Tenderness of Beef Round Roasted at Two Oven Temperatures in Relation to Cooking Losses, Cooking Time, Power Consumption, and Other Sensory Properties

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8-1965

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Bernadine Meyer, Major Professor

We have read this thesis and recommend its acceptance:

Ada Marie Campbell, Mary Rose Gram

Accepted for the Council:

Dixie L. Thompson

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)
To the Graduate Council:

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[Signature]
Major Professor

We have read this thesis and recommend its acceptance:

[Signature]

Accepted for the Council:

[Signature]
TENDERNESS OF BEEF ROUND ROASTED AT TWO OVEN TEMPERATURES
IN RELATION TO COOKING LOSSES, COOKING TIME, POWER
CONSUMPTION, AND OTHER SENSORY PROPERTIES

A Thesis
Presented to
the Graduate Council of
The University of Tennessee

In Partial Fulfillment
of the Requirements for the Degree
Master of Science

by
Robin Dalrymple Simmers
August 1965
ACKNOWLEDGMENT

It is with sincere gratitude that the author acknowledges the patient guidance and encouragement given by Dr. Bernadine Meyer throughout the planning, conducting, and reporting of this study. Appreciation is also extended to Dr. Ada Marie Campbell and Dr. Mary Rose Gram for their understanding advice and suggestions.

The author wishes to thank Mrs. Mary Nelle Connelly for her invaluable assistance in the laboratory and for checking data; the members of the evaluation panel for their cooperation; and Professor J. W. Cole and Dr. C. B. Ramsey, Department of Animal Husbandry and Veterinary Science, for their help in procuring the roasts.

The author is especially grateful to the American Home Economics Association for awarding her the Sybil L. Smith International scholarship for 1964-65 and also the College of Home Economics, University of Tennessee which granted a special Graduate scholarship. These awards helped greatly to make the student's year of graduate study possible.

R. D. S.
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CHAPTER I

INTRODUCTION

The relation of temperature and length of cooking time to the tenderness of meat has had limited investigation for many years. As a result of these investigations some evidence has accumulated that low oven temperatures are advantageous. Cover (1943) was among the first to point out the possible role of slow heat penetration in the production of tender roast beef. More recently Bramblett et al. (1959) used less tender cuts of beef and found that the meat roasted at 145°F. was more tender than that cooked at 155°F., and that at the lower temperature cooking losses were reduced. In a further study the same group (Bramblett and Vail, 1964) found that roasts cooked at 155°F. were more tender and had better flavor than those cooked at 200°F., but the cooking losses were greater and the meat was less juicy. One theory that has been proposed to explain the increased tenderness of roasts cooked at very low oven temperatures is the increased interval of time during which the roast is held in the temperature range most favoring the conversion of collagen to gelatin. There is a need to study further the effect of low oven temperatures on the quality of beef roasts, and some of the practical aspects of cooking time and power consumption.

The present study was designed to compare the tenderness and quality of adjacent top-round roasts cooked at 300°F. and 200°F. oven
temperatures. The higher oven temperature is the one usually recommended for roasting beef.

The meat was obtained from seven heifers and one steer, of which five were graded U. S. Good, and three U. S. Choice. Two adjacent top-round roasts cut two-and-one-half inches thick were taken from each animal. The more anterior one was labeled A, and the adjacent one B. The roasts weighed an average of 2.46 pounds before cooking. The plan assigned cuts A and B from each animal alternately to the higher and lower oven temperatures so that any differences associated with location would be distributed between the two temperatures. The plan had been to test roasts from nine animals and cook three roasts on each of six days, two at one of the oven temperatures. The plan was changed slightly as explained in Chapter III.

The data obtained included: percentage cooking losses; rate of heat penetration; power consumption; shear values as an objective measurement of tenderness; and sensory evaluations of tenderness, juiciness, and flavor.

It was hoped that these data would give further evidence of the relationship of temperature of cooking to tenderness of roasted top round of beef and give increased insight into the practical and economical aspects of low temperature cookery.
CHAPTER II

REVIEW OF LITERATURE ON SOME FACTORS RELATED TO TENDERNESS OF BEEF

Of the many factors affecting the acceptability of meat, tenderness is possibly that most often and most readily judged by the consumer as the important criterion of quality. It is also a factor which can be determined in the laboratory by both subjective and mechanical tests, and in many cases the results of these tests are significantly correlated with each other. The elements causing differences in the tenderness of cooked meat, and in the various cuts of raw meat are less clearly defined. Other factors such as flavor and juiciness also contribute to the overall acceptability of a piece of meat, and may affect the subjective scoring of tenderness. The tenderness inherent in any cut of meat is influenced by many factors. The effect of some of these on the natural components of the voluntary cross-striated muscles known to the consumer as "meat" will be considered in this review.

I. NATURE OF MUSCLE TISSUE

Striated muscles are made up of primary muscle-fiber bundles held together by connective tissue. Several primary muscle bundles are bound together by connective tissue to form secondary bundles, and these in turn are bound together to form a tertiary bundle. This
is continued until a large muscle is formed. Each muscle bundle comprises a very large number of parallel independent muscle fibers held together by interstitial connective tissue or endomysium. This endomysium is a thin layer of collagenous tissue, which may or may not contain elastic fibers (Hiner et al., 1953).

**Muscle fibers.** The contractile matter of muscle tissue is composed of two proteins, actin and myosin, which combine to form a soft elastic gel, actomyosin. The mechanism of contraction is not fully understood, but seems to involve the interaction of actomyosin and the nucleotide adenosine triphosphate (Szent-Györgyi, 1953).

Ramsbottom, Strandine, and Koonz (1945) made a study of twenty-five muscles from three heifer carcasses and concluded that the texture of different muscles varied greatly and was determined by the size of the muscle-fiber bundles and the amount of connective tissue surrounding them. They found that small bundles and fine texture were indications of greater tenderness.

Hiner et al. (1953) found a curvilinear relationship between fiber diameter of beef muscles and tenderness, and a decrease in tenderness as the animal became older. The greatest change with age occurred between eight and fourteen months. As the fiber diameter increased, so did the resistance to shear, indicating a decreased tenderness.

