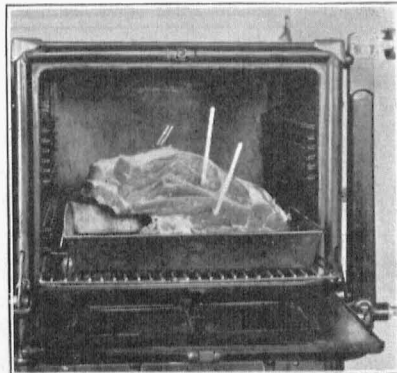


UNIVERSITY OF MISSOURI COLLEGE OF AGRICULTURE  
AGRICULTURAL EXPERIMENT STATION  
BULLETIN 293

# How Certain Methods of Cooking Affect the Quality and Palatability of Beef



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### **ACKNOWLEDGMENT**

This bulletin is a contribution from the Agricultural Experiment Station of the University of Missouri on the national cooperative project, "A Study of the Factors Which Influence the Quality and Palatability of Meat." The cooperating agencies are: National Livestock and Meat Board, United States Department of Agriculture, and the State Agricultural Experiment Stations

# How Certain Methods of Cooking Affect the Quality and Palatability of Beef

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**ABSTRACT.** This bulletin deals with investigations carried on in meat cookery during the past four years at the Missouri Agricultural Experiment Station. Authorities differ as to the best methods for roasting the tender cuts of beef. Also the question has arisen as to whether the less tender cuts can be roasted to produce a palatable product. The investigations show that searing does not hold in the juices of meat; that low oven temperatures for roasting result in less cooking losses and greater palatability, than do high oven temperatures; that boneless roasts take longer to cook than do cuts with bone; and that there is no relation between the total percentage loss in cooking and the size of the cut. The results also seem to indicate that even the less tender cuts from good grade heifers can be roasted and broiled to give a fair degree of palatability.

## INTRODUCTION

A study of the diets and expenditures of 200 typical American families has revealed that from one-sixth to one-third of the total expenditure for food was for meat. The meat consumption per person in the United States in 1928, when this nation ranked fourth in this respect among the countries of the world, was 152.7 pounds, of which 51.7 pounds was beef. The total value of fresh meat produced in the United States in 1927 was \$1,564,232,313 and the value of beef was \$762,614,133. In Missouri alone the total value of meat produced that year was \$45,393,705.

At present a few well known cuts of beef are in great demand and hence a portion of the carcass (loin and ribs), forming only about one-fourth of its weight, represents nearly one-half of its retail cost. Percentage composition determinations show that there is little relation between market prices and percentage of protein, fat, extractives, and ash.

Authorities differ as to the best methods for the roasting and broiling of beef. The recommendations regarding length of time, oven temperatures, and internal meat temperatures necessary to give beef a certain degree of doneness, vary greatly.

Realizing the vast economic importance of the meat industry and the lack of authentic information concerning the best methods of handling meat, the National Live Stock and Meat Board, cooperating with the United States Department of Agriculture and the state experiment stations, instituted the project: "A Study of the Factors Which Influence the Quality and Palatability of Meat." This bulletin reports a part of this investigation carried on at the Missouri Station under the plans of the project mentioned above.

The problem given major attention in this investigation has been a comparison of results from different methods of cooking. Studies have been made to determine the best temperature and cooking period for roasting tender cuts of beef. An effort has also been made to determine whether the cuts which are now less popular can be roasted and broiled in such a way as to give them a degree of palatability comparable to the rib and loin cuts.

### GENERAL METHODS

The methods used in all phases of this investigation have been, in so far as possible, those recommended by the National Committee of the cooperative project, "A Study of the Factors Which Influence the Quality and Palatability of Meat."

### METHODS OF ROASTING

During the past four years two general methods of roasting have been used: (1) searing, or browning the roasts at a relatively high temperature for a short time and cooking to the desired degree of doneness at a lower temperature; and (2) cooking the roasts to the desired degree of doneness at a constant oven temperature. Five variations of each of these methods have been studied. The searing methods tested were as follows:

Method No.	Searing Oven Temperature °C. <sup>1</sup>	Length of Time Searcd - Minutes	Reduced Oven Temperature °C. <sup>1</sup>
1	277	20	127
2	288	20	149
3*	232	30	149
4**	277		110
5***	260	20	260

<sup>1</sup>Started in a cold oven with the regulator set at 232°C.

\*\*The temperature of the oven was raised to searing after the internal temperature of the roast reached 50°C.

\*\*\*After searing, 1 cup water was added, the roast covered, and cooking continued.

1. TABLE OF TEMPERATURES USED IN THIS BULLETIN, SHOWING EQUIVALENTS IN THE CENTIGRADE AND THE FAHRENHEIT SCALES.

°C.	°F.	°C.	°F.	°C.	°F.	°C.	°F.	°C.	°F.	°C.	°F.
50	122	62	144	125	257	163	325	218	425	277	530
57	135	70	158	127	260	165	329	232	450	288	550
60	140	110	230	149	300	191	375	260	500		

The constant oven temperature methods tested were as follows:

Method No.	Oven Temperature °C. <sup>1</sup>
6	110
7	163
8	191
9	218
10	260

In all but one series of experiments the roasts were cooked until the internal temperatures, that is, the temperatures at, or near, the centers of the roasts, were 57°C. This degree of doneness is what most persons would consider "medium rare" as the lean is still pink in color. In one series, the roasts were cooked to the "well-done" stage (70°C.) to compare the cooking losses with those roasts cooked only to 57°C.

During the first two years of the work, each of the methods stated above was tested, using standing prime rib roasts, each including the ninth, tenth, and eleventh ribs.<sup>2,3</sup> The roasts were procured from the local meat markets and were of the average grades sold. The five methods, Nos. 1, 3, 7, 8, and 9, found to be among the best, were used the following year on chuck roasts each cut to include the third, fourth, and fifth ribs.<sup>4</sup> These roasts were also procured from the local meat markets and were of the average grades sold.

The two methods (of the five so tested) found to give the best results on chuck were Nos. 1 and 7. Number 1 is a method requiring two ovens and, therefore, not practical for the housewife. Since method Number 7, which produced as satisfactory a product, was a constant oven temperature (163°C.), it was chosen as one method in the next series of tests.

In the early experiments of this investigation it was found that a constant oven temperature of 110°C. produced the *smallest cooking losses* and the *greatest uniformity of doneness*, but this temperature was too low to be uniformly maintained in the ovens used. Since this extremely low oven temperature had these two distinct advantages, this next series of tests included a method of roasting at the lowest constant oven temperature which could be practically maintained, that of 125°C. Therefore cooking at the constant oven temperatures, 125°C. and 165°C. were compared in the latest series of experiments.

2. Godfrey, R. S. and Cline, J. A., *The Losses of Weight by Beef Roasted at Different Oven Temperatures and the Possible Effects of These Losses Upon the Quality and Palatability of Beef*. Abstracts of Reports of Research, A. H. E. A., 1927.

3. Craghead, C. W., *A Study of Temperatures and Time of Cooking on the Quality and Palatability of Meat*, thesis, University of Missouri, 1929.

4. Cover, S., *A Study to Determine the Best Method of Roasting a Chuck Cut of Beef*, thesis, University of Missouri, 1929.

## LESS POPULAR CUTS

The first three year's work showed that chuck ribs and prime ribs could be roasted so that the most desirable part of the chuck gave a degree of palatability\* comparable to that of prime rib roasts. In order to determine the degree to which the other less popular cuts of beef could be roasted to give a palatability comparable to the rib, the fourth or latest series of experiments included six kinds of roasts from a grade and class of beef which is obtainable at most good meat markets. The meat was secured from six animals of known history.<sup>5</sup>

The results of these experiments were judged on two points: percentage cooking losses, both from drippings and evaporation, and the degree of palatability obtained. Actual weights were used to measure the cooking losses and the palatability was graded by having samples of the meat eaten by a group of experienced judges. The palatability for all of the meat was graded by the same group of judges. These judges did not know the cut of beef being graded or the method by which it had been cooked.

## METHODS FOR BROILING STEAKS

The initial work on cooking steaks has included the use of two kinds of broilers, and the palatability of the less tender cuts.

The only work done on steaks, previous to this, in connection with the national cooperative meat project, was done at the Bureau of Home Economics, U. S. D. A., in the spring of 1929. At that time a method for broiling steaks, using an electric oven broiler, was developed, and used in comparing steaks from five different cuts of four different grades of animals.<sup>6</sup> This kind of broiler was therefore chosen as one to be used in this study.

Since gas ovens were being used for the roasting problems, it was thought advisable to use the broiler units of these same gas ovens for the other kind of broiler.

The same plan was followed as with the roasts, that is, the steaks from the right side of an animal were broiled on one kind of broiler and the steaks from the opposite side of the animal on the other kind of broiler. The steaks were cut from the same carcasses as the roasts.

\*Sensations experienced when the meat was eaten.

5. Fry, H. E., *The Effect of Two Methods of Roasting on the Palatability and Cooking Losses of Six Cuts from Heifers of Known History*, thesis, University of Missouri, 1930.

6. Bureau of Home Economics, U. S. D. A., *To Determine the Relation Between the Grade of Animal, and the Palatability of Steaks Cut from Chuck, Rib, Porterhouse, Sirloin*, Report of Conference of Representatives of Institutions Engaged in Cooperative Quality-in-Meat Investigation, August, 1929.

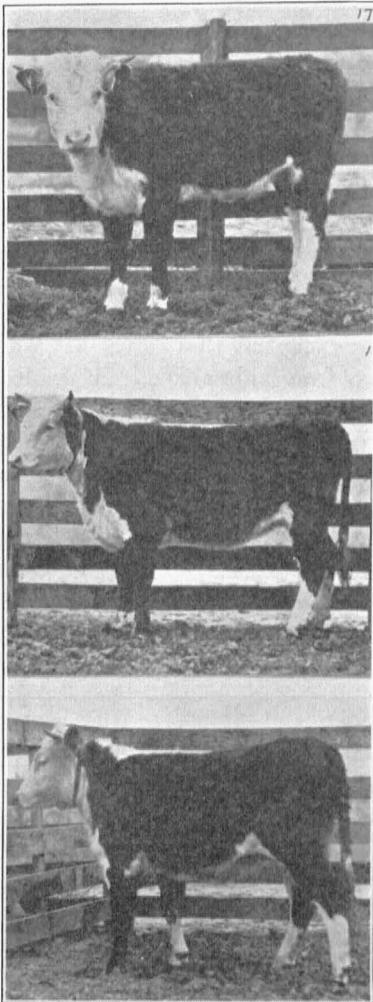


Fig. 1.—First lot of heifers slaughtered with final weights as follows: No. 17, 644 lbs.; No. 11, 733 lbs.; No. 8, 686 lbs.

