
	B	1937.3	4.3	170	39.5	15.1	5.8	21.1	T3

* Position.
T1 Untreated.
T2 Treated three hours at room temperature.
T3 Treated eighteen hours at refrigerator temperature.

Table 20. Percentage increase or decrease in thickness, length, and width of broiled steaks.

Animal	*	Thickness		Length		Width	
		Treated	Untreated	Treated	Untreated	Treated	Untreated
I	1	-8.6		-6.3		-4.9	
	1'		-5.3		-3.4		-8.4
	2		-27.8		-0.9		-4.0
	2'	-9.7		+1.1		-0.9	
	3	-3.6		+5.9		+2.4	
	3'		-16.7		+2.6		+3.0
	4		-33.3		-14.6		+31.0
	4'	-13.8		-13.8		+18.2	
II	5	-25.9		-0.8		+4.5	
	5'		-11.1		-2.0		-6.8
	6	-19.5		+2.5		-4.6	
	6'		-18.4		-10.4		+8.3
	7	-38.1		+20.0		-40.7	
	7'		-16.7		-4.3		+11.6
	8	-20.5		+9.1		+9.1	
	8'		-14.7		-6.3		+15.4
III	9		+2.6		-4.0		-8.0
	9'	-10.3		-1.7		-6.1	
	10	-13.9		-4.3		0.0	
	10'		-7.9		+5.5		-12.6
	11		-10.0		-7.1		+6.3
	11'	-15.9		+3.4		0.0	
	12	-22.2		-11.1		+16.7	
	12'		-18.2		-10.4		+14.4

* Position of steak in the round.

Table 21. Percentage increase or decrease in thickness, length, and width of braised steaks.

Animal	*	Thickness		Length		Width	
		Treated	Untreated	Treated	Untreated	Treated	Untreated
I	B1		-10.9		-4.3		0.0
	B1'	-19.1		-14.2		-2.4	
	B2		-2.8		-1.3		0.0
	B2'	-25.5		-5.7		-6.3	
II	B3	-21.7		-15.8		-1.1	
	B3'		-16.3		-10.4		-21.1
	B4	-18.2		-14.1		0.0	
	B4'		-10.6		-3.6		-12.6
III	B5		-23.5		-8.7		-12.0
	B5'	-8.3		-15.7		+32.3	
	B6	-22.9		-14.6		-22.0	
	B6'		-16.7		-11.5		-15.0

* Position of steak in the round.

Table 22. Percentage increase or decrease in thickness, length, and width of one-half-inch pan-fried steaks.

Animal	*	Thickness		Length		Width	
		Treated	Untreated	Treated	Untreated	Treated	untreated
I	C1		-12.5		-6.0		-9.7
	C1'	-6.7		-4.2		0.0	
	C2	-21.4		-7.4		-6.7	
	C2'		-12.5		0.0		-3.1
	C3		-35.3		-5.9		0.0
	C3'	-17.6		-13.7		-5.0	
	C4	0.0		-15.3		-7.0	
	C4'		+6.7		-17.9		0.0
II	C5		-16.7		+9.3		-7.1
	C5'	0.0		-5.0		-9.3	
	C6	-14.3		-14.5		+33.3	
	C6'		-6.7		-14.9		-16.6
	C7		-6.7		-20.7		+25.0
	C7'	+6.7		-16.1		+10.0	
	C8	0.0		-18.2		+50.0	
	C8'		0.0		-19.6		-9.1
III	C9	-22.2		-5.0		-7.1	
	C9'		-15.9		-16.7		+9.5
	C10		+14.3		-16.1		-10.8
	C10'	0.0		-8.9		1.2	
	C11		-12.5		-15.2		-6.3
	C11'	-23.5		-8.3		+3.8	
	C12	-13.3		-24.2		-5.7	
	C12'		-12.5		-15.2		-14.6

* Position of steak in the round.

Table 23. Percentage increase or decrease in thickness, length, and width of one-inch pan-fried steaks.

Animal	*	Thickness		Length		Width	
		Treated	Untreated	Treated	Untreated	Treated	Untreated
I	D1		+16.7		-5.6		-12.4
	D1'	+38.5		-2.5		0.0	
	D2		-12.0		+23.0		-20.7
	D2'	-22.2		-12.8		0.0	
	D3	+3.6		+21.2		-20.7	
	D3'		0.0		-12.5		+14.8
	D4	+7.7			+7.4		+4.7
	D4'		-8.0	-15.0		+28.5	
	D5	-13.0		+1.9		+9.1	
II	D5'		-9.1		+6.7		-13.5
	D6	-8.3		-11.6		+11.1	
	D6'		0.0		-9.1		+17.3
	D7		-15.4		+12.3		-10.0
	D7'	0.0		-2.3		+16.8	
	D8		+8.7		-28.0		-22.3
	D8'	+12.5		+11.8		-12.5	
	D9	+4.4		-11.1		+22.0	
III	D9'		0.0		+10.5		-15.6
	D10		-9.5		-14.8		+11.3
	D10'	-7.7		+12.4		-3.4	
	D11	-8.9		+8.5		+5.7	
	D11'		-16.0		-18.0		+40.8
	D12	-16.0		-2.2		+3.8	
	D12'		-9.7		-21.8		+30.8

* Position of the steak in the round.