**Connective tissue.** For many years the amount and kind of connective tissue has been considered a most important factor affecting
the tenderness of meat. Connective tissue (Griswold, 1962) contains two fibrous proteins, collagen and elastin, embedded in an amorphous material called ground substance. Collagen is the principle constituent of tendons, which attach muscle to bone, while elastin is more important in ligaments. Ramsbottom, Strandine, and Koon (1945) showed that the collagen and elastin content of various muscles was different, and that as the content of these increased, so did the shear values, indicating reduced tenderness. Husaini et al. (1950) found that tenderness of muscle tissue decreased with an increase in the amount of connective tissue.

It is generally accepted that muscles which are used more are inclined to be less tender. Hiner, Anderson, and Fellers (1955) showed that the elastic fibers in most-used muscles were more numerous and larger than those in muscles not used so extensively. They also found an increase in collagenous fibers in the most-used muscles. By histological means, they demonstrated that in muscles which were used less strenuously, fatty deposits were evident, and the collagenous fibers formed a loose network between the muscle bundles. In those muscles exercised frequently there was less fat, and the collagen fibers appeared to be bunched.

II. AGE, SEX, AND GRADE OF THE ANIMAL

Although the tenderness of meat may be influenced very appreciably by the method of cooking, there are factors involved before the
meat even reaches the market. These may include: age, sex, and grade of the animal; feed; and post-mortem aging.

In 1950 Husaini and co-workers tested short-loin roasts from twenty carcasses of widely varying age, grade, and sex. Conditions of aging of the loins were carefully controlled, and the samples of meat were ground for the purposes of chemical determinations. They found a significant correlation between carcass grade and tenderness, and between tenderness and alkali-insoluble protein which was used as an index to the connective tissue content of the tissues.

Hiner and Hankins (1951) tested steaks from nine muscles, representing the principle beef cuts, of fifty-two animals of varying age and sex, including nine-week-old veal, five-hundred-pound steer calves, nine-hundred-pound steers, three-year-old barren heifers, and five-year-old cows. The muscles were all aged under controlled conditions. In the younger animals there were only slight differences in tenderness of different muscles. There was a marked decrease in tenderness of all the muscles, and a greater difference in tenderness between muscles with increasing age of the animal. Hiner, Anderson, and Fellers (1955) took samples from the same animals and, by fixing and staining sections of the muscles, examined them histologically with regard to collagen and elastin. It was found that the samples with high resistance to shearing had an abundance of elastic fibers, and in the less tender cuts the elastic fibers tended to be bunched into definite areas.
The size of elastic fibers increased noticeably with age. It was also found that collagenous fibers increased in size with increasing maturity.

Relation of fat to grade and tenderness. One of the factors considered in the grading of beef carcasses is the degree of marbling or intramuscular fat, although the predictive value of this measure is being questioned at present. Cover, Butler, and Cartwright (1956) were among the first to cast doubt on the importance of marbling as related to tenderness. They measured the fatness of steers by marbling, physical separation, and ether extract. These factors were correlated with each other and with the palatability of cooked loin and bottom-round steaks. They reported a low correlation between fat as determined by ether extract and by marbling or separation, which could be explained by the fact that ether will extract small deposits not readily visible. It was also found that tenderness was correlated with marbling and ether-extracted fat in the bottom-round steaks but not in the loin. The ether extract of the ribeye muscle was the only measurement of fatness showing close correlation with tenderness of both cuts.

III. FEED

In an attempt to determine the feeding practices that would produce beef of the highest grade, Wanderstock and Miller (1948) used five different feeding regimens, varying from pasture only to full
grain-feeding in dry lot. There were only small differences in tenderness of the meat but the animals fed only on pasture tended to be slightly inferior.

Hershberger et al. (1951) studied the gain in weight of animals on different rations and related this to tenderness. All animals were full-fed on the basic ration which was supplemented with soya-bean meal for one group and with alfalfa-leaf meal for the other. The protein content of the supplements was equal. The steers having the alfalfa supplement gained weight more rapidly, and produced as much or more edible meat than the group receiving soya-bean meal. The faster-gaining animals produced less-tender carcasses, but this was not sufficient to interfere with market value.

Meyer et al. (1960) indicated that roasts from grain-finished beef were more tender than those from grass-finished animals of the same breed, sex, and age. Roasts were taken from the longissimus dorsi (loin) muscle and cooked by dry heat, and from the semimembranosus (round) muscle for cooking by moist heat. Greater differences in tenderness were observed between loin roasts from the grain- and grass-finished animals than between the round roasts from steers on the two dietary regimens.

IV. POST MORTEM AGING

Changes in meat with aging. After the death of the animal, glycogen is converted to sugars, and finally, by anaerobic oxidation,
to lactic acid. The associated lowering of the pH is often accompanied by an increase in tenderness over a period of several days.

Deatherage and Harsham (1947) reported an increased tenderness during aging, with a maximum at seventeen days, and no further improvement up to twenty-four days, after which there was a slight decrease in tenderness. In a study of the histological changes taking place, Ramsbottom and Strandine (1949) revealed that in the pre-rigor state muscle fibers were slightly wavy. Rigor mortis was identified by the formation of hard lumps which eventually involved the whole muscle. The fibers themselves were arranged in sharply-defined waves, beginning from eight to twenty-four hours after slaughter, and lasting for twenty-four to seventy-two hours. By the end of the eighth to the twelfth day there was a progressive breakdown of muscle fibers by enzymatic action or autolysis. The fibers broke in both transverse and longitudinal directions. These changes were associated with meat that was very tender for two days after slaughter, and then decreased in tenderness for two to six days, after which it again became more tender, reaching a maximum in twelve days.