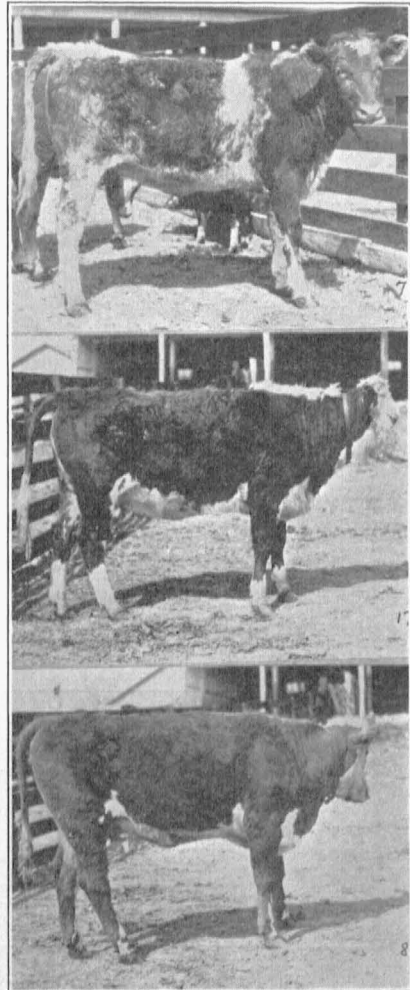


Fig. 2.—Second lot of heifers slaughtered with final weights as follows: No. 72, 730 lbs.; No. 171, 650 lbs.; No. 8b, 664 lbs.

### QUALITY OF BEEF AND ANIMALS USED

The animals used were fed under the direction of the animal husbandry department of this Station. Good grade heifers which averaged approximately 700 pounds in weight were used in this experiment because this class and grade of beef constitutes an important part of the

beef retailed in the Middle West. Two lots of three heifers each were fed so that they were in as nearly equal condition when slaughtered as it was possible to have them. The first lot of animals consisted of Hereford heifers Nos. 8, 11 and 17, and was bought on the St. Louis market. From August 29 to November 24, an 87 day feeding period, this lot of heifers was full fed on a ration consisting of eight parts shelled corn and one part cotton seed meal by weight with alfalfa hay as roughage. The carcasses from this lot of animals graded "high-good" to "low-choice." The second lot of three heifers, two Herefords, Nos. 8b and 17b, and one Shorthorn, No. 72, were locally produced heifers. From December 23 to March 14, an 80 day feeding period, these heifers were full fed on the same ration as those in lot one excepting that clover hay was substituted for alfalfa hay. The carcass from animal No. 17b graded "high-medium" and the carcasses from animals Nos. 8b and 72, graded "low-good." All six heifers were approximately 18 months old when slaughtered. They were slaughtered at the University abattoir and the carcasses were allowed to ripen for 10 days at a temperature between 28°F. and 38°F. before any of the cuts were removed for the cooking tests.

The final weights, total gains while on grain feed, average daily gains, warm carcass weights, and dressing percentages of the six animals used were as follows:

Animal No.	Final Weight	Total Gain	Average Daily Gain	Warm Carcass Weight	Dressing Percentage
	<i>pounds</i>	<i>pounds</i>	<i>pounds</i>	<i>pounds</i>	<i>pounds</i>
8	644.0	169.5	1.95	398	57.96
11	733.3	223.3	2.56	403	54.97
17	686.6	184.9	2.13	378	58.69
8b	644.6	171.0	2.14	372	56.02
17b	650.0	114.0	1.43	389	58.46
72	730.0	197.7	2.47	436	59.72

The average daily ration per heifer, and the average total amount of feed per heifer for the period of full feeding is as follows:

LOT I. ANIMALS No. 8, 11 AND 17			LOT II. ANIMALS No. 8b, 17b, AND 72		
Ration	Average total amount per heifer per period	Average total amount per heifer per day	Ration	Average total amount per heifer per period	Average total amount per heifer per day
	<i>pounds</i>	<i>pounds</i>		<i>pounds</i>	<i>pounds</i>
Corn.....	997	11.46	Corn.....	865	10.81
Cotton Seed Meal	124	1.46	Cotton Seed Meal	108	1.35
Alfalfa Hay.....	294	3.38	Clover Hay	386	4.83

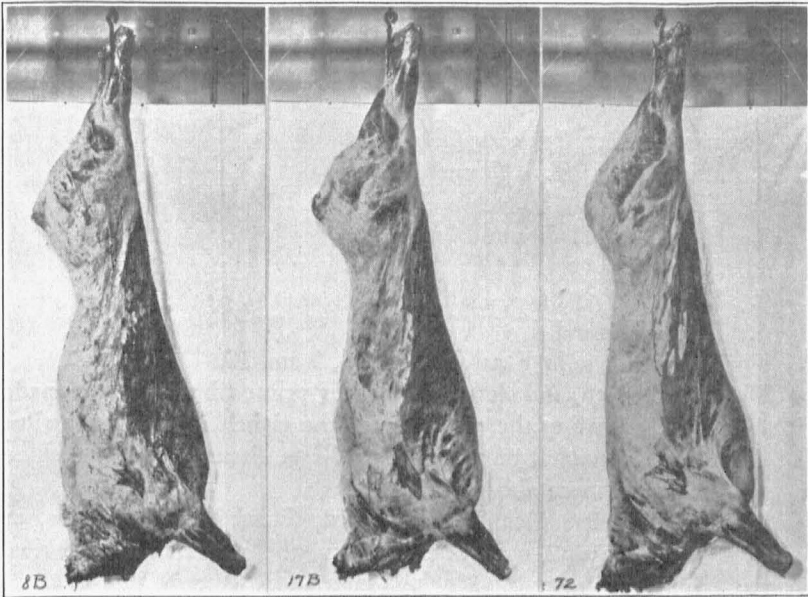


Fig. 3.—The carcasses (outside view) from the second lot of heifers.

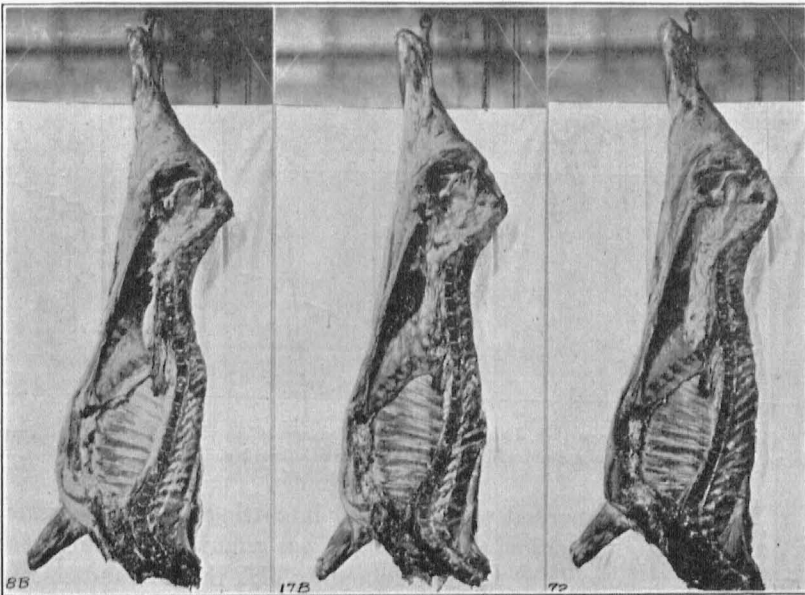


Fig. 4.—Inside view of the carcasses from the second lot of heifers.

## CUTS OF MEAT USED

As far as possible, roasts and steaks were cut from the carcasses according to the "Chicago Method"<sup>7</sup> and the directions given in the plans of the National Cooperative Project.

The roasts selected were as follows:

1. Prime Rib (9th, 10th and 11th ribs)
2. Chuck Rib I (3rd, 4th and 5th ribs)
3. Chuck Rib II (1st and 2nd ribs)
4. Sirloin Tip
5. Rump
6. Heel of Round

These are shown in Figures 5, 6, 7, 8, 9 and 10.

The ninth, tenth, and eleventh standing prime rib roasts were made with the knife crowding the rear edge of the eighth and eleventh ribs. The chine bones were left on the rib cuts. The distance from the chine bone to the rib end was about ten inches.

The chuck roasts including the third, fourth, and fifth ribs, or Chuck I, were cut with the knife crowding the second and fifth ribs. The cut was made about twelve inches long.

The chuck roasts including the first and second ribs, or Chuck II, were cut the same length as Chuck I and with the knife crowding the second rib and the front edge of the first rib.

The rump was removed from the round, parallel to the pelvic bone and as close to it as the knife will cut. The rump roasts used were made 4 inches thick by cutting parallel to the cut which removed the rump from the round.

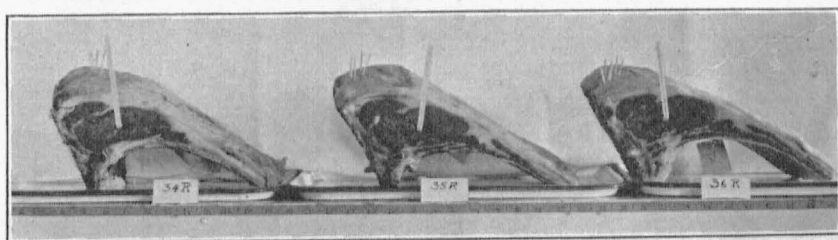


Fig. 5.—Prime rib roasts (9th, 10th, and 11th ribs) from second lot of animals. No. 34R from Animal No. 8b; No. 35R from Animal No. 11b; No. 36R from Animal No. 72.

The following method was employed in cutting the hind quarter, in order to secure the sirloin tip. The flank was removed by a cut which crowded the stifle joint just closely enough to nick the lean and crossed

7. Davis, W. C. and Whalin, C. V., *Market Classes and Grades of Dressed Beef*, U. S. D. A. Department Bulletin No. 1246, p. 33, 1924.

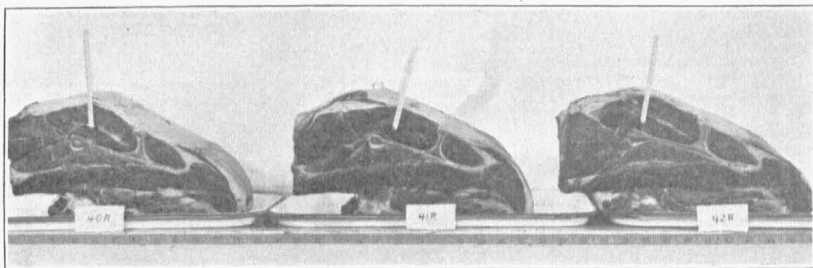


Fig. 6.—Chuck I, 3d, 4th and 5th ribs from second lot of animals. No. 40R from Animal No. 8B; No. 41R from Animal No. 17B; No. 42R from Animal No. 72.

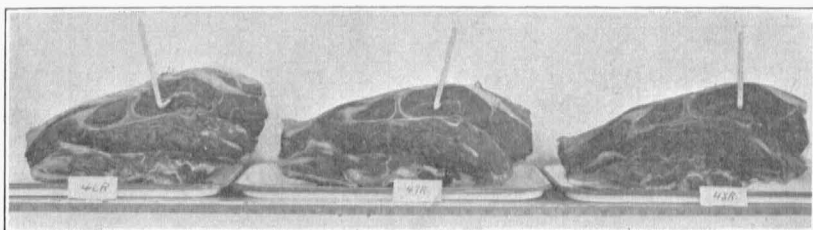


Fig. 7.—Chuck II, 1st and 2d ribs from second lot of animals. No. 46R from Animal No. 8B; No. 47R from Animal No. 17B; No. 48R from Animal No. 72.