Form I

SCORE CARD FOR MEAT

Judge____________ Sample No.______ Kind__________ Date______

FACTOR	10	9	8	7	6	5	4	3	2	1		
Aroma	Extreme-ly good	Very good	Good	Plus	Medium	Minus	Fair	Poor	Very poor	Extreme-ly poor		
Flavor of lean	Extreme-ly good	Very good	Good	Plus	Medium	Minus	Fair	Poor	Very poor	Extreme-ly poor		
Tenderness	Extreme-ly tender	Very tender	Tender	Plus	Medium	Minus	Fair	Tough	Very tough	Extreme-ly tough		
Juiciness	Extreme-ly juicy	Very juicy	Juicy	Plus	Medium	Minus	Fair	Dry	Very dry	Extreme-ly dry		
Flavor of fat	Extreme-ly good	Very good	Good	Plus	Medium	Minus	Fair	Poor	Very poor	Extreme-ly poor		

Preference:

EFFECTS OF A MEAT TENDERIZER ON LESS TENDER CUTS OF BEEF COOKED BY FOUR METHODS

by

PATTIE PATRICE HAY

B. S., Kansas State College
of Agriculture and Applied Science, 1941

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

1952

INTRODUCTION

Commercial meat tenderizers are now on the market for consumer use, but few reports were found in the literature regarding the effectiveness of these tenderizers. Therefore, the purpose of this study was to determine the effects of a commercial meat tenderizer on the palatability, especially the tenderness, of thick and thin round steaks, sirloin tip steaks, and of rump roasts.

PROCEDURE

The meat used for this study was three pair of rounds from Commercial grade beef. The steaks were cut as pairs and one steak from each pair was treated with the tenderizer for one hour for each inch of thickness and the other steak was untreated. The top round steaks were cut one and one-half inches thick and were broiled. The bottom round was cut into two-inch and into one-half-inch steaks; the thick steaks were braised and the thin steaks were pan-fried. The sirloin tip was cut into one-inch steaks which were pan-fried.

The rump was boned and rolled and three three-inch roasts were cut from each rump; one-third of the roasts were untreated, one-third were treated with the tenderizer and allowed to stand at room temperature one hour for each inch of thickness, and one-third were treated with the tenderizer and allowed to stand in the refrigerator eighteen hours. The method of cooking was roasting.

Total cooking losses were determined for each cut of meat, and volatile and dripping losses were calculated on the broiled steaks and the roasts. The cooking time per pound was determined for the thick steaks and rump roasts. Changes in the shape of the steaks were recorded by tracings made before and after cooking.

A palatability committee scored the cooked meat for aroma, flavor of the lean, tenderness, and juiciness. Objective tests for tenderness and press fluid yield were carried out on the cooked meat by means of the Warner-Bratzler shear apparatus, the Precision penetrometer, and the Carver Laboratory press.

A consumer preference test was made to determine if a group of 100 people had a preference for meat treated with the commerically prepared seasoned and nonseasoned tenderizers or for meat that was not treated.

RESULTS

Statistical analyses showed no significant differences in the total cooking losses resulting from the use of the tenderizer for any of the cuts of meat. The average total cooking losses were less for the broiled and one-half-inch pan-fried treated steaks than for the untreated, but the cooking losses were less for the untreated braised steaks, one-inch pan-fried steaks, and rump roasts.

The cooking time per pound of the broiled and braised steaks and rump roasts treated with the tenderizer was less than for the untreated steaks or roasts. The treated cuts appeared more well done than the untreated when cooked the same length of time (pan-fried steaks), or to the same internal temperature (broiled and braised steaks and rump roasts).

Most of the broiled and braised steaks, both those treated with tenderizer and the untreated steaks, decreased in thickness or shrank in the direction of the fibers. There was some variation in the direction of the shrinkage of the pan-fried steaks.

Average scores for the flavor of the treated broiled, braised, and pan-fried steaks were slightly higher than for the untreated steaks. The average scores for flavor were higher for the untreated than for the treated roasts. The average flavor scores were in agreement with the preference ratings of the judges for the treated and untreated samples. The difference in the scores for the treated or untreated samples was not significant according to statistical analysis of the data.

The tenderizer used in this study was effective in increasing the tenderness of the broiled, braised, and pan-fried steaks, and the rump roasts treated at room temperature. Statistical analysis of the tenderness scores indicated that the increase in tenderness was highly significant for the broiled and one-inch pan-fried steaks. When the shear values were analyzed statistically, the increase in tenderness due to treatment was highly significant for the broiled and braised steaks and significant for the one-inch pan-fried steaks. The tenderizer was not effective in increasing the tenderness of the rump roast treated at refrigerator temperature.

The juiciness scores were higher for the untreated cuts than for the treated cuts. Statistical analysis showed that this difference was highly significant for the broiled and one-inch pan-fried steaks and significant for the rump roasts. The difference in press fluid yields between the treated and untreated cuts was not great enough to be significant. However, in two instances, the broiled steaks and the roasts treated at refrigerator temperature, the press fluid yields were slightly higher for the treated than for the untreated cuts.

In the consumer preference test 93 percent of the consumers indicated a preference for the meat treated with the tenderizer; 40 percent chose that treated with the seasoned tenderizer and 53 percent that treated with the nonseasoned.