In 1960 Meyer et al. showed that ripening caused a significant improvement in the tenderness of both grain- and grass-finished beef roasts, and that most of the increase in tenderness occurred in the first twenty-one days of ripening. There was relatively more improvement in the tenderness of the grass-finished beef.
Mechanisms of changes during post-mortem aging. In 1954, Wierbicki et al. proposed that the increased tenderness on aging was related to either: a) a dissociation of actomyosin; or, b) redistribution of ions within the muscle and as a result, increase in hydration of the protein. Myosin, actin, and actomyosin account for about half of the muscle plasma proteins. As plasma goes through a series of changes after death, and there did not appear to be a change in the alkali-insoluble protein, much interest was felt in the possibility that muscle plasma changes were involved in the increased tenderness of the post-mortem muscle. In 1956, however, the same group of workers (Wierbicki et al.) found that the dissociation of actomyosin was not responsible for tendering, although the actomyosin formed in the early rigor was held responsible for the initial toughening of the muscle. Then it was suggested that the second theory of the effect of redistribution of ions within the muscle was more reliable, and this was studied and reported by Arnold, Wierbicki, and Deatherage (1956). They found that during the period after slaughter there was a continual release of sodium and calcium ions from the muscle protein, and during the first twenty-four hours magnesium ions were released and potassium ions absorbed. The total movement of these cations caused an increase in the hydration of the muscle proteins, which resulted in increased tenderness. Calcium is one of the ions causing dehydration of the protein so its release would have a beneficial effect on hydration. The authors concluded that it was not the
amounts of each cation that affected tenderness, but their combined
effect and movement.

Freezing. There are some indications that freezing may cause
tendering of beef but the literature is conflicting and will not be
reviewed here.

V. EFFECT OF HEAT ON MEAT PROTEINS

Hamm and Deatherage (1960) concurred that the hydration of
muscle protein is very closely associated with the tenderness of
meat, and that heating results in the release of juice in amounts
proportional to the temperature. It is possible that this dehydration
may influence denaturation which occurs on heating of meat. These
workers found that mild denaturation began between 30°C. and 40°C.
(86°F. and 104°F.), with an unfolding of protein chains and the
formation of new salt and/or hydrogen bonds. Strong denaturation
began at 40°C. (104°F.) and resulted in the formation of new stable
cross linkages. At 65°C. (149°F.) the denaturation which had caused
a tighter network of protein structure was almost complete. There was
a sharp decrease in hydration between 45°C. and 65°C. (113°F. and 149°F.)
indicating a decrease in available polar groups which would bind water.
These groups were rendered unavailable by the formation of new stable
cross linkages.

Direct evidence of Wang et al. (1956) indicated that cooking
may toughen muscle fibers and Griswold (1962) proposed that if a
muscle tends to toughen on cooking it is the muscle fiber which is responsible, as heating causes collagen to be converted to gelatin by hydrolysis, and results in an increase in the tenderness of cooked meat.

Cover and Hostetler (1960) suggested that there is a need to compromise between the necessity for a high temperature to increase collagen-conversion, and a low temperature to avoid toughening of the muscle proteins. The temperatures critical for these reactions are therefore important.

Machlik and Draudt (1963) heated cylinders of beef muscle in test tubes at 1°C. intervals in a temperature-controlled water bath. They found that hardening of the muscle was accomplished between 66°C. and 75°C (151°F. and 167°F.). They also determined that conversion of collagen began at 55-56°C. (131-133°F.). Cover (1943), Ritchey, Cover, and Hostetler (1963), and Winegarden et al. (1952) have reported that the temperature at which hydrolysis of collagen begins is 58°C., 61°C., and 60-65°C. (136°F., 142°F., and 140-149°F.), respectively. From these data it would seem that this important reaction begins in the range of 55-65°C. (131-149°F.).

VI. EFFECT OF COOKING METHOD ON TENDERNESS

In recent years, the classical method of cooking less tender cuts of beef by braising has been questioned and investigated. Cover and Hostetler (1960) state that the use of moist heat results in a
much higher internal temperature of the meat, and that the internal temperature rises more quickly with moist-heat than with dry-heat cooking, as the heat is not lost to the air by evaporation. They felt that this increase in temperature, while causing greater conversion of collagen to gelatin, may also result in an excessive toughening of the muscle fibers, and suggested that the time during which the meat was held in the temperature range most favoring collagen conversion was the most important factor relating to tenderness of braised round roasts.

Griswold (1955) compared braising, roasting, and pressure-braising of top- and bottom-round roasts. An internal temperature of 85°C. (185°F.) was taken as the end-point of cooking for all methods. It was found that meat roasted at 250°F. required the longest time to cook and resulted in the lowest shear values.

Cover, Bannister, and Kehlenbrink (1957) trained a panel of judges to differentiate between muscle fiber and connective tissue in scoring tenderness, and separate scores for each component were recorded. Steaks from loin and bottom-round cuts were broiled and braised to the rare and well-done stages. Retention of collagen nitrogen was considered in relation to results of palatability and tenderness tests. They found that the loin was most tender when broiled to the rare stage, and the round when braised to the well-done stage. Collagen content decreased with a longer braising time. In each muscle the highest score for tenderness of the connective
tissue was found when the meat was braised to the well-done stage, but only in the case of the bottom round was this increase in the tenderness of the connective tissue accompanied by a maximum score for overall tenderness. The two different muscles showed dissimilar responses to an increase in end-point temperature and to the method of cooking. Whereas in the loin, the muscle fiber seemed to take precedence in the final judgment of overall tenderness, the tenderness of the bottom-round steaks was influenced by both connective tissue and muscle fiber.

Working with bottom-round steaks, Dawson and co-workers (1959) found that tenderness scores were in favor of the dry-heat method of cooking. These authors used temperatures representing different stages of doneness as the end-point of cooking for all methods, while Griswold (1955) used the same end-point temperatures for the three different methods of cooking.

On the theory (Cover and Hostetler, 1960) that connective tissue is the principal cause of natural toughness, Ritchey, Cover, and Hostetler (1963) analysed the collagen content of raw and cooked steaks from the longissimus dorsi (loin) muscle, and from the biceps femoris (bottom-round). The steaks were broiled to 61°C. (142°F.) and 80°C. (176°F.). The raw loin was found to have less collagen than the round; and after the conversion of collagen to gelatin during cooking, the residual collagen in the tissues was the principal factor in determining tenderness. The rate of disappearance of collagen was similar in
both tissues and increased with an increase in temperature, but as the temperature was raised the difference in tenderness of the two muscles was reduced. The authors concluded that this may have been due to a difficulty to detect the tenderness of the loin, or that the panel was scoring for total tenderness which includes other factors in addition to collagen.