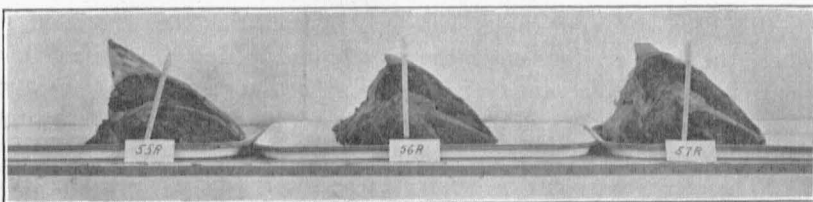


Fig. 8.—Sirloin tip roasts from the second lot of animals. No. 55R from Animal No. 8B; No. 56R from Animal No. 17B; No. 57R from Animal No. 72.

the 13th rib at a point coincident with the plate cut. The round was then removed by cutting parallel and close to the pelvic bone, leaving the rump on the loin and a portion of the bottom sirloin on the round. The sirloin tip was removed from the round by starting to cut at the stifle joint cutting along the femur bone to the cut which removed the round from the loin. (See Figure 15).

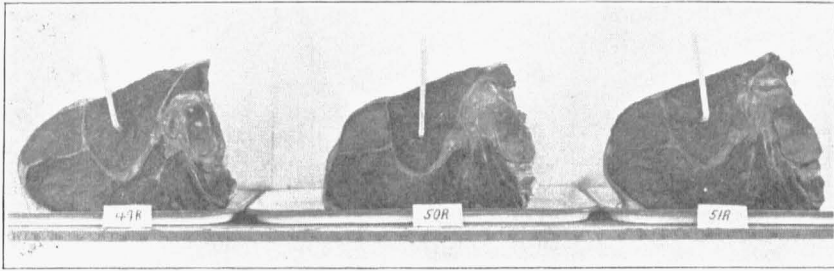


Fig. 9.—Rump roasts from second lot of animals. No. 49R from animal No. 8B; No. 50R from Animal No. 17B; No. 51R from Animal No. 72.

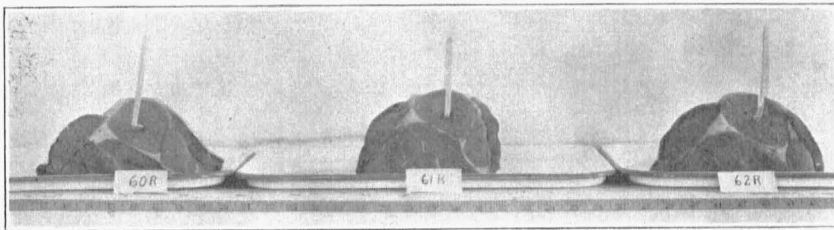


Fig. 10.—Heel of round roasts from the second lot of animals. No. 60R from animal No. 8B; No. 61R from Animal No. 17B; No. 62R from Animal No. 72.

The heel of round roasts were made by cutting into the meat to where the large tendons enter the muscle and letting the knife follow the tibia to the stifle joint then removing the triangular piece known as "heel of the round," or "Pike's Peak Roast", by cutting parallel to the cut which separated the rump from the round.

The steaks were cut in pairs, just as the roasts, that is, identical cuts from the right and the left side of each animal. The following cuts were used:

1. Rib Steaks (12th Rib)
2. Porterhouse Steaks (1st cut from short loin, next to loin end)
3. Sirloin Steaks (1st cut from loin end next to rump)
4. Round Steaks (1st cut from round, next to rump)

These are shown in Figures 11, 12, 13, and 14.

The steaks used were cut two inches thick, so there would be plenty left for sampling after the seared parts were removed.

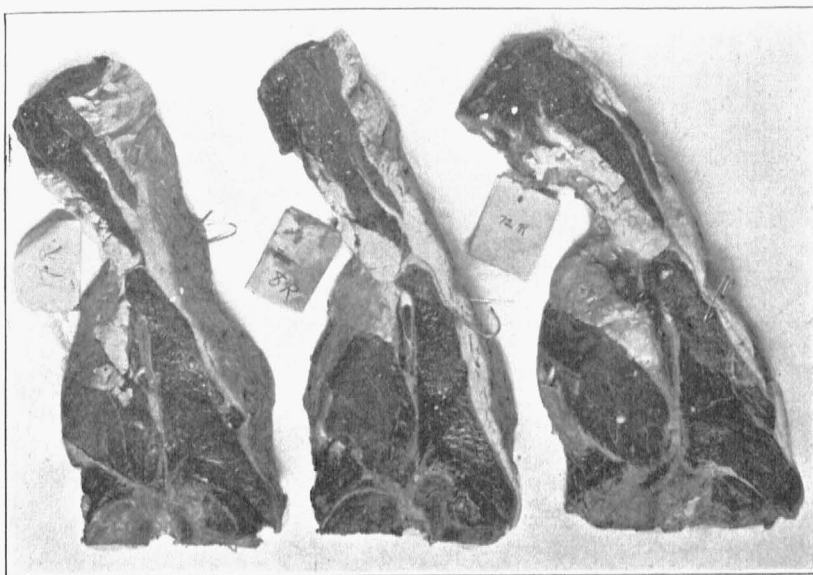


Fig. 11.—Rib steaks from the second lot of animals.

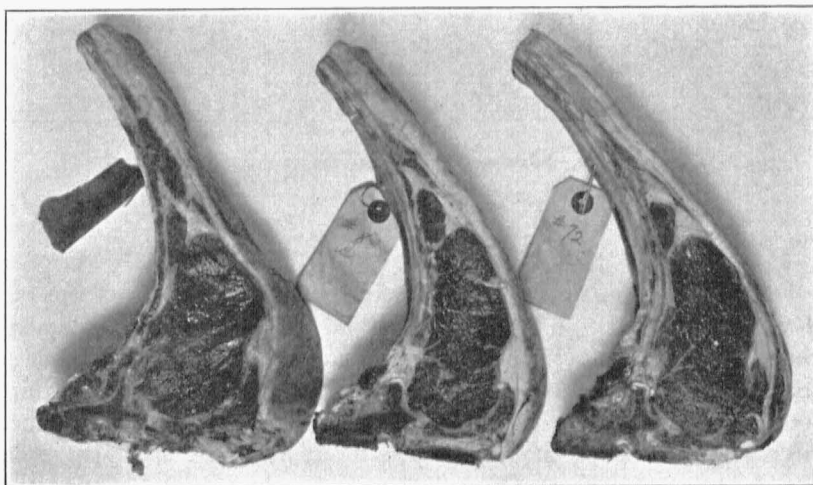


Fig. 12.—Porterhouse steaks from the second lot of animals.

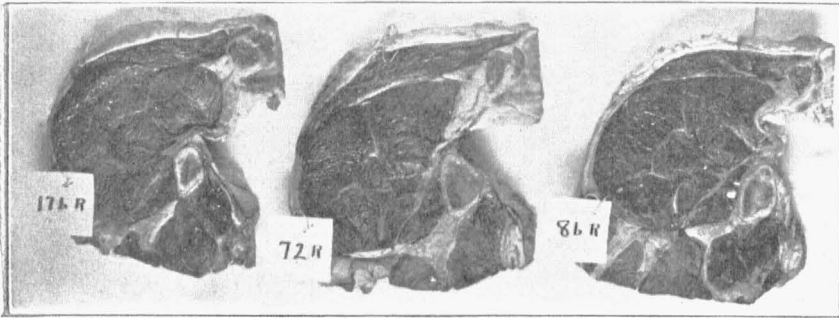


Fig. 13.—Sirloin steaks from the second lot of animals.

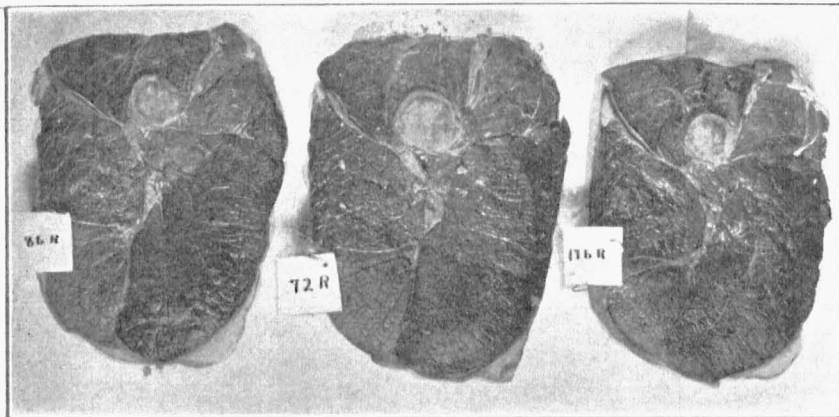


Fig. 14.—Round steaks from the second lot of animals.

### RIPENING PERIOD

The minimum time of ripening for any of the cuts used was ten days. While a variation in the length of the ripening time existed among the different cuts, the time was kept constant for each kind of roast or steak. That is, all of the prime rib roasts aged for 10 days, the third fourth and fifth chuck rib roasts for 13 days, the first and second chuck rib roasts for 14 days, the rump roasts for 15 days, the sirloin tip roasts for 16 days, and the heel of the round roasts, or the "Pike's Peak roasts," as they are known in some localities, for 17 days. The greatest difference between the aging period of the roasts was 7 days between the prime rib roasts and the heel of the round roasts.

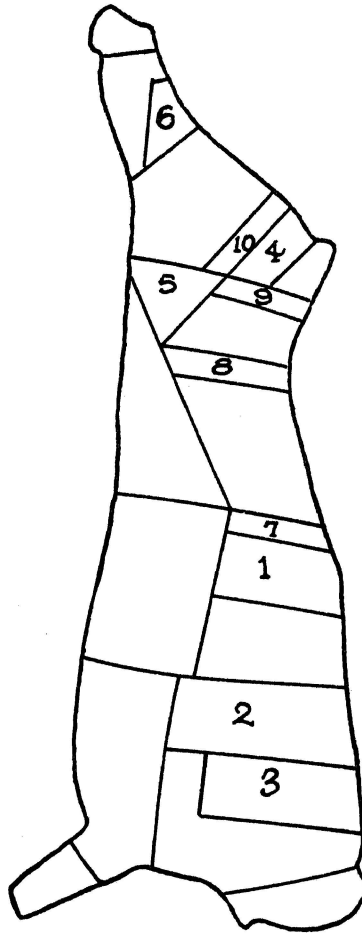


Fig. 15.—Beef chart showing cuts of meat used for testing. (1) 9th, 10th, and 11th prime rib roasts; (2) 3d, 4th, and 5th chuck rib roasts. (3) 1st and 2d chuck rib roasts. (4) rump roast. (5) sirloin tip roasts. (6) heel of round roasts. (7) rib steaks. (8) porterhouse steaks, (9) sirloin steaks. (10) round steaks

The rib steaks aged for 10 days, the porterhouse steaks for 13 days, the sirloin steaks for 15 days, and the round steaks for 16 days. The greatest difference between the aging period of the steaks was 6 days between the rib steaks and the round steaks.