VII. EFFECT OF OVEN TEMPERATURE ON THE TENDERNESS OF BEEF

The generally-accepted oven temperature for roasting beef is 300°F. Some of the earliest work relating cooking time to tenderness of meat was reported by Cover (1937), who roasted both chuck and rump roasts at oven temperatures of 257°F. and 437°F. Tenderness scores were in favor of the lower temperature for 93 per cent of the rump roasts and 97 per cent of the chuck roasts. Cover suggested that tenderness might be more dependent on cooking time than on oven temperature, and showed that the internal temperature of the meat rose rapidly at first and then more slowly. Further work by Cover (1943) showed that if two roasts were cooked at 257°F. and 176°F. the higher oven temperature produced a roast that was juicier but less tender. The roast cooked at 176°F. was more tender and although it took five times longer to cook, the cooking losses were only slightly greater. Cover attributed the increased tenderness of the latter roast to a slow rate of heat penetration, and a release of the water of hydration that was slow enough to convert collagen to gelatin.
In 1959 Bramblett et al. used extremely low oven temperatures of 145°F and 155°F for roasting beef. Cooking time for these roasts was thirty hours at 145°F and eighteen hours at 155°F. The cooking losses at 145°F were 23.5 per cent lower than at 155°F. At this temperature the meat was more tender also, as indicated by both panel scores and shear tests. Further work by the same group (Bramblett and Vail, 1964) gave results which showed that roasts cooked at 155°F were more tender and had better flavor than those cooked at 200°F, but cooking losses were greater and the meat was less juicy.

Tuomy, Lechnir, and Miller (1963) heated cylinders of low-grade beef muscle at temperatures of 140°, 160°, 180°, 190°, 200°, and 210°F. for varying periods up to seven hours. The initial effect of the heat was a toughening which increased as the temperature increased. When the meat was held below 180°F, the tenderness of the meat was dependent on the temperature, but at temperatures of 180°F and above the meat became tender at a rate and to a degree dependent on both time and temperature.

In a very recent study (Nielsen and Hall, 1965) paired four-pound rump and blade roasts were roasted at oven temperatures of 325°F and 225°F, to 71°C (160°F.) internal temperature, and blade roasts were braised until "fork tender." The blade roasts were significantly more tender, as determined by shear tests, when roasted at 225°F than at 325°F., but the difference was not reflected in panel scores for tenderness. The authors concluded that roasting is quite satisfactory
for choice blade roasts, and the use of an oven temperature of 225°F. will produce meat that is more tender than a roast cooked at 325°F., and equally as tender as a braised blade roast. Choice-grade rump roasts cooked at 225°F. were not found to be superior in any way to their pair-mates roasted at 325°F.
CHAPTER III

PROCEDURE

The temperature usually recommended for roasting beef is 300°F. The purpose of this study was to compare data on cooking losses, cooking time, power consumption, shear values, and palatability of top-round roasts cooked at this oven temperature, with similar data for adjacent roasts from the same animals cooked at an oven temperature of 200°F.

I. DESIGN OF THE STUDY

Top-round roasts were obtained from seven heifers and one steer procured for another study by the Animal Husbandry Department, University of Tennessee. From each animal two adjacent top-round roasts were cut two-and-one-half inches thick. The more anterior roast was taken just posterior to the long axis of the pubis, and labeled "cut" A, and the one adjacent to it was "cut" B. They were frozen at -15°F. and stored at 0°F. until used. Cuts A and B were assigned alternately to the two oven temperatures, so that any differences associated with location of the cut would be distributed between the two heat treatments. A summary of the cooking plan is shown in Table I.

In order to avoid a paired comparison test with the obvious possibilities for bias on the part of the judges, the plan had been
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<td>2.25</td>
<td>300</td>
</tr>
<tr>
<td>4</td>
<td>Heifer</td>
<td>Choice</td>
<td>A</td>
<td>2.27</td>
<td>300</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>B</td>
<td>2.46</td>
<td>200</td>
</tr>
<tr>
<td>5</td>
<td>Heifer</td>
<td>Choice</td>
<td>A</td>
<td>1.96</td>
<td>200</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>B</td>
<td>2.40</td>
<td>300</td>
</tr>
<tr>
<td>6</td>
<td>Heifer</td>
<td>Good</td>
<td>A</td>
<td>2.43</td>
<td>300</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>B</td>
<td>2.35</td>
<td>200</td>
</tr>
<tr>
<td>7</td>
<td>Heifer</td>
<td>Good</td>
<td>A</td>
<td>2.41</td>
<td>200</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>B</td>
<td>3.25</td>
<td>300</td>
</tr>
<tr>
<td>8</td>
<td>Heifer</td>
<td>Good</td>
<td>A</td>
<td>2.27</td>
<td>300</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>B</td>
<td>2.94</td>
<td>200</td>
</tr>
</tbody>
</table>
to test roasts from nine animals, cooking three roasts on each of six days, two at one of the oven temperatures. The roasts were cooked as planned but due to an unexplained error the data for one animal could not be used. All the sensory data that were averaged however had been obtained by triplicate test. Data were analyzed for four A roasts and four B roasts cooked at each of the oven temperatures.

II. COOKING METHODS

The roasts were removed from the freezer and thawed at room temperature on the day before cooking. When completely thawed they were stored in a household refrigerator overnight. In an attempt to have the roasts ready for testing at about the same time, those to be roasted at the lower temperature were started early in the morning, and those to be roasted at the higher temperature were held in the refrigerator and started about noon. The roasts were weighed to the nearest gram on a Mettler Type K5 balance, and placed fat-side up in tared shallow pans with racks. It was found necessary to support the roasts with wooden blocks to prevent them from falling over in the oven. A thermometer was placed in the approximate geometric center of each roast and used as a final indication of the end-point of cooking. In some roasts the center was not the thickest part of the muscle. In these cases the thermometer was placed in the thickest part of the roast. A thermocouple was inserted into the meat close to the thermometer. The roasts were placed in a cold oven of a household electric
range, and the thermostat was set in a position predetermined to maintain a temperature of 200-225°F. or 300-325°F. Previous tests had indicated that there was about a 25°F. range in the thermostat of each oven. Thermocouple readings were taken at fifteen-minute intervals to determine heat penetration, and were used as a check on the end-point temperature. A watt-hour meter was connected to the power line of each range to measure power consumption. Readings were taken before and after cooking to determine the amount of power consumed. An end-point temperature of 158°F. was chosen for the 300°F. roasts. When the roasts in the 200°F. oven reached an internal temperature of 154°F. and maintained this temperature for one hour, the meat was removed from the oven. Preliminary work indicated that roasts cooked at 200°F. were more well-done at 154°F. than roasts cooked at 300°F. to an internal temperature of 158°F.

III. COOKING LOSSES, COOKING TIME, AND POWER CONSUMPTION

Ten minutes after removal from the oven, the roasts were weighed in the pan. The difference between this weight and the total weight before cooking indicated evaporation losses. The meat was removed from the pan which was weighed again to determine loss due to drippings. Evaporation and drippings loss were added to give a figure for total loss. Cooking losses were expressed as a percentage of the original weight of the roast. Forms for recording cooking data are
found on page 45 in the Appendix. The weight of the roasts was con-
verted to pounds, and cooking time per pound and watt-hours consumed
per pound were calculated.

IV. SENSORY EVALUATIONS

The roasts were cut in half and three slices three-eighths
inch thick were taken from each half using a hand-operated meat slicer.
The slices were numbered one, two, and three, beginning at the center
cut. The three slices from the right half were used for scoring, and
those from the left half for "chew count." The samples to be scored
were coded by letters and judged by a panel of five, all experienced
in the evaluation of beef. Each judge was assigned a top or bottom
half of a specified slice from each roast. The three samples for each
judge were placed on individual plates marked with the code letter, and
set on a white enamel tray. The order of presentation was randomized.
In preliminary work it was found that there was a considerable differ-
ence in the color of the roasts cooked at the two oven temperatures.
Those cooked at the lower oven temperature were quite brown inside and
appeared well-done, while those at the higher temperature appeared medium-
done. To minimize the possibility of bias arising from this color differ-
ence, the tray for each judge was placed under a red light in order to
mask the color differences in the samples. The judges did not see the
meat at all until it was under the light. The judges were asked to score
for juiciness, flavor, and tenderness, using a nine-point scale where nine
was designated as optimum quality. (See sample score card in the Appendix,
page 47.)
From each of the slices from the other half of the roast two
discs one-inch in diameter were cut with a corer, one from the top
half, and the other from the bottom half of each slice. Each judge
was assigned a top or bottom disc from a specified slice from each
roast. These were coded differently from the samples that were
scored, and presented separately to the panel members. Each judge
was asked to record the number of chews required for the complete
mastication of each disc assigned to him.

V. SHEAR TESTS

An objective index to tenderness was obtained by the use of the
Warner Bratzler shear machine. Six cores one-half inch in diameter
were removed parallel to the muscle fibers, three from each half-roast
remaining after the slices for sensory evaluation had been removed.
Each core was sheared three times and the average for all six cores
was calculated.

VI. ANALYSIS OF DATA

Means were calculated for each of the measurements made. The
data were analyzed for significance of the difference between the means
by the use of the t-test, which depends on the assumption that the popu-
lation is normally-distributed. Coefficients of correlation between the
three measurements of tenderness were also calculated.
CHAPTER IV

RESULTS AND DISCUSSION

I. EFFECT OF TWO OVEN TEMPERATURES ON COOKING LOSSES

The data obtained for the cooking losses of the roasts at the two oven temperature are shown in Table II.

**Evaporation loss.** Evaporation loss was 9.3 per cent higher at 200°F. than at 300°F. This difference was significant ($P < 0.01$), and was noted in the appearance of the roasts after cooking. The roasts cooked at 200°F. appeared hard, dry, and slightly shrunken in size, while those cooked at the higher oven temperature were plump and had a glossy, moist outer surface.

**Drippings loss.** Drippings loss from the 300°F. roasts was significantly ($P < 0.01$) higher than from roasts cooked at 200°F. Some of the difference could be due to the fact that the drippings from the roasts in the lower-temperature oven had a longer time in which to evaporate. The drippings in the pan of the 300°F. roasts were lighter in color and more fluid than the rather dry and dark residue from the roasts cooked at 200°F.
TABLE II
PERCENTAGE COOKING LOSSES OF TOP ROUND OF BEEF
ROASTED AT TWO OVEN TEMPERATURES

<table>
<thead>
<tr>
<th>Animal Number</th>
<th>Evaporation Loss</th>
<th>Drippings Loss</th>
<th>Total Cooking Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Oven Temperature</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>200°F.</td>
<td>300°F.</td>
<td>200°F.</td>
</tr>
<tr>
<td>1</td>
<td>29.5</td>
<td>18.5</td>
<td>5.0</td>
</tr>
<tr>
<td>2</td>
<td>32.5</td>
<td>20.6</td>
<td>6.4</td>
</tr>
<tr>
<td>3</td>
<td>29.2</td>
<td>27.1</td>
<td>5.4</td>
</tr>
<tr>
<td>4</td>
<td>30.0</td>
<td>23.6</td>
<td>3.6</td>
</tr>
<tr>
<td>5</td>
<td>34.4</td>
<td>23.2</td>
<td>2.6</td>
</tr>
<tr>
<td>6</td>
<td>30.4</td>
<td>20.8</td>
<td>4.7</td>
</tr>
<tr>
<td>7</td>
<td>30.0</td>
<td>22.1</td>
<td>4.1</td>
</tr>
<tr>
<td>8</td>
<td>30.7</td>
<td>16.1</td>
<td>5.2</td>
</tr>
<tr>
<td>Average</td>
<td>30.8</td>
<td>21.5</td>
<td>4.6</td>
</tr>
<tr>
<td>Difference</td>
<td>9.3**</td>
<td>3.8**</td>
<td>5.6**</td>
</tr>
</tbody>
</table>

**Significant (P<0.01).
Total cooking loss. Total cooking loss was 35.5 per cent and 29.9 per cent for the roasts from the 200°F. and 300°F. ovens respectively. The difference was significant (P<0.01). The increased evaporative losses from the 200°F. roasts were largely responsible for the greater total losses from these roasts. The difference in total loss was, however, reduced by the greater drippings loss from the 300°F. roasts.