U.S. DEPARTMENT OF AGRICULTURE  
 BUREAU OF AGRICULTURAL ECONOMICS  
 DIVISION OF LIVESTOCK, MEATS AND WOOL

**BEEF CHART**  
 WHOLESALE AND RETAIL CUTS

① **HIND SHANK**  
 1 TO 3 SOUP BONES  
 4 - HOCK

② **ROUND**  
 1 TO 14 ROUND STEAKS  
 15 HEEL OF ROUND

③ **RUMP**  
 STEAKS OR ROASTS

④ **LOIN END**  
 1 TO 6 SIRLOIN STEAKS

⑤ **SHORT LOIN**  
 1 TO 3 CLUB OR DELMONICO STEAKS  
 4 TO 11 PORTERHOUSE STEAKS

⑥ **FLANK**  
 1 - FLANK STEAK  
 2 - STEWS OR HAMBURGER

⑦ **RIB**  
 1 TO 4 RIB ROASTS  
 5 SHORT RIBS

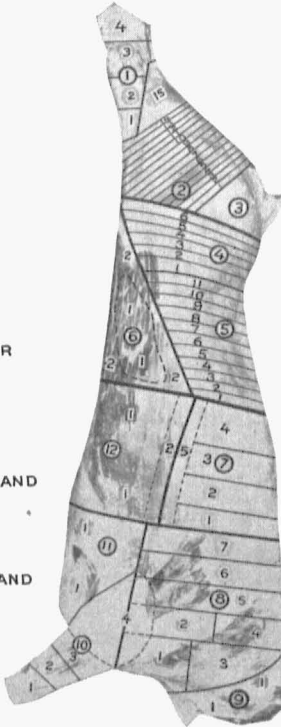
⑫ **PLATE**  
 1 - STEWS OR BONED AND ROLLED ROASTS  
 2 - SHORT RIBS

⑪ **BRISKET**  
 1 - STEWS OR BONED AND ROLLED ROASTS

⑧ **TRIMMED CHUCK**  
 1 & 2 BOTTOM CHUCK ROASTS  
 3 & 4 TOP CHUCK ROASTS  
 5 TO 7 CHUCK RIB ROASTS

⑩ **FORE SHANK**  
 1 TO 3 SOUP BONES  
 4 - SHOULDER CLOD

⑨ **NECK**  
 1 - BONELESS ROASTS  
 STEWS OR HAMBURGER



*Numerals in circles ○ refer to wholesale cuts and major subdivisions of such cuts. Other numerals refer to retail cuts*

**WHOLESALE CUTS AND SUBDIVISIONS**  
**ALL PERCENTAGES BASED ON CARCASS WEIGHT**

① TO ⑥ HINDQUARTER.....	48.0%	⑦ TO ⑫ FOREQUARTER.....	52.0%
① TO ③ ROUND AND RUMP.....	24.0	⑦ RIB.....	9.5
① HIND SHANK.....	4.0%	⑧ & ⑨ CHUCK.....	22.0
② BUTTOCK.....	15.0	⑧ TRIMMED CHUCK.....	17.0%
③ RUMP.....	5.0	⑨ NECK.....	5.0
④ & ⑤ FULL LOIN INC. SUET	20.5	⑩ FORE SHANK.....	5.5
④ LOIN END.....	7.0	⑪ BRISKET.....	6.5
⑤ SHORT LOIN.....	10.5	⑫ PLATE.....	8.5
KIDNEY KNOB.....	3.0		
⑥ FLANK.....	3.5		

Fig. 16.—Beef chart showing wholesale and retail cuts.

## EQUIPMENT USED FOR ROASTING

The roasts were cooked in sheet iron pans, 17 inches long, 12 inches wide, and 2½ inches deep, and roasted in six gas ovens with glass doors and oven regulators. Oven thermometers and right-angled meat thermometers in the centigrade scale were used for determining the temperatures of the oven and the interior of the meat.

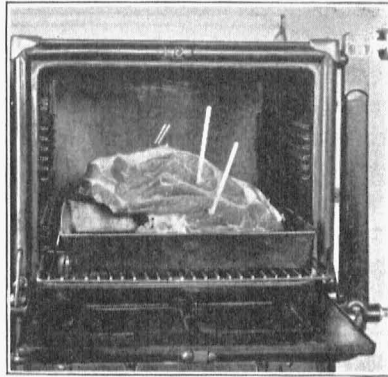


Fig. 17.—Roasting pan with roast and meat thermometer in oven.

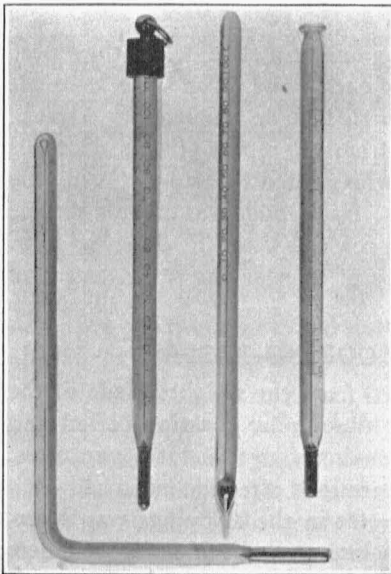


Fig. 18.—Four kinds of meat thermometers.

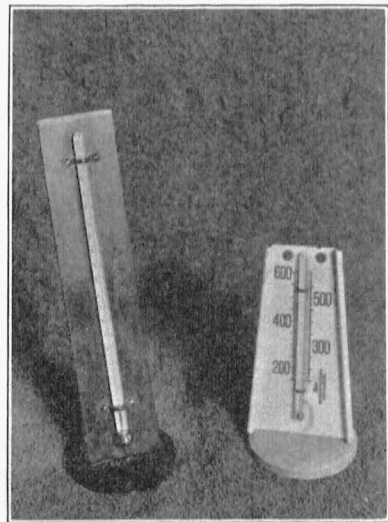


Fig. 19.—Two kinds of oven thermometers.

## PREPARATION OF ROASTS

The roasts after being cut from the carcasses were kept in an electric refrigerator until time to prepare them for roasting. After wiping each roast with a damp cloth a meat thermometer was inserted into the center of the muscle to be tested. The roasts were placed in the open sheet iron pans with the fat side up. Racks were used under those roasts not having bones to support the meat and keep it from coming in contact with the pans and the drippings. No seasoning was used.

## ROASTING PERIOD

The ovens were pre-heated to the required temperatures and the roasts were put into the ovens with as nearly identical internal temperatures as it was possible to obtain. Craghead had found that cooking losses were greater when the roasts had very low internal temperatures. The experimental temperature of the ovens was maintained until the internal temperature of the meat reached 57°C. (This is considered medium rare in doneness, with the inside of the meat pink in color.) The roasts were then removed from the oven and allowed to stand in a warm place until their maximum internal temperature had been reached. It was found in the early phases of these investigations that roasts cooked to an internal temperature of 57°C. increased in temperature several degrees after their removal from the oven.

## GRADING THE ROASTS

The roasts were carved for grading, one at a time, while they were still hot, discarding the outside slices of each roast. The slices were cut across the muscle fibers about one-fourth inch in thickness. A piece about one by two inches was then cut from the center of each slice and served on a warm plate to each judge, who graded the sample, using the grading chart of the cooperative project. Each judge was given a sample from as near the same location in each roast as could be done, so as to have all the samples for any one judge of as near the same degree of doneness as was possible.

## DETERMINATION OF COOKING LOSSES

The cooking losses were determined from the weights made of the roasts and equipment before and after the regular roasting period and after the roasts had come to their maximum internal temperatures. The percentage bone in the cut was determined after the meat had been graded by the judges. The percentage fat in the drippings was determined by pouring all of the drippings into pyrex graduated cylinders and allowing them to stand until cold when the number of cubic centimeters of fat could be read.

### EQUIPMENT USED FOR BROILING

Two kinds of broilers, one electric and two gas were used. Oven thermometers in the Fahrenheit scale used to determine the temperature of the broiler, were placed flat on the broiling rods. Straight meat thermometers, in the centigrade scale, were used to determine the degree of doneness of the steaks.

### PREPARATION OF STEAKS

The steaks were kept in the same refrigerator as the roasts until time to prepare them for broiling. They were cleaned in the same way as the roasts, and were cooked without further trimming. A meat thermometer was inserted horizontally into the center of the muscle to be tested placing the bulb of the thermometer in as near the center of the muscle as possible. No seasoning was used.

### BROILING PERIOD

The broiling ovens were all pre-heated for forty-five minutes before using, with the regulators of the gas ovens set at 500°F., and the automatic control of the electric oven set at "12" (the highest place). The steaks were put into the broilers with as nearly identical internal temperatures as it was possible to obtain. With both kinds of broilers, the broiling racks were placed far enough from the heating element (about three and one-half inches) so that the top side of the steaks would be nicely browned in approximately half the cooking period. In this way, only one turning of the steaks was necessary. Since in previous work on temperatures for roasting beef it had been found that searing does not hold in the juices, it was not considered necessary to sear each side of the steaks at the beginning of the cooking period. It was also thought that more uniform results could be obtained with only one turning of each steak. The steaks were cooked to an internal temperature of 57°C. A steak from one side of an animal was broiled in the electric broiler and the same steak from the opposite side of the same animal in one of the gas broilers. Equal numbers of steaks from the right and left sides of the carcasses were broiled in the two broilers.

### GRADING THE STEAKS

The steaks were judged one at a time while still hot, using much the same method as for the roasts. Pieces were cut one inch square from the muscles to be graded and then each piece cut in two so that each sample was half the original thickness of the steak. The outside browned portions were then cut off and discarded. Each judge was given a sample from the same location in the muscles tested in identical steaks.

## DETERMINATION OF COOKING LOSSES

The total cooking losses were determined from the weights made of the steaks and equipment before and after the regular broiling period and after the steaks had come to their maximum internal temperatures.

### RESULTS ON ROASTING

Table 1 gives a summary of the results obtained from the ten methods of roasting prime ribs. The average cooking time per pound is given for each method, with the average per cent cooking losses and the resulting palatability grades.

The roasts cooked in an oven at 110°C., took over 28 minutes per pound, while those cooked at 260°C., took less than 13 minutes per pound.

The extremely high temperature produced the greatest cooking losses, 30.44 per cent, while the extremely low temperature had only 6.79 per cent. The other temperatures fit in gradation between these two extremes, as regards total losses. From the data, this investigation does not bear out the generally taught and generally accepted idea that searing, by coagulating the protein on the outside, tends to hold in the meat juices. Generally speaking, roasts that were seared lost more than those that were never seared. It seemed to make little, if any, difference whether the searing was done at the beginning or at the end of the roasting period, it always increased the cooking losses.

The important factors of palatability, tenderness, juiciness and flavor of the lean, were decreased when the meat was roasted by the extremely high temperatures. As the temperature of the oven is increased the grading in tenderness is decreased; also with the higher oven temperatures the juiciness and flavor of the lean were lower than with the low oven temperatures. It is also evident that searing did not increase the palatability of the roasts. It did, however, very decidedly improve their external appearance.

The roasts which were cooked in water graded low in palatability, the lowest of all the methods in tenderness, and flavor of the lean, and also very low in juiciness. The cooking losses for this method were also very great, 26.43 per cent.

These data indicate a rather definite correlation between cooking losses and palatability. All roasts that ranked low in shrinkage ranked high in palatability. As a general thing with increased shrinkage there was decreased palatability especially in tenderness, juiciness, and flavor of the lean.