These results show similar trends to those for the blade roasts of Nielsen and Hall (1965). Total cooking losses for the round roasts cooked at 200°F. in the present study were approximately 9.3 per cent higher than losses from blade roasts cooked at 225°F. in their study. At 300°F. in the present study losses were about 13 per cent greater than for the blade roasts cooked at 325°F. in the Nielsen and Hall (1965) study. There was also a greater difference in total cooking losses for the round roasts in the present study than for the rump roasts of the Nielsen and Hall (1965) work. The size and shape of the roasts and presence of bone would probably account for the differences in cooking losses in the two studies. The rump is a chunky roast, and the blade is more rectangular, with a larger surface area. Roasts in the Nielsen and Hall (1965) study averaged four pounds. The top-round roasts of the present study would resemble blade roasts in shape but were boneless.
II. EFFECT OF TWO OVEN TEMPERATURES ON COOKING TIME
HEAT PENETRATION, AND POWER CONSUMPTION

Cooking time. There was a significant difference in cooking time for the roasts cooked at the two oven temperatures as shown in Table III. At 200°F, the roasts required an average of approximately three hours per pound to reach the desired end-point temperature, while those cooked at 300°F required only fifty-four minutes per pound.

Nielsen and Hall (1965) also reported a longer cooking time for rump and blade roasts at 225°F as compared to 325°F, but the differences between the cooking times per pound for their roasts were not as great as in the present study. At 225°F, the roasts in their study required an average of 2.35 hours per pound, and at 325°F, rump roasts required an average of forty-seven minutes per pound, and the blade roasts an average of twenty-five minutes per pound. Again, differences in size, shape, and surface area of the roasts, as well as differences in oven temperature were probably contributing factors.

Heat penetration. An average heat-penetration curve for five roasts at each of the oven temperatures is shown in Figure 1. The data indicate that the internal temperature of the roasts was similar during the first twenty minutes. Then the temperature of the roasts in the 200°F oven rose an average of 56°F in the first hour, only 22°F in the second hour, and required three-and-one-half more
# TABLE III

**TIME REQUIRED AND POWER CONSUMPTION TO ROAST TOP ROUND OF BEEF AT TWO OVEN TEMPERATURES**

<table>
<thead>
<tr>
<th>Animal Number</th>
<th>Cooking Time (min./lb.)</th>
<th>Power Consumption (watt-hr./lb.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Oven Temperature 200°F.</td>
<td>300°F.</td>
</tr>
<tr>
<td></td>
<td>1410</td>
<td>755</td>
</tr>
<tr>
<td>1</td>
<td>177</td>
<td>46</td>
</tr>
<tr>
<td>2</td>
<td>199</td>
<td>54</td>
</tr>
<tr>
<td>3</td>
<td>203</td>
<td>67</td>
</tr>
<tr>
<td>4</td>
<td>185</td>
<td>61</td>
</tr>
<tr>
<td>5</td>
<td>236</td>
<td>58</td>
</tr>
<tr>
<td>6</td>
<td>179</td>
<td>52</td>
</tr>
<tr>
<td>7</td>
<td>172</td>
<td>48</td>
</tr>
<tr>
<td>8</td>
<td>160</td>
<td>44</td>
</tr>
<tr>
<td>Average</td>
<td>189</td>
<td>54</td>
</tr>
<tr>
<td>Difference</td>
<td>135**</td>
<td>433**</td>
</tr>
</tbody>
</table>

**Significant (P < 0.01).**

*aData not obtained.*
FIGURE 1
AVERAGE HEAT PENETRATION CURVES FOR FIVE TOP-ROUND BEEF ROASTS AT TWO OVEN TEMPERATURES
hours to increase from 138°F to 160°F. The temperature of the roasts in the 300°F oven continued to rise rapidly and reached the end-point temperature in about two hours. There was not perfect agreement between thermocouples and the mercury thermometers. Therefore the final end-point of cooking was determined by the thermometer readings. The curves are included here merely to give an indication of the difference in the rate of heat conduction at the two oven temperatures.

**Power consumption.** The watt-hours of power consumed per pound of meat at each oven temperature are shown in Table III (page 28) also. The large increase in cooking time of the roasts in the 200°F oven resulted in an increase of approximately 50 per cent in the consumption of power per pound of meat. The average power consumption per pound of meat was 1248 watt-hours at 200°F and 815 watt-hours at 300°F. The difference was highly significant (P<0.01). These results also agree with those of Nielsen and Hall (1965) who reported a 100 per cent increase in power consumption at 225°F as compared to 325°F. The increased fuel consumed by the lower temperatures might be a factor to consider when determining the practical aspects of the use of the two oven temperatures.

### III. EFFECT OF TWO OVEN TEMPERATURES ON FLAVOR AND JUICINESS OF TOP-ROUND ROASTS

Average panel scores for flavor and juiciness of top-round roasts cooked at the two oven temperatures are presented in Table IV.
### TABLE IV

**PANEL SCORES\(^a\) FOR FLAVOR AND JUICINESS OF TOP ROUND OF BEEF ROASTED AT TWO OVEN TEMPERATURES**

<table>
<thead>
<tr>
<th>Animal Number</th>
<th>Flavor</th>
<th>Juiciness</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Oven Temperature</td>
<td></td>
</tr>
<tr>
<td></td>
<td>200(^\circ)F.</td>
<td>300(^\circ)F.</td>
</tr>
<tr>
<td>1</td>
<td>7.4</td>
<td>7.2</td>
</tr>
<tr>
<td>2</td>
<td>7.0</td>
<td>7.4</td>
</tr>
<tr>
<td>3</td>
<td>8.0</td>
<td>6.6</td>
</tr>
<tr>
<td>4</td>
<td>7.6</td>
<td>7.0</td>
</tr>
<tr>
<td>5</td>
<td>7.0</td>
<td>7.8</td>
</tr>
<tr>
<td>6</td>
<td>7.6</td>
<td>7.2</td>
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<tr>
<td>7</td>
<td>7.0</td>
<td>6.8</td>
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<tr>
<td>8</td>
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<td>7.8</td>
</tr>
<tr>
<td>Average</td>
<td>7.4</td>
<td>7.2</td>
</tr>
<tr>
<td>Difference</td>
<td>0.2</td>
<td></td>
</tr>
</tbody>
</table>

\(^*\)Significant (P < 0.025).

\(^a\)Maximum score is 9. Each score is the mean of five evaluations.
Flavor. Cooking temperature had no detectable effect on the flavor of the roasts. Average scores were 7.4 for the roasts in the 200°F oven and 7.2 for the roasts cooked at 300°F. The difference of 0.2 was not significant.

Juiciness. Average panel scores for juiciness were 5.9 and 6.6 for the roasts in the 200°F and 300°F ovens respectively. The difference, 0.7, was significant (P<0.025). Scores for juiciness probably reflect the higher evaporative loss at the lower oven temperature. The roasts cooked at 200°F had greater cooking losses, and were slightly less juicy than the 300°F roasts. On the nine-point scale used, a score of 5.9 is approaching "fair plus," and 6.6 is approaching "good" (see Appendix, page 47).

IV. EFFECT OF TWO OVEN TEMPERATURES ON TENDERNESS

The data obtained for the tenderness of roasts cooked at the two oven temperatures are presented in Table V.

Panel scores. Panel scores for the 200°F roasts ranged from 7.2 to 8.4, with an average of 7.6; the range for the 300°F roasts was 6.4 to 7.8, with an average of 7.2. The difference of 0.4 was significant (P<0.05), indicating that the panel evaluated the roasts from the lower-temperature oven as being more tender.
### TABLE V
COMPARISON OF THREE ESTIMATES OF TENDERNESS OF TOP ROUND OF BEEF ROASTED AT TWO OVEN TEMPERATURES

<table>
<thead>
<tr>
<th>Animal Number</th>
<th>Panel Scores</th>
<th>Number of Chews</th>
<th>Shear Values (lbs.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Oven Temperature</td>
<td></td>
<td>Oven Temperature</td>
</tr>
<tr>
<td></td>
<td>200°F.</td>
<td>300°F.</td>
<td>200°F.</td>
</tr>
<tr>
<td>1</td>
<td>7.2</td>
<td>7.2</td>
<td>27.6</td>
</tr>
<tr>
<td>2</td>
<td>7.4</td>
<td>7.8</td>
<td>36.8</td>
</tr>
<tr>
<td>3</td>
<td>7.6</td>
<td>7.0</td>
<td>25.4</td>
</tr>
<tr>
<td>4</td>
<td>8.2</td>
<td>7.4</td>
<td>24.8</td>
</tr>
<tr>
<td>5</td>
<td>8.4</td>
<td>7.2</td>
<td>23.6</td>
</tr>
<tr>
<td>6</td>
<td>7.6</td>
<td>7.2</td>
<td>25.6</td>
</tr>
<tr>
<td>7</td>
<td>7.4</td>
<td>6.8</td>
<td>24.2</td>
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<tr>
<td>8</td>
<td>7.2</td>
<td>6.4</td>
<td>23.2</td>
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<tr>
<td>Average</td>
<td>7.6</td>
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<td>26.4</td>
</tr>
<tr>
<td>Difference</td>
<td>0.4*</td>
<td></td>
<td>1.2</td>
</tr>
</tbody>
</table>

*Significant (P<0.05).

**Significant (P<0.01).
Number of chews. The difference of 1.2 between the "chew count" for the 200°F. and 300°F. roasts was not significant. For the roasts cooked at 200°F. the average number of chews ranged from 23.2 to 27.6 for all but one of the samples which had a "chew count" of 36.8. This figure increased the average and deviations considerably and was possibly the reason for the lack of significance in the results. The range of "chew counts" for the roasts cooked at 300°F. was 24.0 to 33.6, with an average of 27.6.

Coefficients of correlation between panel scores and chews were -0.29 and -0.45 for the 200°F. and 300°F. roasts respectively. Neither of these was significant.

Shear values. The shear values for the 200°F. roasts were significantly lower (P<0.01) than those for the roasts cooked at 300°F., an objective measure indicating that roasts cooked at 200°F. were more tender. Coefficients of correlation between shears and chews were 0.431 and 0.025 for the higher and lower temperatures respectively, neither being significant. Considering the correlation between panel scores and shears, it was found that there was a highly significant (P < 0.01) negative correlation of -0.88 for the 200°F. roasts, but a nonsignificant correlation of -0.33 for the roasts cooked at 300°F.

Comparison of results for tenderness. Tenderness of the meat was found to increase in roasts cooked at the lower oven temperature. This trend was indicated by all methods of estimating tenderness, and
differences between the two oven temperatures were significant when determined by panel scores and shear values.

Cover (1943) was one of the first to propose that lower oven temperatures were desirable in the roasting of beef. She stated that a slow rate of heat penetration would produce meat that was less juicy, but more tender, and had only slightly greater cooking losses. The reasons for this increased tenderness of roasts cooked at lower oven temperatures are not altogether clear, but there seems to be some indication that slow penetration of heat is an important factor.