During this year's work a series of experiments was conducted to determine the comparative cooking losses in roasts cooked to an internal

TABLE 1.—AVERAGES OF RESULTS OF TEN METHODS OF ROASTING PRIME RIBS OF BEEF TO AN INTERNAL TEMPERATURE OF 57°C. (1928)

Method	Time per lb. in oven	Total cooking losses	Aroma	Texture	Flavor		Tender-ness	Juiciness	
					Fat	Lean		Quality	Quantity
	<i>min.</i>	<i>per cent</i>							
1. Seared at 277°C. for 20 minutes and cooked at 127°C.	18.6	13.96	3.75	7.21	3.82	23.24	18.10	11.68	7.54
2. Seared at 288°C. for 20 minutes and cooked at 149°C.	17.9	17.36	3.67	7.27	3.69	23.25	18.37	10.58	7.27
3. Started in cold oven set at 232°C., seared for 30 min., and cooked at 149°C.	19.0	15.93	3.67	7.24	3.77	22.67	19.18	10.47	7.24
4. Cooked at 110°C. and seared last at 277°C.	28.0	14.18	3.79	7.38	3.61	22.37	18.23	10.20	7.39
5. Seared at 260°C., water added and cooked in covered pan	15.0	26.43	3.49	6.83	3.64	20.07	15.50	9.28	6.03
6. Cooked at a constant temperature of 110°C.	28.8	6.79	3.74	7.47	3.83	23.34	20.89	11.18	7.57
7. Cooked at a constant temperature of 163°C.	20.5	15.83	3.93	7.44	3.68	23.76	19.56	11.17	6.76
8. Cooked at a constant temperature of 191°C.	19.8	18.69	3.92	7.30	3.95	23.07	18.76	11.30	7.26
9. Cooked at a constant temperature of 218°C.	15.4	25.76	3.95	6.64	3.63	22.01	17.65	10.71	7.14
10. Cooked at a constant temperature of 260°C.	12.9	30.44	3.50	6.40	3.51	20.69	16.87	10.23	6.97

temperature of 70°C. (well done) and those cooked to 57°C. (medium done). The increased time required to reach this higher internal temperature caused a decided increase in the per cent loss in cooking. In the roasts cooked at 110°C., when 57°C. was the internal temperature of the meat on removal from the oven, the shrinkage averaged only 6.79 per cent; but when similar roasts were cooked to an internal temperature of 70°C., the per cent loss had increased to 10.74 per cent. The same was true of all the other methods, as the internal temperature of the meat was increased the cooking losses were also increased.

In all but one series of experiments the roasts were put into the ovens at an internal temperature of between 8°C. and 12°C. In one series, a comparison of the cooking losses and time required for roasting was made of roasts having an initial internal temperature of 1°C. and those having an initial internal temperature of 8°C. to 12°C. Four of the original ten methods of roasting were used. It was found that there was a greater shrinkage, especially with the lower oven temperatures, in the roasts having a low initial internal temperature. Also, the cooking time required per pound in each case increased with the low temperature.

It was found in the last year's work, where six different kinds of roasts were used, that the cuts containing bone took less time to roast than did the boneless ones. Prime rib roasts, using a constant oven temperature of 125°C., took slightly over 24 minutes to the pound to reach 57°C. The two cuts from the chuck averaged about 18 minutes to the pound, and the unboned rump cut took about 23 minutes to the pound. The sirloin tip roasts, and the heels of round, with no bone at all, cooked in approximately 33 minutes and 29 minutes to the pound respectively. The same thing was true with the constant oven temperature of 165°C., except that in each case the number of minutes per pound was decreased with the higher temperature.

The prime ribs roasted by either of the two methods had an average rise in temperature (outside the oven) that was greater than it was in any of the other cuts roasted by that method. The chuck roasts, having an equal amount of bone and the rump roasts having more bone than any of the other cuts, did not rise in internal temperature after removal from the oven any more than did the boneless roasts, so it would seem there is no correlation between the percentage bone and the rise in temperature after the roasts had been removed from the oven.

In all the work of the last year, using six kinds of roasts and the two constant oven temperatures, 125°C. and 165°C., the higher temperature always decreased the time per pound required for roasting. The range of decrease in average time per pound required for roasting with the

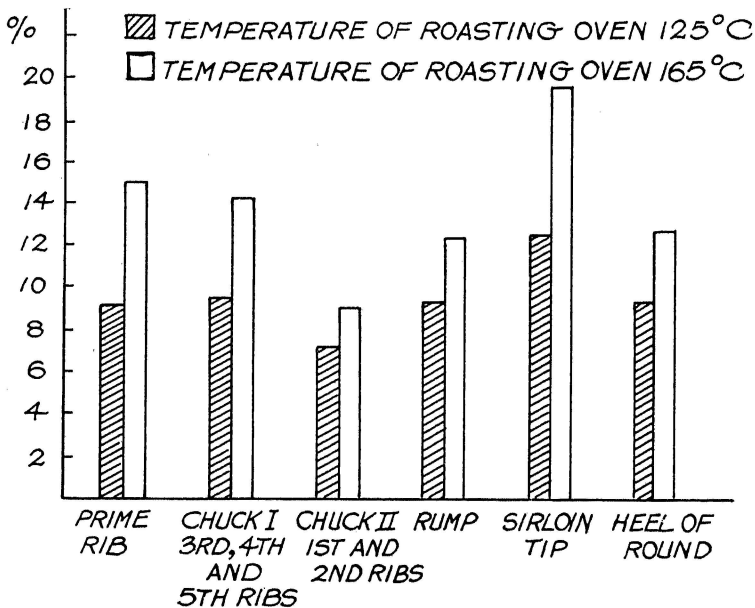


Fig. 20.—Chart showing the average percentage cooking losses of six kinds of roasts.

higher oven temperature was from 4.4 minutes to 8.6 minutes per pound. Also the higher temperature increased the internal rise in temperature after the roasts were out of the oven and the time required to reach that temperature. The higher oven temperature increased the total cooking losses and the amount of fat in the drippings in every case. The oven at 165°C. slightly decreased the tenderness of the roasts and the quantity of the juice.

Table 2 shows a summary of the cooking data obtained from the six different kinds of roasts cooked at 125°C., which method proved itself very slightly superior to that of 165°C. (See Fig. 20.)

When only roasts from similar cuts are under consideration, there is a prevailing opinion that the per cent cooking losses vary inversely with the size of the roasts. Such a generalization does not hold when the six kinds of roasts used in this experiment are considered in one group. The heels of round were the smallest of all the roasts, averaging 4.86 pounds, and these roasts had the greatest per cent cooking losses, 12.47 per cent. The rumps, heavier roasts than the heels of round, averaging 7.41 pounds, had a lower per cent loss, 9.06 per cent; but the largest of the roasts, the chuck including the 3rd, 4th and 5th ribs, averaging over 12 pounds; lost next to the greatest 11.23 per cent.

An opinion also prevails that the cooking time per pound for roast beef varies inversely with the size of the roasts. Investigation might

TABLE 2.—AVERAGES OF RESULTS ON ROASTING SIX DIFFERENT CUTS OF BEEF AT A CONSTANT OVEN TEMPERATURE OF 125°C.

Roast	Weight	Time per lb.	Total time in oven	Amount of bone	Cooking losses	Average cost in local market	Cost per lb. meat lean	Cost per lb. edible meat (fat plus lean)
	<i>lbs.</i>	<i>min.</i>	<i>min.</i>	<i>per cent</i>	<i>per cent</i>	<i>per lb.</i>		
Prime Rib.....	6.22	24.3	152	16.21	8.95	.26	.49	.34
3rd, 4th and 5th Rib Chuck.....	12.08	16.9	204	15.45	11.23	.24	.35	.28
1st and 2nd Rib Chuck.....	7.56	17.8	135	14.11	7.30	.22	.29	.25
Rump.....	7.41	22.5	167	23.42	9.06	.27	.51	.37
Sirloin Tip.....	5.64	31.3	177		14.46	.34	.41	.34
Heel of Round.....	4.86	31.6	153		12.47	.27	.34	.27

show this to be true when roasts of the same or similar cuts are used, but when the six kinds of roasts used in this experiment are considered in one group this condition exists only in a very general way. The first chuck roasts, averaging 12.08 pounds, required 16.9 minutes per pound, while the second chuck roasts, averaging 7.56 pounds, required 17.8 minutes per pound, about one minute per pound less than the very much heavier roasts. The rump roasts, averaging 7.41 pounds, almost the same weight as the second chuck roasts, required 22.5 minutes per pound.

It seems from the data presented that there is a difference in the length of time required to roast those cuts containing bone as compared with that required to roast those cuts without bone. Both cuts, with no bone at all, required over 31 minutes per pound, while those with bone required from 16.9 minutes to 24.3 minutes per pound to cook to an internal temperature of 57°C.

Table 2 also shows the relative economy of the various cuts (based on local prices and Edinger's analysis of half fat steer)<sup>8</sup>. The chuck cuts and the heel of round were the most economical sources of lean and edible (lean and fat) meat.

The palatability grades on the last year's work seemed to show that it is possible to roast even the less tender of the six cuts from good grade heifers, by either constant oven temperature, 125°C., or 165°C., to produce a fairly tender product. The average grades for tenderness of the sirloin tip, prime rib, and the third, fourth and fifth ribs of the chuck were nearly equal, these being the most tender of the six cuts. No one of these cuts seemed to have any constant advantage over the other two cuts. The heel of round and the rump roasts approximately tied for the place of least tender, while the first and second chuck ribs ranked about third lowest in tenderness. The range of the tenderness grades for all of the roasts was from 3.33-6.75 in a possible scale of 7.00. A grade of three meant the meat was tough while a grade of six showed it to be tender. The grade of 3.33 was given to rump roasts, and the grade of 6.75 to the third, fourth and fifth ribs of the chuck. The range of average grades for tenderness of all the cuts roasted at 125°C. was 4.17 to 5.63. Of those cuts roasted at 165°C., the range of average grades for tenderness was from 3.98 to 5.75. In other words, all of the cuts roasted at these two temperatures came within a descriptive range of slightly tough to tender.

8. Edinger, A. T., *The Physical Composition of a Lean, Half Fat and a Fat Beef Carcass and the Relative Cost of the Nutrients Contained in Each*, Mo. Agr. Exp. Sta. Research Bulletin, No. 83, 1925.

## RESULTS ON BROILING

Table 3 shows a summary of the cooking data obtained from the four different kinds of steaks. Since the cooking losses and the palatability grades of the steaks broiled on the two kinds of broilers were so close, averages from the two methods are shown here.

TABLE 3.—STEAKS COOKED BY BROILING (AVERAGES OF BOTH METHODS)

Steaks	Weight	Time per lb.	Total time in oven	Cooking losses	Average cost in local market	Cost per lb. lean	Cost per lb. edible meat
	<i>pounds</i>	<i>minutes</i>	<i>minutes</i>	<i>per cent</i>	<i>per pound</i>		
Rib.....	1.88	18	34	21.24	.30	.54	.39
Porterhouse.....	2.82	13	37	21.42	.38	.67	.44
Sirloin.....	3.48	11	38	23.95	.34	.57	.38
Round.....	5.14	6	30*	17.93	.34	.45	.39

\*The round steaks from the first lot of animals were cut  $1\frac{1}{2}$ - $1\frac{3}{4}$  inches thick while all the other steaks were cut 2 inches thick. This accounts for the lower average total time in oven for the round steaks.

A study of this table shows the heavier steaks required less time per pound to cook them to an internal temperature of 57°C. than did the lighter steaks; and the lighter steaks took a shorter total time in the broiler to reach an internal temperature of 57°C. than did the heavier ones of the same thickness. Steaks cut two inches thick, and weighing from slightly under two to three and one half pounds took from 34 to 38 minutes in the broiler to reach an internal temperature of 57°C.

Table 3 also shows there was no relation between the percent loss in cooking and the size of the steaks. (This same thing was found with the roasts.)

By preheating the gas oven with the regulator set at 500°F. (260°C.) the broiler was hot enough, and remained so, to cook the steaks with the broiler door left open, the top side of the steaks becoming nicely browned in approximately half the cooking time. With the broiler door open, the appearance of the steak, the temperature of the broiler, and the internal temperature (doneness) of the steak could all be determined at any time without changing the temperature of the broiler. To keep the electric broiler hot enough the door had to be kept closed.

Ease of manipulation seemed to be the main point in favor of the gas broiler, as the palatability grades were very close for the two methods, using the same cut. The gas broiler gave slightly less tender steaks but slightly more juicy ones than did the electric broiler.

A study of Table 3 shows the economy of the various steaks. Round is the most economical of the four in cost of lean meat; sirloin, round and rib are about the same in cost of edible meat. In both cases the porterhouse is the most expensive of the four.

TABLE 4. AVERAGES OF PALATABILITY GRADES ON STEAK (BY BROILERS)

Steak	Broiler	Intensity					Juiciness		Desirability			
		Aroma	Texture	Flavor of Fat	Flavor of Lean	Tenderness		Quality	Quantity	Aroma	Flavor of Fat	Flavor of Lean
Rib	Armstrong	3.30	5.02		3.87	4.96		2.81	4.38	4.16		4.32
Rib	Clark Jewel	3.59	5.06		3.99	4.89		2.94	4.14	4.39		4.72
Rib	Average	3.45	5.04		3.93	4.93		2.68	4.26	4.28		4.52
Porterhouse	Armstrong	3.00	5.34	4.50	4.21	No. 1	No. 2	4.05	3.90	3.45	4.10	5.25
	Clark Jewel	3.63	4.97	3.95	4.47	5.19	6.50					
	Average	3.32	5.12	4.23	4.34	4.72	6.31					
Sirloin	Armstrong	3.87	4.97	5.23	4.26	4.73	5.83	2.79	3.99	3.82	2.89	4.68
	Clark Jewel	3.89	4.71	5.00	4.26	4.51	5.81					
	Average	3.88	4.84	5.12	4.26	4.62	5.82					
Round	Armstrong	3.42	5.18		3.87	No. 1	No. 2	2.62	3.81	4.08		4.36
	Clark Jewel	3.77	5.00		3.94	4.51	3.26					
	Average	3.60	5.09		3.91	4.68	3.94					
						4.60	3.46	2.51	4.35	4.15		4.45

The palatability grades, averages of which are shown in Table 4, seemed to show that it is possible to broil even the less tender cuts from this grade of animal, by either method tried, to give a fairly tender product. The tenderloin muscle of the porterhouse steak was the most tender muscle graded in the steaks. In this grade of animal the porterhouse and rib steaks graded more tender than the sirloin and round steaks.

The range of the tenderness grades for all the steaks was from 2.80 to 6.80 in the scale of 7.00,\* 7.00 representing the most tender. The grade of 2.80 was for the center muscle of a bottom round, and the grade of 6.80 was for the tenderloin muscle of a porterhouse. The average grades for these two muscles were 3.46 and 6.41, respectively. The grade of 3.46 meant that this part of the round was between "tough" and "slightly tough", and the tenderloin muscle of the porterhouse was between "tender" and "very tender." An average of the averages of the three muscles tested in the round steaks gave a grade of 4.00 or "slightly tough". In other words, all the steaks broiled by either method of broiling came within a descriptive range of "slightly tough" to "tender".

### SUMMARY

During the past four years of meat cookery investigations at the Missouri Agricultural Experiment Station, two main problems have been studied: (1) Methods of Cooking Beef, and (2) Palatability of the Less Tender cuts.

Approximately 450 cuts of beef have been cooked, the results of which form the bases for the following conclusions:

#### 1. Methods of Cooking.

- a. Searing increases cooking losses, and therefore if used, should be only for improving outside appearance, developing aroma, and developing flavor of the outside of the meat.
- b. Low oven temperatures for roasting result in less cooking losses and greater palatability, than do high oven temperatures. High temperatures decrease juiciness and tenderness, particularly.
- c. Low oven temperatures cook roasts more uniformly than do high oven temperatures; the higher the temperature, the less the uniformity of doneness.
- d. The time per pound required for roasting is decreased by the higher oven temperatures.
- e. Roasting beef by the addition of water (not true roasting) decreases its palatability and increases its cooking losses.
- f. A low internal temperature of a roast at the time it is put into the oven increases the cooking losses and the time of cooking.

\*See grading chart in the Appendix.

- g. Roasts cooked to the well-done stage have greater cooking losses than do those made medium done.
- h. When prime rib, chuck I, chuck II, sirloin tip, rump and heel of round roasts are considered in one group, other factors of greater importance than their size seem to affect their cooking losses to such an extent that there is little relation between the size of a roast and the per cent cooking losses.
- i. There is a tendency for the cooking time required per pound to vary inversely with the size of the roast, but when the six roasts are considered in one group there seems to be other factors than size which affect the cooking time.
- j. Boneless roasts seem to require more time per pound than do roasts with bone.
- k. The larger steaks (sirloin and round) require less time per pound to broil than do the smaller ones; the smaller steaks take a shorter total time to cook than do the larger ones of the same thickness.
- l. The doneness of a roast can be accurately determined only by a meat thermometer, since the length of time per pound varies with different cuts and with different roasting temperatures.
- m. The doneness of a steak can also be accurately and easily determined by a meat thermometer placed horizontally in the steak before putting the steak in the broiler; however, a certain kind of steak, cut a definite thickness, can be timed fairly accurately. For the time required to broil two inch steaks, medium done, see Table 3, p. 26.

## 2. Palatability of Less Tender Cuts.

- a. The palatability of the less tender cuts can be improved by methods of cooking.
- b. The results, so far, seem to indicate that even the less tender cuts from good grade heifer beef can be roasted and broiled, using comparatively low temperatures, to give fairly palatable products.
- c. With the roasting temperatures used, the sirloin tip, prime rib, and chuck including the 3rd, 4th, and 5th ribs are about equal in tenderness in good grade heifers.
- d. The heel of round and rump roasts are the least tender, with the 1st and 2nd ribs of chuck third lowest in tenderness.
- e. The tenderloin muscle of the porterhouse steak is the most tender muscle graded in the steaks used, and a muscle from the bottom round the least tender.
- f. In good grade heifers the porterhouse and rib steaks are more tender than the sirloin and round steaks.

### ACKNOWLEDGMENTS

The authors wish to acknowledge the valuable work of the meat judging committee, without whose assistance the investigations upon which this bulletin is based could not have been carried out: Miss Mabel V. Campbell, chairman of the department of home economics; Dr. Margaret C. Hessler, and Miss Bertha K. Whipple, of the department of home economics; Mr. J. E. Comfort of the department of animal husbandry; and Dr. W. S. Ritchie of the department of agricultural chemistry. The authors also wish to thank Miss Mary I. Schell of the department of home economics for her work in determining the color of the roasts; and Mr. H. C. Moffett, under whose directions the feeding of the animals used the last year was carried out.

### APPENDIX

The grading chart used in the National Cooperative Meat Project appears below. In the experiments described in this bulletin, each judge used one chart for each sample of meat graded. The factors of palatability are arranged in the first column, with the degree of intensity and desirability of each arranged opposite them. The terms most nearly describing a sample of meat were checked by each judge. From the numerical values at the head of each column the grades were transferred to the second chart where averages for each factor were made.

MEAT COOKING RECORD  
GRADING CHART FOR COOKED MEAT

SHEET No. 7    Cooking Laboratory No. \_\_\_\_\_    Sample No. \_\_\_\_\_    Kind \_\_\_\_\_    Date \_\_\_\_\_

Factor	Phase	7	6	5	4	3	2	1	Remarks
Aroma	Intensity	Very pronounced	Pronounced	Moderately pronounced	Slightly pronounced	Perceptible	Slightly perceptible	Imperceptible	What aroma? _____
	Desirability	Very desirable	Desirable	Moderately desirable	Slightly desirable	Neutral	Slightly undesirable	Undesirable	Normal or abnormal? _____
Texture	Intensity	Very fine	Fine	Moderately fine	Slightly coarse	Coarse	Very coarse	Extremely coarse	
Flavor of fat	Intensity	Very pronounced	Pronounced	Moderately pronounced	Slightly pronounced	Perceptible	Slightly perceptible	Imperceptible	What flavor? _____
	Desirability	Very desirable	Desirable	Moderately desirable	Slightly desirable	Neutral	Slightly undesirable	Undesirable	Normal or abnormal? _____
Flavor of lean	Intensity	Very pronounced	Pronounced	Moderately pronounced	Slightly pronounced	Perceptible	Slightly perceptible	Imperceptible	What flavor? _____
	Desirability	Very desirable	Desirable	Moderately desirable	Slightly desirable	Neutral	Slightly undesirable	Undesirable	Normal or abnormal? _____
Tenderness	Intensity	Very tender	Tender	Moderately tender	Slightly tough	Tough	Very tough	Extremely tough	
Juiciness	Quality	Very rich	Rich	Moderately rich	Slightly rich	Perceptible	Slightly perceptible	Imperceptible	
	Quantity	Very juicy	Juicy	Moderately juicy	Slightly dry	Dry	Very dry	Extremely dry	

- COLOR OF LEAN**
- Light red.
  - Dark pink.
  - Light pink.
  - Pinkish brown.
  - Light brown.
  - Dark brown.

- COLOR OF FAT**
- White.
  - Creamy white.
  - Grayish cream.
  - Yellowish brown.
  - Yellow.
  - Amber.

NOTE.—Encircle the words which describe intensity; mark desirability and color with a check.

\_\_\_\_\_  
(Signature of judge)



TABLE 1.—AVERAGE PALATABILITY GRADES FOR SIX KINDS OF ROASTS FROM SIX GOOD GRADE HEIFERS  
(COOKED AT CONSTANT OVEN TEMPERATURES OF 125°C. AND 165°C.)

Roasts	Oven temperature	Intensity					Juiciness		Desirability		
		Aroma	Texture	Flavor of fat	Flavor of lean	Tenderness	Quality	Quantity	Aroma	Flavor of fat	Flavor of lean
Prime Rib	125°C.	4.02	4.33	4.32	4.47	5.56	3.39	4.84	4.99	5.54	5.33
	165°C.	3.97	4.54	4.25	4.43	5.29	3.41	4.62	5.07	5.36	5.45
Chuck I 3rd, 4th, and 5th ribs	125°C.	3.50	4.92	3.96	4.21	5.63	3.29	5.43	4.48	5.13	4.75
	165°C.	3.58	4.96	4.50	4.38	5.75	3.46	5.50	4.17	5.21	4.96
Chuck II 1st and 2nd ribs	125°C.	4.05	4.98	3.93	4.53	5.33	3.48	5.03	3.69	4.49	4.74
	165°C.	4.10	4.89	4.51	4.62	4.92	3.46	4.71	4.13	4.21	4.52
Rump	125°C.	4.04	4.02	4.66	4.41	4.17	3.08	5.05	3.56	3.66	4.35
	165°C.	4.07	4.10	5.11	4.38	3.98	3.25	4.79	4.17	3.22	4.93
Sirloin Tip	125°C.	3.41	4.73	3.68	3.71	5.44	2.15	5.05	4.14	4.38	4.84
	165°C.	3.82	4.98	4.00	3.88	5.21	2.44	4.67	4.17	4.40	4.92
Heel of Round	125°C.	3.63	4.30		3.75	4.55	1.89	3.42	4.19		3.88
	165°C.	3.49*	4.35		3.58	4.30	1.58	3.15	4.00		4.16

TABLE 2.—AVERAGE PALATABILITY GRADES FOR FOUR KINDS OF STEAKS FROM SIX GOOD GRADE HEIFERS  
(BROILED IN AN ARMSTRONG ELECTRIC OVEN AND A CLARK JEWEL GAS BROILER).

Steak	Broiler	Intensity				Tenderness			Juiciness		Desirability		
		Aroma	Texture	Flavor of Fat	Flavor of Lean				Quality	Quantity	Aroma	Flavor of Fat	Flavor of Lean
Rib Rib	Armstrong	3.30	5.02		3.87				2.81	4.38	4.16		4.32
	Clark Jewel	3.59	5.06		3.99				2.94	4.14	4.39		4.72
Porterhouse Porterhouse	Armstrong	3.00	5.34	4.50	4.21	5.19	6.50*		4.05	3.90	3.45	4.10	5.25
	Clark Jewel	3.63	4.97	3.95	4.47	4.72	6.31*		3.69	4.78	4.07	4.37	5.08
Sirloin Sirloin	Armstrong	3.87	4.97	5.23	4.26	4.73	5.83		2.79	3.99	3.82	2.89	4.68
	Clark Jewel	3.89	4.71	5.00	4.26	4.51	5.81		2.66	4.43	3.41	5.00	4.63
Round Round	Armstrong	3.42	5.18		3.87	4.51	3.26	3.94	2.62	3.81	4.08		4.36
	Clark Jewel	3.77	5.00		3.94	4.68	3.66	3.94	2.40	4.88	4.22		4.54

\*Tenderloin muscle.

The Appendix tables 3 to 8 inclusive show the palatability grades for all the roasts from each animal, both those cooked at a constant oven temperature of 125°C., and those cooked at a constant oven temperature of 165°C. The comparative palatability of the six cuts from the same animal is shown.

TABLE 3.—MEANS OF GRADES FROM COOKED MEAT GRADING CHARTS  
ANIMAL No. 8—TEMP. OF ROASTING OVEN 125°C.

Roast	Lab. No.	Intensity					Juiciness		Desirability		
		Aroma	Texture	Flavor of Fat	Flavor of Lean	Tenderness	Quality	Quantity	Aroma	Flavor of Fat	Flavor of Lean
Prime Rib	1R	5.80	4.40	5.20	5.20	5.80	4.00	5.40	5.40	5.80	5.20
Chuck I	7R	3.75	4.50	4.25	4.00	5.75	3.50	5.75	4.50	5.75	5.00
Chuck II	13R	3.75	4.75	3.75	4.75	5.00	3.50	5.25	3.25	4.25	5.25
Rump	19L	4.33	3.66	4.66	5.33	4.33	3.33	5.66	4.00	4.33	4.66
Sirloin Tip End	25L	4.13	4.66		4.00	5.00	2.50	4.66	4.83		5.00
Heel of Round	31L	3.20	4.00		4.20	4.80	2.20	4.20	4.50		5.00

ANIMAL No. 8—TEMP. OF ROASTING OVEN 165°C.

Prime Rib	1L	5.20	4.80	4.60	5.40	5.40	3.20	4.80	5.60	6.40	6.00
Chuck I	7L	5.00	4.75	5.50	5.25	6.75	3.50	5.50	5.00	5.00	5.50
Chuck II	13L	4.75	5.00	4.25	4.75	5.75	3.75	4.25	5.50	5.25	5.50
Rump	19R	4.33	4.00	5.33	5.50	4.00	3.50	5.66	3.66	3.00	5.50
Sirloin Tip End	25R	4.13	4.83		4.33	5.83	3.00	4.83	4.16		5.00
Heel of Round	31R	4.20	4.00		4.20	4.20	2.00	3.80	4.80		5.20

TABLE 4.—MEANS OF GRADES FROM COOKED MEAT GRADING CHARTS  
ANIMAL No. 11—TEMP. OF ROASTING OVEN 125°C.

Roast	Lab. No.	Intensity					Juiciness		Desirability		
		Aroma	Texture	Flavor of Fat	Flavor of Lean	Tenderness	Quality	Quantity	Aroma	Flavor of Fat	Flavor of Lean
Prime Rib	2R	4.60	4.00	4.20	4.20	4.60	2.60	4.60	5.40	6.00	5.20
Chuck I	8R	4.00	5.25	4.50	4.75	5.50	4.00	5.33	5.33	5.50	5.25
Chuck II	14R	4.75	5.25	4.25	4.25	6.00	3.75	5.00	4.50	5.00	5.00
Rump	20L	4.33	4.00	4.33	4.33	3.33	3.50	4.50	3.33	4.00	4.33
Sirloin Tip End	26L	3.66	4.50		3.66	4.16	1.83	4.66	4.66		5.16
Heel of Round	32L	4.20	4.00		3.40	4.80	1.60	4.40	4.40		4.80

ANIMAL No. 11—TEMP. OF ROASTING OVEN 165°C.

Prime Rib	2L	3.60	4.20	4.20	3.80	4.00	2.40	4.40	5.50	4.80	4.80
Chuck I	8L	3.25	4.50	4.50	3.75	5.75	3.25	5.50	3.50	5.50	5.00
Chuck II	14L	4.25	4.75	3.50	4.50	4.25	3.25	4.50	3.00	3.75	3.75
Rump	20R	4.33	4.33	4.66	4.66	4.00	3.00	5.00	5.00	2.66	5.33
Sirloin Tip End	26R	4.16	5.00		4.16	5.16	2.33	4.66	4.50		5.33
Heel of Round	32R	3.40	4.20		3.00	4.20	1.60	3.60	4.60		4.40

TABLE 5.—MEANS OF GRADES FROM COOKED MEAT GRADING CHARTS  
ANIMAL NO. 17—TEMP. OF ROASTING OVEN 125°C.

Roast	Lab. No.	Intensity					Juiciness		Desirability		
		Aroma	Texture	Flavor of Fat	Flavor of Lean	Tenderness	Quality	Quantity	Aroma	Flavor of Fat	Flavor of Lean
Prime Rib	3R	4.40	4.40	4.00	4.40	5.60	2.60	5.20	5.20	5.25	5.60
Chuck I	9R	3.25	4.00	4.75	4.25	5.50	3.25	5.75	4.50	5.75	5.25
Chuck II	15R	4.50	5.00	4.25	5.25	5.25	4.00	4.75	3.75	4.00	5.25
Rump	21L	4.00	3.66	5.00	5.00	3.66	2.66	5.66	4.00	2.66	5.33
Sirloin Tip End	27L	3.66	5.00		3.83	5.66	2.16	5.00	4.33		5.16
Heel of Round	33L	3.40	3.80		3.40	4.40	1.80	4.00	4.75		4.00

ANIMAL NO. 17—TEMP. OF ROASTING OVEN 165°C.

Prime Rib	3L	4.20	4.60	4.20	4.40	5.00	3.20	5.20	5.50	4.80	5.40
Chuck I	9L	4.00	5.00	5.50	4.50	6.00	3.25	5.50	4.25	5.50	5.00
Chuck II	15L	4.25	5.00	5.75	5.00	4.50	3.66	5.00	4.00	4.50	5.00
Rump	21R	4.33	3.66	5.33	4.33	3.66	3.00	4.66	4.33	4.00	4.33
Sirloin Tip End	27R	3.83	5.66		4.00	4.66	2.13	4.66	4.16		5.00
Heel of Round	33R	3.60	4.40		4.00	4.40	2.22	4.00	4.60		4.60

TABLE 6.—MEANS OF GRADES FROM COOKED MEAT GRADING CHARTS  
ANIMAL NO. 8b—TEMP. OF ROASTING OVEN 125°C.

Roast	Lab. No.	Intensity					Juiciness		Desirability		
		Aroma	Texture	Flavor of Fat	Flavor of Lean	Tenderness	Quality	Quantity	Aroma	Flavor of Fat	Flavor of Lean
Prime Rib	34L	3.00	4.33	4.00	4.33	6.00	3.66	4.83	5.13	5.50	5.16
Chuck I	40L	3.75	5.00	3.75	4.75	6.00	3.25	4.75	4.50	4.50	4.75
Chuck II	46L	3.50	5.50	3.75	3.75	5.50	3.25	5.00	3.25	5.50	4.75
Rump	49R	3.60	4.20		3.80	4.70	3.00	5.20	3.00		4.40
Sirloin Tip End	55R	3.00	5.00		3.60	6.20	2.00	5.80	4.20		4.60
Heel of Round	63R	4.00	5.00		3.50	4.50	2.00	2.75	4.25		3.50

ANIMAL NO. 8b—TEMP. OF ROASTING OVEN 165°C.

Prime Rib	34R	4.00	5.00	4.16	4.66	5.83	3.50	4.00	5.33	5.83	5.66
Chuck I	40R	3.25	5.25	4.00	5.00	5.25	3.75	5.50	4.50	5.00	4.75
Chuck II	46R	3.75	5.00	4.75	4.25	5.00	3.50	4.50	4.50	4.75	5.25
Rump	49L	3.00	4.00		3.40	4.20	3.40	4.40	3.60		4.60
Sirloin Tip End	55L	3.60	4.80	4.80	3.80	5.40	2.20	5.00	4.00	4.20	4.80
Heel of Round	63L	3.25	4.00		3.75	4.75	1.75	1.75	3.25		2.00

TABLE 7.—MEANS OF GRADES FROM COOKED MEAT GRADING CHARTS  
ANIMAL No. 17b—TEMP. OF ROASTING OVEN 125°C.

Roast	Lab. No.	Intensity					Juiciness		Desirability		
		Aroma	Texture	Flavor of Fat	Flavor of Lean	Tenderness	Quality	Quantity	Aroma	Flavor of Fat	Flavor of Lean
Prime Rib	35L	3.16	4.00	4.16	4.00	5.50	3.50	4.66	4.50	5.33	5.00
Chuck I	41L	3.25	5.50	3.75	3.75	6.00	3.00	6.00	4.00	4.75	4.50
Chuck II	47L	3.80	4.80	4.20	4.80	5.60	3.20	5.00	3.60	3.60	3.80
Rump	50R	3.60	4.20		3.80	4.80	3.00	4.50	2.80		2.60
Sirloin Tip End	56R	2.60	4.60	2.60	3.20	5.80	2.00	5.00	2.60	4.25	4.00
Heel of Round	62R	3.75	4.25		4.00	4.00	2.00	2.66	3.00		2.25

ANIMAL No. 17b—TEMP. OF ROASTING OVEN 165°C.

Prime Rib	35R	3.50	4.16	4.00	4.16	5.83	3.50	5.16	3.83	4.83	5.16
Chuck I	41R	2.75	5.00	3.75	3.75	5.50	2.50	5.25	4.00	5.25	4.50
Chuck II	47R	3.80	4.80	3.80	4.40	5.00	3.20	5.00	3.60	4.40	4.00
Rump	50L	4.60	4.20		4.20	3.80	3.40	4.60	4.40		4.80
Sirloin Tip End	56L	3.40	5.00	3.20	3.60	5.00	2.40	4.60	4.20	4.60	4.60
Heel of Round	62L	3.75	5.00		3.00	4.25	2.00	2.50	3.25		3.50

TABLE 8.—MEANS OF GRADES FROM COOKED MEAT GRADING CHARTS  
ANIMAL No. 72—TEMP. OF ROASTING OVEN 125°C.

Roast	Lab. No.	Intensity					Juiciness		Desirability		
		Aroma	Texture	Flavor of Fat	Flavor of Lean	Tenderness	Quality	Quantity	Aroma	Flavor of Fat	Flavor of Lean
Prime Rib	36L	3.16	4.83	4.33	4.66	5.80	4.00	4.33	4.33	5.33	5.83
Chuck I	42L	3.00	5.25	2.75	3.75	5.00	2.75	5.00	4.00	4.50	3.75
Chuck II	48L	4.00	4.60	3.40	4.40	4.60	3.20	5.20	3.80	4.60	4.40
Rump	51R	4.40	4.40		4.20	4.20	3.00	4.80	4.20		4.80
Sirloin Tip End	57R	3.40	4.60	4.75	4.00	5.80	2.40	5.20	4.20	4.50	5.20
Heel of Round	63R	3.25	4.75		3.25	4.87	1.75	2.50	4.25		3.75

ANIMAL No. 72—TEMP. OF ROASTING OVEN 165°C.

Prime Rib	36R	3.33	4.50	4.33	4.16	5.66	3.66	4.16	4.66	5.50	5.66
Chuck I	42R	3.25	5.25	3.75	4.00	5.25	3.50	5.75	3.75	5.00	5.00
Chuck II	48R	3.80	4.80	5.00	4.80	5.00	3.40	5.00	4.20	2.60	3.60
Rump	51L	3.80	4.40		4.20	4.20	3.20	4.40	4.00		5.00
Sirloin Tip End	57L	3.80	4.60	4.00	3.40	5.20	2.60	4.20	4.00	4.40	4.80
Heel of Round	63L	2.75	4.50		3.50	4.00	1.66	3.25	3.50		3.25

The appendix tables 9 to 14 inclusive, show the palatability grades for all the steaks from each animal, both those cooked in the electric oven and those cooked in the gas broiler. The comparative palatability of the four steaks from the same animal is shown.

TABLE 9.—MEANS OF GRADES FROM COOKED MEAT GRADING CHARTS. ANIMAL No. 8, ELECTRIC BROILER

Steak	b. No.	Intensity					Juiciness		Desirability			
		Aroma	Texture	Flavor of fat	Flavor of lean	Tenderness	Quality	Quantity	Aroma	Flavor of fat	Flavor of lean	
Rib	4L	3.80	5.40		4.40	5.00	3.20	4.60	4.80		5.00	
Porterhouse		Electric stove out of commission—both porterhouse steaks cooked on gas broiler.										
Sirloin	22L	5.00	5.00	5.34	4.67	5.00	6.00	2.67	3.67	4.67	3.67	5.67
Round	28L	4.17	5.34		3.67	4.60	3.00	1.84	2.67	4.67		3.67
ANIMAL No. 8—GAS BROILER												
Rib	4R	3.80	5.00		3.80	4.80	2.20	4.00	4.75			4.80
Porterhouse	10L	3.50	5.00	4.50	4.50	4.75	6.50*	3.75	4.75	3.67	3.00	5.50
Porterhouse	10R	3.50	5.00	4.00	4.25	4.50	6.00*	3.50	5.00	4.00	4.75	5.25
Sirloin	22R	4.34	4.67	5.34	4.67	4.34	5.67	3.00	4.67	3.34	5.00	5.00
Round	28R	4.17	4.84		4.00	5.40	3.40	2.34	5.17	5.00		5.00

\*Tenderloin muscle.

TABLE 10.—MEANS OF GRADES FROM COOKED MEAT GRADING CHARTS. ANIMAL No. 11—ELECTRIC BROILER

Steak	Lab. No.	Intensity					Juiciness		Desirability			
		Aroma	Texture	Flavor of fat	Flavor of lean	Tenderness	Quality	Quantity	Aroma	Flavor of fat	Flavor of lean	
Rib	5L	4.00	4.80		3.80	4.40	2.40	3.80	5.00		4.00	
Porterhouse		Electric stove out of commission—both porterhouse steaks cooked on gas broiler.										
Sirloin	23L	5.00	4.00	5.00	5.00	5.00	5.00	2.67	4.34	3.67	2.00	4.34
Round	29L	3.34	5.00		4.00	4.60	3.17	2.00	4.34	3.84		4.20
ANIMAL No. 11—GAS BROILER												
Rib	5R	3.80	5.00		3.60	4.40	2.40	3.50	5.00			5.00
Porterhouse	11L	4.25	5.25	2.50	4.25	4.75	6.50*	3.50	4.25	3.75	3.25	5.25
Porterhouse	11R	3.50	5.00	4.50	4.25	4.00	6.00*	2.75	5.50	3.67	4.75	4.50
Sirloin	23R	3.67	4.67	4.67	4.34	5.00	5.00	2.67	4.00	4.00	5.00	5.00
Round	29R	4.00	5.00		3.84	4.67	3.34	1.50	5.17	4.34		5.00

\*Tenderloin Muscle.

TABLE 11.—MEANS OF GRADES FROM COOKED MEAT GRADING CHARTS. ANIMAL NO. 17—ELECTRIC BROILER

Steak	Lab. No.	Intensity					Juiciness		Desirability		
		Aroma	Texture	Flavor of fat	Flavor of lean	Tenderness	Quality	Quantity	Aroma	Flavor of fat	Flavor of lean
Rib	6L	3.80	4.40		4.00	5.00	2.60	5.20	3.80		4.20
Porterhouse Electric stove out of commission—both porterhouse steaks cooked on gas broiler.											
Sirloin	24L	5.00	4.34	5.34	4.67	4.00	6.00	3.00	4.34	4.00	5.67
Round	30L	3.00	5.34		3.17	4.88	2.80	2.17	4.34	4.17	4.67
ANIMAL NO. 17, GAS BROILER											
Rib	6R	4.40	5.20		4.20	4.60	2.60	3.80	5.25		5.00
Porterhouse	12L	4.00	4.75	4.50	4.75	4.75	6.25*	3.75	4.67	4.50	5.25
Porterhouse	12R	3.50	4.75	4.00	4.75	5.00	6.25*	4.50	5.25	4.00	5.00
Sirloin	24R	4.34	4.34	5.00	4.34	4.34	6.00	2.67	5.00	4.34	5.34
Round	30R	3.84	5.34		4.00	5.00	3.15	2.34	5.34	5.00	4.80

\*Tenderloin muscle.

TABLE 12.—MEANS OF GRADES FROM COOKED MEAT GRADING CHARTS ANIMAL NO. 8b—ELECTRIC BROILER

Steak	Lab. No.	Intensity					Juiciness		Desirability		
		Aroma	Texture	Flavor of fat	Flavor of lean	Tenderness	Quality	Quantity	Aroma	Flavor of fat	Flavor of lean
Rib	37R	2.34	5.00		3.34	4.84	3.00	4.17	4.00		4.34
Porterhouse	43R	2.80	5.60	4.20	4.25	5.40	6.00*	3.20	3.40	3.60	4.80
Porterhouse	43L**	3.00	5.00	4.40	4.40	4.75	6.80*	4.60	4.00	3.80	5.80
Sirloin	52R	2.40	5.80		4.00	5.00	6.20	3.00	3.60	3.80	5.00
Round	58R	3.20	5.00		3.80	3.80	3.20	3.00	2.40	4.40	4.60

\*Tenderloin muscle.

ANIMAL NO. 8b—GAS BROILER

Rib	37L	3.00	5.17		3.84	5.17	3.17	4.67	3.84		4.84
Porterhouse Cooked in the electric broiler.											
Sirloin	52L	4.20	4.80		4.20	4.40	6.00	2.20	4.60	3.80	3.40
Round	58L	4.00	5.20		4.20	4.60	4.20	3.80	3.20	4.40	4.80

\*\*Since in the first lot the porterhouse had to all be cooked in the gas broiler, it was thought best to cook these in the electric.

TABLE 13.—MEANS OF GRADES FROM COOKED MEAT GRADING CHARTS. ANIMAL No. 17b—ELECTRIC BROILER

Steak	Lab. No.	Intensity					Juiciness		Desirability		
		Aroma	Texture	Flavor of fat	Flavor of lean	Tenderness	Quality	Quantity	Aroma	Flavor of fat	Flavor of lean
Rib	38R	2.50	5.17		3.50	5.34	2.67	4.50	4.34		4.34
Porterhouse	44R	3.20	5.20	4.80	4.00	5.20 6.40*	4.20	4.00	3.20	3.80	5.00
Sirloin	53R	2.60	5.50		3.40	4.60 5.60	2.60	3.80	4.00		3.80
Round	59R	3.40	5.40		4.20	4.80 3.80 4.00	3.20	4.60	3.60		4.80

ANIMAL No. 17b—GAS BROILER

Rib	38L	3.17	5.00		4.17	5.17	3.60	4.84	3.84		4.17
Porterhouse	44L	3.00	5.00	3.60	4.00	5.00 6.60*	3.20	4.40	3.80	4.20	4.00
Sirloin	53L	3.20	5.00		4.00	4.20 5.80	2.40	4.10	2.40		4.20
Round	59L	3.20	5.00		3.80	4.40 3.40 3.40	2.40	4.60	4.00		4.00

\*Tenderloin muscle.

TABLE 14.—MEANS OF GRADES FROM COOKED MEAT GRADING CHARTS. ANIMAL No. 72—ELECTRIC BROILER

Steak	Lab. No.	Intensity					Juiciness		Desirability		
		Aroma	Texture	Flavor of fat	Flavor of lean	Tenderness	Quality	Quantity	Aroma	Flavor of fat	Flavor of lean
Rib	39R	3.34	5.34		4.17	5.17	3.00	4.00	3.00		4.00
Porterhouse	45R	3.00	5.60	4.60	4.20	5.40 6.80*	4.20	4.20	3.20	4.20	5.40
Sirloin	54R	3.20	5.20		3.80	4.80 6.20	2.80	4.20	2.80		3.60
Round	60R	3.40	5.00		4.40	4.40 3.60 4.80	3.50	4.50	3.80		4.20

ANIMAL No. 72—GAS BROILER

Rib	39L	3.34	5.00		4.34	5.17	3.67	4.00	3.67		4.50
Porterhouse	45L	3.80	5.00	4.00	5.00	5.00 6.40*	4.60	4.40	5.20	5.00	5.60
Sirloin	54L	3.60	4.80		4.00	4.80 6.40	3.00	4.20	2.60		4.80
Round	60L	3.40	4.60		3.80	4.00 4.40 4.60	2.60	4.60	3.00		3.60

\*Tenderloin muscle.