Machlik and Draudt (1963) worked with one-half inch cylinders of muscle and found that hardening of the muscle was accomplished between 151°F. and 167°F. and that the conversion of collagen was achieved between 131°F. and 149°F. In the present study the rise in internal temperature from 131°F. to 149°F. occurred in approximately twenty-five minutes in the 300°F. roasts (Figure 1, page 29) while at the 200°F. oven temperature, ninety-five minutes were required for the meat to pass through this temperature range. There is a possibility that the increased time during which the 200°F. roasts were held in the temperature range that has been reported as favorable for the conversion of collagen to gelatin was a factor in the increased tenderness at this temperature. Work would need to be done in determining the collagen content of raw meat and of meat cooked at each of the oven temperatures before it could be shown that the increased hydrolysis of collagen was the true cause of the increased tenderness of the roasts cooked at the lower oven temperature.
The results in this study were very similar to those obtained by Nielsen and Hall (1965). They found that blade roasts cooked at 225°F. were significantly more tender than the 325°F. roasts, as indicated by shearing tests, but the difference was not reflected in their panel scores. Rump roasts also tended to be more tender when cooked at 225°F. than at 325°F. but the difference was not significant. In the present study, both panel scores and shear tests indicated that top-round roasts were significantly more tender when roasted at 200°F. than at 300°F.

**Other considerations.** The practical aspects of using either of the oven temperatures tested in this study for roasting top-round of beef need to be considered.

The lower oven temperature gives meat that is more tender, but this is achieved at the expense of cooking time, power consumption, and juiciness. The meat cooked at the lower oven temperature did not have such an attractive outer appearance. There was no apparent difference in flavor which would seem to indicate that the tenderness and juiciness differences did not influence the scores for flavor.

The increased cooking time at the lower oven temperature could be an advantage in certain instances such as institutions which use large roasts that could be cooked overnight. It seems possible, also, that cooking losses for larger roasts would not be as great as those obtained in the present study. Further work in this field to determine
the temperature at which increased tenderness is achieved without sacrificing other factors is necessary.
CHAPTER V

SUMMARY

I. SCOPE OF THE STUDY

The purpose of this study was to determine the effect of roasting at two oven temperatures on the cooking losses, cooking time, power consumption, sensory quality, and tenderness of top round of beef.

Roasts weighing an average of 2.46 pounds and cut two-and-one-half inches thick were obtained from seven heifers and one steer. Two adjacent roasts were taken from each animal for cooking at oven temperatures of 200°F. and 300°F. Four anterior and four posterior roasts were cooked at each oven temperature. End-point temperatures of 154°F. and 158°F. were used for the 200°F. and 300°F. roasts respectively. Three roasts were cooked each day, two at one of the oven temperatures.

Sensory evaluations of flavor, juiciness, and tenderness were obtained. Tenderness was also determined objectively by use of the Warner Bratzler shear machine. Heat penetration at each oven temperature was measured.

II. PRINCIPAL FINDINGS

Evaporation loss was about one-third lower at 300°F. than at 200°F., being 21.5 and 30.8 per cent respectively. On the other hand, drippings loss was about twice as large at 300°F. as at 200°F.,
being 8.4 and 4.6 per cent respectively. The high evaporation loss contributed to the high total cooking losses at 200°F, 35.5 as compared to 29.9 per cent at 300°F.

The roasts cooked at 200°F. required approximately three hours per pound to reach the desired end-point temperature, while those cooked at 300°F. required fifty-four minutes per pound. The increased cooking time at the lower oven temperature required 53 per cent more watt-hours of power.

Sensory evaluation indicated that there was no apparent difference in the flavor of roasts cooked at the two oven temperatures, but the roasts cooked at 300°F. were significantly more juicy than those cooked at 200°F. As indicated by shear values and panel scores, roasts cooked at 200°F. were significantly (P < 0.01) more tender than those cooked at 300°F. When tenderness was determined by "chew count" the difference between samples cooked at the two oven temperatures was not significant.

While reducing the oven temperature 100°F. for roasting beef round yielded meat that was more tender than was obtained by roasting at the conventional temperature of 300°F. this improvement in tenderness was achieved at the expense of increased cooking losses, cooking time, fuel consumption, and decreased juiciness of the meat. All these factors need to be considered when deciding on the temperature most practical for use.
BIBLIOGRAPHY


Cover, S., J. A. Bannister, and E. Kehlenbrink. 1957. Effect of four conditions of cooking on the eating quality of two cuts of beef. Food Research 22, 635.


Hiner, R. L., and O. G. Hankins. 1951. Effects of freezing on tenderness of beef from different muscles and from animals of different ages. Food Technol. 5, 374.


APPENDIX
DATA ON COOKING AND COOKING LOSSES

<table>
<thead>
<tr>
<th>Animal No.:</th>
<th>Cut No.:</th>
<th>Pan No.:</th>
<th>Oven No.:</th>
<th>Oven Temperature:</th>
</tr>
</thead>
</table>

A. BEFORE COOKING
   1. Wt. of pan and rack
   2. Wt. of roast
   3. Total wt. before cooking

B. AFTER COOKING
   1. Total wt. of pan, roast, and rack
   2. Wt. loss due to evaporation
   3. Wt. of pan, rack and drippings
   4. Wt of pan and rack
   5. Wt. of drippings
   6. Total cooking losses (2 + 5)

C. COOKING DATA
   1. Time into oven
   2. Time out of oven
   3. Total cooking time (min.)
   4. Wt. in lbs.
   5. Time per lb.

D. PERCENTAGE COOKING LOSSES
   1. Loss due to evaporation \((B_2/A_2 \times 100)\)
   2. Drippings loss \((B_5/A_2 \times 100)\)
   3. Total loss \((B_6/A_2 \times 100)\)
DATA ON COOKING AND COOKING LOSSES (CONTINUED)

E. POWER CONSUMPTION

1. Final watt-hr. reading
2. Initial watt-hr. reading
3. Total watt-hr. consumed
### GRADING CHART FOR MEAT

Directions: Give full value for excellent quality. Do not use fractional points.

Values:  
- **9** - Excellent  
- **8** - Very good  
- **7** - Good  
- **6** - Fair plus  
- **5** - Fair  
- **4** - Fair minus  
- **3** - Poor  
- **2** - Very poor  
- **1** - Extremely poor

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Flavor</th>
<th>Juiciness</th>
<th>Tenderness</th>
</tr>
</thead>
</table>

Comments: