TENDER CUTS OF THREE GRADES OF BEEF: EFFECT OF EXTENT OF COOKING ON WEIGHT LOSSES AND COST

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Pearl J. Aldrich
Major professor

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TENDER CUTS OF THREE GRADES OF BEEF: EFFECT OF EXTENT OF COOKING ON WEIGHT LOSSES AND COST

By

Grace M. Masuda

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ABSTRACT

The primary objectives of this study were to determine the effect of the progressive increases in the internal temperature on the cooking weight losses and portion costs of the tender cuts from Choice, Good, and Commercial beef carcasses. The secondary objective was to compare the palatability of all tender cuts of the three grades cooked to a final internal temperature of 90° C.

Boneless oven-ready roasts were prepared from the ribs, sirloin, short loin, and round. The rolled rib and top round were each divided into three cuts; the sirloin butt was divided into two cuts and the strip loin was left whole for roasting.

The individually wrapped oven-ready roasts were frozen at -12.2° C and stored at the same temperature until defrosting just prior to cooking. They were defrosted in a refrigerator at 5° C to an internal temperature of approximately 0° C.

Each cut was cooked uncovered at a constant oven temperature of 150° C. Four cuts were roasted simultaneously. The roasts and drippings were weighed during the cooking period at the following specified internal temperatures: 50°, 60°, 70°, 80°, and 90° C. Percentage losses were calculated for volatile and total cooking weight losses and drippings at these intervals.

The average cost per pound of the individual cooked roasts for each of the three grades at specified internal temperatures was found by dividing the raw weight cost of the roast by the cooked weight. The average portion cost of the cooked roasts was based on 2.5 ounce portions,

with the exception of the strip loin which was based on 4 ounce portions.

Samples were scored for palatability by a taste panel, using a scale with a range from 0 to 10, with 10 high.

The increased total cooking weight losses and the corresponding increased cost per pound of the cooked roasts point out the importance of the extent of cooking roast meats, particularly in relation to food budget control. Overcooking of meats from the well done stage to 90° C internal temperature resulted in products with fairly low palatability scores as well as increased cooking losses and increased portion costs.

The roasts of Commercial grade compared favorably in palatability factors, except for tenderness, with similar cuts of Good and Choice grades. The roasts from Choice grade were appreciably more tender than those from Good and Commercial grades. However, this quality alone did not make the roasts from Choice grade more acceptable than roasts from Good and Commercial grades.

Since no significant differences in total cooking weight losses among the three grades were found, it appeared that tender cuts of Commercial grade might be considerably more economical to purchase than similar cuts from Good and Choice grades. On the basis of total cooking weight losses and costs of edible portion of roasts at 80° C internal temperature, it appeared in this study that the sirloin butt cuts were the most economical of the tender cuts prepared.

ACKNOWLEDGMENTS

The writer wishes to express her sincere appreciation to Dr. Pearl Aldrich for her guidance, assistance, and inspiration throughout the course of this study. She is also indebted to Professor Katherine Hart for her interest and helpful suggestions.

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INTRODUCTION

All food service directors are concerned with one common objective: to serve food of the highest quality, consistent with budget allowances. From the standpoint of nutritive value, popularity, and cost, meat is one of the most important items on the institution menu. Meat purchases constitute approximately 24 per cent of total expenditures for food in restaurants (92) and 30 per cent in hotels (71). A recent study of the distribution of the food cost dollar in a college women's residence hall showed the total percentage cost of meat, poultry, and fish to be 33 per cent (86). Since expenditures for meat comprise a large percentage of the food dollar, information regarding the cost of meat is of great concern to the food service director.

The cooking weight losses of meat attributable to the internal temperature to which meat is cooked are of utmost importance when cost is considered. When other conditions are standardized, the total cooking weight losses of meats are found to increase with rise in internal temperature. The primary objective of this study is to determine the cooking weight losses that occur with each progressive increase in the internal temperature of the meat. Excessive cooking weight losses of meat have been shown to decrease the quantity of edible cooked meat and thus to increase the cost of the edible cooked portion. Low oven temperatures have also been correlated with minimal cooking losses. Fortunately, the internal temperature to which meat is cooked and the oven temperature, both factors which affect cooking weight losses, can be controlled. Excessive cooking losses of meat have been found to result in marked undesirable effects in its appearance, palatability, and nutritive value. Therefore, data about the cooking weight losses of meat are of interest from both the practical and scientific standpoint.

Meat cookery studies were conducted at the University of Illinois as early as 1898. Since that time Agricultural Experiment Stations and colleges, the United States Department of Agriculture, and individual investigators have contributed many findings. The majority of these studies has been limited to family-size cuts or to single muscles. Because of the importance of meat cookery in institution kitchens, this experiment is based on large-size beef cuts suitable for institution use.

The first objective of this study is to determine the effect of the internal temperatures on the cooking weight losses of the roasts prepared from the tender cuts of Choice, Good, and Commercial beef carcasses. The second objective is to compare the effect of the degree of internal temperature on the edible portion cost of the roasts. The third objective is to compare the palatability of all the cuts of the three grades, cooked to a final internal temperature of 90° C.

This study presents the average percentage weight losses of beef roasts that occur with each 10° C rise in internal temperature from 50° to 90° C. These average percentage cooking weight losses and the original cost of the meat provide a basis for calculating the edible portion cost of the cooked meat. The increase in cost and decrease in palatability attributable to over cooking of meats are of special concern to the food service operator.

REVIEW OF LITERATURE

Factors Affecting the Cooking Weight Losses of Meat

The total loss that occurs during the cooking of meat may vary from approximately 5 to more than 50 per cent (55). Both volatile and dripping losses are included in the total cooking loss. The volatile loss consists chiefly of the evaporation of water, whereas the drippings contain fat, water, salts, and extractives. Investigations have revealed several factors which may affect the cooking weight losses.

Composition of meat

The earliest research on the cooking losses of meat was begun in 1898 at the University of Illinois. Grindley, McCormack, and Porter (41) observed that the evaporation of water during the cooking of meat constituted the major portion of the weight loss. They also found that the amount of water lost when meats were pan-broiled, boiled, or stewed varied inversely with the fat content of the meat. No experiments on roasted meats were reported from these investigations. In 1904, Grindley and Mojonnier (42) noted that both water and fat accounted for the weight loss in meats that were roasted. They reported the average water loss for boiled meats to be 30.75 per cent and the average fat loss, 1.21 per cent. In comparison, meats roasted to the rare stage showed an average water loss of 17.53 per cent and an average fat loss of 9.83 per cent.

Bevier, Grindley, and their associates (8, 41, 42), from their intensive research on meat cookery, concluded that the composition of the meat was one of three factors which affected the nature and extent of the cooking losses. The other two factors mentioned by Bevier and co-workers were the cooking temperature and the internal temperature to which the meat was cooked.

According to studies of Alexander (3) on rib roasts ranging from Choice to Canner grade beef, well-fattened beef ribs of high grade had greater dripping losses and lower volatile losses than did the lean ribs of low grades. She found that dripping losses for rib roasts cooked at an oven temperature of 125° C to an internal temperature of 58° C varied from 3.7 per cent for the Choice grade to 0.4 per cent for the Canner grade; the evaporation losses ranged from 6.5 per cent for Choice to 10.9 per cent for the Canner grade. The results of Black, Warner, and Wilson (9) substantiated the findings of Alexander.

Since increased fat content is generally associated with increase in grade, cuts from carcasses of higher grade usually have greater cooking losses. Alexander and Clark (5) found this relationship evident in their experiments with lamb and mutton roasts. Lowe (55) makes the following statement concerning the composition of meat.

> "In general a cut of meat containing a high percentage of fat has a greater cooking loss than a comparable cut containing a smaller proportion of fat."

Helser, Nelson, and Lowe (47) concluded from their studies that beef roasts with a high fat content had a greater total cooking weight loss and also a higher dripping loss than the lean roasts. For ribs of feeder and fattened two year old steers cooked at 125° C oven temperature to an internal temperature of 57° C, total cooking weight losses were 10.6 per cent and 15.4 per cent and the dripping losses were 1.2 per cent and 6.9 per cent, respectively.

In 1932, Thille, Williamson, and Morgan (88) also presented evidence that the total cooking weight losses of fat roasts were greater than those of lean roasts. They cooked standing ribs of beef in a 210° C oven to an internal temperature of 65° C. Their findings showed the average total weight loss for lean roasts to be 28.6 per cent and the average total weight loss for fat-covered roasts to be 32.9 per cent. The difference in total weight losses was attributed to the rendering out of the surface fat.

The cooking weight losses, according to the results of the study by Dunnigan (38) on two grades of sirloin butts, were directly related to the composition of the meat. For the fatter roasts, the total cooking losses were greater.

From the study by Brown (15) in 1948, it appeared that the amount of external fat did not increase the total cooking weight loss. She cooked the inside and outside cuts of both rounds and chucks of U. S. Good grade at an oven temperature of 149° C to an internal temperature of 79° C. Her results indicated that the inside chuck cut had a higher total cooking weight loss than the outside chuck, inside round, and outside round cuts. The inside chuck roast was the only fabricated cut used without a thick layer of external fat. Brown did find that the cuts with a heavier fat covering showed higher dripping losses than cuts with a relatively small amount of external fat. This is in agreement with the findings of other investigators (3, 9, 47,).

Oven temperature

The total cooking weight losses of meat were found to be related directly to oven temperature by Bevier and Sprague (8). They reported that the total cooking weight losses of seared one-rib beef cuts, cooked to the rare stage, varied from 5.9 per cent for roasts finished at 83° C oven temperature to 20.6 per cent for those finished at 260° C oven temperature.

Three-rib beef cuts were roasted to the medium stage by Latzke (53,54). She found the weight loss for seared roasts ranged from 13.52 per cent at 110° C oven temperature to 22.49 per cent at 175° C oven temperature for finishing. Cline and co-workers (26) presented similar results. They noted that the total cooking weight losses of three-rib beef cuts roasted to an internal temperature of 57° C varied from 6.79 per cent for cuts cooked at 110° C constant oven temperature to 30.44 per cent for those cooked at 260° C constant oven temperature.

Child and Satorius (22) obtained increased cooking losses with increased oven temperatures when meat was cooked to an internal temperature of 58° C. The oven temperatures used were 125° C, 150° C, 175° C, and 200° C. When the meat was cooked well done, however, there was no significant difference in cooking losses attributable to oven temperatures. The increased losses of well done meats roasted at low oven temperatures were attributed to the long cooking period required for meats to reach the well done stage. Alexander and Clark (4) also commented that cooking losses of meat at the well done stage were less definitely related to oven temperature than were the losses for meats at lower internal temperature.

Cover (64) found that cooking losses for paired three-rib beef roasts cooked medium rare averaged 7.1 per cent when a 125° C oven was used and 20.2 per cent when a 225° C oven temperature was used. For three-rib beef cuts cooked to the well done stage at these same two oven temperatures, Cover reported the cooking losses to be 23.0 and 37.5 per cent, respectively. Other studies (3, 24, 56) have verified that low oven temperatures for roasting result in lower cooking weight losses than those obtained with high oven temperatures.

From their intensive study on flesh foods, McCance and Shipp (59) reported that higher temperatures increased the rate and extent of the cooking weight losses of meat. They cooked pieces of loin, liver, kidney, tripe, and brain of beef in steam at 80°C, 100° C, and 120° C.

More recently, Stech and West (85) have experimented with roasting meats for institution use at 250° F (121° C) oven temperature. They reported an average shrinkage of 25 per cent for boned beef chuck cooked to 170° F, 36 per cent shrinkage for boned leg of lamb cooked to 180° F, and 30 per cent shrinkage for boned leg of veal cooked to 170° F.

Internal temperature

The internal temperature to which meat is cooked has a marked influence on the total cooking weight losses. Bevier and Sprague (8) cooked paired left and right one-rib beef roasts at the same oven temperature but for different lengths of time. They found that the more thoroughly cooked roasts shrank more than those which were not cooked to the well done stage. From experiments on roasting one-rib beef cuts to rare, medium, and well done stages, in which degree of doneness was determined by their appearance when carved, Grindley and Mojonnier (42) concluded that the cooking weight losses increased in proportion to the degree of cooking.

Beef rib roasts were cooked at 125° C oven temperature to three varying internal temperatures by Latzke (54). She reported losses of 16.8 per cent for roasts cooked to 51° C, 18.6 per cent for roasts cooked to 61° C, and 22.3 per cent for roasts cooked to an internal temperature of 71° C. Cover's data (64), cited previously, also indicated that well done roasts have greater total cooking losses than medium rare roasts.

Child and Fogarty (21), in their experiments with the semitendinosus muscle of beef round cooked at 150° C oven temperature to 58° C and 75° C internal temperature, showed that the higher internal temperature increased the total cooking weight losses.

According to Paul and McClean (70), who cooked veal roasts at 163° C oven temperature to four different internal temperatures, 71° C, 77° C, 82° C, and 88° C, the total cooking losses increased steadily with increase in the internal temperature.

Aldrich (1) cooked paired cuts of U. S. Choice and U. S. Good beef rounds at 150° C constant oven temperature to an internal temperature of 90° C. One cut of each pair was cooked an additional hour. The average losses for Choice and Good cuts cooked to 90° C internal temperature were 34.4 and 35.0 per cent; for the cuts cooked an additional hour, the average losses were for Choice and Good grades, 38.2 and 39.6 per cent, respectively.

Method of cooking

As early as 1904, Grindley and Mojonnier (42) published results of experiments on changes occuring in meat cooked by different methods. Their data showed that meats cooked in hot water had the highest average total weight loss and roasted meats had the least average cooking weight loss of the methods studied. Sauteed meats showed a slightly higher weight loss than pan-broiled meats.

Harrison (46) studied the shrinkage of beef cooked to 70° C internal temperature in air, steam, water, and fat at 100° C. Both loss of weight and decrease in volume were considered under the term "shrink". Cuts cooked in air had the least loss and those cooked in fat had the greatest loss. The amount of total losses obtained from cuts cooked in steam and water were similar and gave intermediate values.

Results of 10 methods of roasting beef were reported by Cline and her associates (26). Prime ribs of beef were first seared and then finished at different oven temperatures; one beef cut was begun in a cold oven and then was seared and finished in a 149° C oven; varying degrees of constant oven temperatures were also used. From their studies, the investigators concluded that searing increases the cooking weight losses and low oven temperatures were correlated with low cooking losses.

Stanley and Cline (84) also observed that searing a roast at the beginning of the cooking period does not reduce the amount of shrinkage. They found the total loss to be 17.36 per cent for beef rib cuts seared at 288° C for 20 minutes and finished at 149° C to an internal temperature of 58° C. The loss was 11.31 per cent for comparable rib cuts cooked at 150° C constant oven temperature to 58° C internal temperature.

The use of skewers to reduce cooking losses has been the subject of a number of experiments. Several investigators (18, 28, 63) have reported that the use of skewers reduced the cooking time and thus lowered the cooking losses. Morgan and Nelson (63) were among the first investigators to report the use of skewers in meat roasting. They found the total loss of weight in skewered roasts averaged 27.3 per cent as compared with 31.5 per cent in the unskewered roasts. Cover (28) cooked paired rounds, arm-bone chuck, and standing rib roasts to the well done stage with and without skewers at an oven temperature of 125° C. Her results supported the findings of Morgan and Nelson.

Grindley and Mojonnier (42) compared the total losses of meats cooked in covered pans with meats cooked in uncovered pans. The total cooking weight losses were greater for the meats cooked in covered pans than in those cooked uncovered. This increased loss was attributed chiefly to the increased amount of water removed from meat in the covered pans. Morgan and Nelson (63), from their experiments with beef ribs cooked in open and covered pans, found the average losses to be 26.8 per cent for the meats cooked in open pans and 29.5 per cent for the meats cooked in covered containers.

Freeman (40) compared beef stews and pot roasts cooked by the conventional method and in the pressure sauce pan. With the exception of the pressure-cooked pot roasts, the meats lost approximately 45 per cent of their weight during cooking. The cooking weight loss of the pressure-cooked pot roasts was 40.6 per cent, but the difference in cooking loss attributable to method was not statistically significant.

Ripening

According to Alexander and Clark (5), increased ripening periods after slaughter decreased the cooking losses and shortened the time required to cook lamb and mutton. Moran and Smith (62) found the average cooking losses of top round, bottom round, and loin of beef after ripening 3, 7, and 16 days to be 29.5, 24.1, and 23.9 per cent, respectively.

Harrison (46) also found that roasts with a longer ripening period had a lower weight loss during cooking in air. However, the roasts cooked in steam, fat, and water all had a greater weight loss with a longer ripening period.

Initial temperature

Cline and co-workers (26) have shown that both the total cooking losses and cooking time were affected by the initial temperature of roasts when they were put into the oven. Roasts with low initial internal temperatures at the beginning of the cooking period showed greater cooking losses than did roasts with higher internal temperatures when cooking began. The Committee on Preparation Factors, National Cooperative Meat Investigations, (64) also concluded that low initial internal temperatures were correlated with increased cooking weight losses.

Fosdick, of Armour and Company in Chicago, (39) mentioned that the weight loss incurred during the defrosting of meat was only 1 to 2 per cent of the total weight. When meat was cooked from the frozen stage without defrosting, the cooking weight loss was reported to be 2 to 3 per cent higher than for similar cuts cooked after they had been defrosted. The total loss was approximately the same whether the meat was thawed before cooking or cooked in a frozen state.

Lowe and co-workers (56) compared the effect of four methods of defrosting meats and of the manner and temperature of cooking upon weight loss and palatability of the roasts. Frozen cuts of meat always required a longer cooking time than comparable cuts which were thawed. Lowe and co-workers' data for 41 groups of roasts showed that the frozen cuts did not always have greater cooking weight losses than the defrosted meat. In 31 of these groups the cooking weight loss was greater for the roasts which were still frozen when cooking was started. However, opposite findings were reported for the other 10 groups of roasts. The weight losses during cooking of paired lamb leg roasts were practically the same for frozen and thawed cuts. Lowe and co-workers stated that the frozen interior of the lamb roast may have slowed the loss of water from the interior of the roast.

Surface area

According to a number of studies (47, 56), compact pieces of meat with small surface areas have less cooking weight losses than pieces which have irregular shapes and greater surface areas. Square or blocky roasts, however, require longer cooking time per pound than thin, flat roasts.

McCance and Shipp (59) observed that although the rate of loss was very different, the total percentage losses of water were the same regardless of the size of the meat. They cooked pieces of top round of beef, which weighed 50, 400, and 1500 grams each, at 100° C in steam.

Style of cutting

Child and Esteros (20) compared standing and boneless rolled rib roasts cooked at an oven temperature of 149° C to an internal temperature

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temperature of 58° C. They found the rolled roasts averaged 2.76 per cent higher in total cooking weight losses than standing roasts. The findings of Alexander and Clark (4) substantiated the results of Child and Esteros. Love and co-workers (56) reported that boned roasts usually lost more weight than similar roasts which were not boned when both were cooked under the same conditions.

Dunnigan (38) found the style of cutting to be more significant than grade in its effect on cooking weight losses. However, her findings were the opposite of the other studies reported. She cooked U. S. Choice and U. S. Utility grade sirloin butts, with and without bone, at a 150° C oven temperature to an internal temperature of 70° C. The bone-in Choice sirloin butts showed a total cooking weight loss of 20.05 per cent; the cooking weight loss for a similar cut, boneless was 12.63 per cent. The total cooking weight losses averaged 19.09 per cent for the boneless Utility grade sirloin butts and 25.79 per cent for similar bone-in cuts of Utility grade in her study.

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Vitamin Losses of Meat during Cooking

The vitamin losses of meat during cooking deserve consideration because meat is an important source of the B - vitamins.

McIntire and co-workers (60) found that both the method of cooking and the size of the cut affect the retention of vitamins in meat. They reported an average thiamine retention of 70 per cent in roast and broiled pork and 50 per cent in braised pork; the average retention of nicotinic acid in roast and broiled pork was 85 per cent and in braised pork, 65 per cent. The average riboflavin retention in pork, cooked by any of the three methods, was 85 per cent. Appreciable amounts of each of the vitamins were found in the drippings. McIntire and co-workers (60) decided that the small percentage of vitamins in the drippings from roast loins and hams was attributable to the size of the roast and the small surface area exposed.

Clark and Van Duyne (23) studied the effect of roasting and pressure saucepan cooking upon the thiamine and riboflavin content of beef roasts. They discovered that the roasts cooked in pressure sauce pans retained more thiamine and less riboflavin than similar cuts of meat roasted in the oven. On the basis of total percentage retentions, the difference in thiamine was not significant. However, the decrease in riboflavin content was significant.

Research by Waisman and Elvehjem (91) showed that roasting caused appreciable destruction of thiamine in meat. The results of their vitamin assays indicated that there is increased destruction of thiamine and riboflavin with the prolonged roasting of meat. Cover and co-workers (30) reported that the retentions of thiamine and pantothenic acid were significantly lower in well done than in rare beef roasts.

Jackson and co-workers (52) observed that the retention of thiamine, riboflavin, and niacin in pork decreased with increased cooking when the meat was roasted or fried. They cooked pork cuts to three degrees of doneness: "correctly cooked", under-cooked, and over-cooked.

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Palatability Factors

Research has shown that many factors affect the palatability of meat. These include the carcass grade, animal variations, muscle differences, length and temperature of frozen storage, length and temperature of ripening period, oven temperature, and the internal temperature to which meat is cooked. Score sheets usually list aroma, flavor, appearance, texture, tenderness, and juiciness as palatability factors to be considered in judging cooked meats.

Aroma and flavor

Because of its aroma and flavor, a properly cooked piece of meat has universal appetite appeal. Zeigler (93) commented that cooked meat surpasses all other foods in aroma. Bull (16) stated, "What we regard as flavor is primarily aroma and secondarily taste."

Cooking method and time. Cline and co-workers (26) reported from their experiments with 10 methods of roasting prime ribs of beef a definite correlation between cooking losses and flavor of the lean. All roasts which ranked low in cooking weight losses rated high in palatability. They suggested that the loss of flavor might be attributed to the loss of juice from the roasts.

The findings of Clark and Van Duyne (23) indicated that more palatable meat was obtained when top rounds were cooked in the oven than when similar roasts were cooked in the pressure sauce pan. They

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reported that the judges preferred the flavor of the lean and fat of the meat roasted in the oven and considered the meat cooked in the pressure sauce pan too dry.

According to Cline and co-workers (26), tender beef cuts cooked in the oven with the addition of water had lower palatability scores than comparable cuts cooked in the oven by dry heat.

Aldrich (1) found that there was marked deterioration in odor and flavor of beef rounds cooked an additional hour at 150° C after the cuts had reached 90° C internal temperature.

Fat content. From their study on the relation of degree of finish in cattle to meat flavors, Branaman, Hankins, and Alexander (13) found that the scores on intensity and desirability of flavor of lean meat showed progressive improvement in the meat with increased fat. The fat content of poultry meat has also been shown to be an important factor in determining its flavor and juiciness (57).

Lowe (55) stated that the flavor of the fat accounts primarily for differences in flavor of the different species, i. e., beef, lamb, pork, chicken, or turkey.

Pork has been found to deteriorate more rapidly than beef or lamb during freezer storage. Palmer and co-workers (67) reported that this was attributable to the high fat content of most pork cuts and to the larger amounts of unsaturated fatty acids in pork fat which increase its susceptibility to development of rancidity. The results of their experiments showed that the degree of unsaturation of fatty

acids involved had a pronounced influence on the development of rancidity in ground pork. The iodine values were determined to indicate the degree of unsaturation in the fat. Rancidity was measured by subjective evaluation of flavor and by peroxide values. It has been established that with an increase in the proportion of unsaturated fatty acids, pork fat becomes softer and is more susceptible to rancidity.

Hiner, Gaddis, and Hankins (49) found that the deterioration in the palatability of beef, pork, and lamb at freezer storage between -7.78° and -17.8° C was due primarily to the oxidation of fat. This was supported by their observation that the greatest change in the fat was an increase in the peroxide value. Hiner and co-workers (49) also added that the desirability of the flavor of the fat was the best subjective index among the palatability factors studied.

Storage conditions. The effect of storage conditions on the palatability of beef was studied by Griswold and Wharton (43). They presented evidence that meat stored 37 days at 34° F had a slightly stronger aroma and flavor than meat stored 9 days at the same temperature. Experiments with storage conditions plus ultra-violet lights were also conducted. The investigators noted that meat held at 60° F for 48 hours with ultra-violet lights was more desirable in appearance and odor than meat held under similar conditions without ultra-violet lights. The growth of bacteria in meats was decreased by ultra-violet irradiation.

Paul, Lowe, and McClurg (69), from their investigation on the changes in beef induced by storage, observed that the greatest increase in

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in palatability of small cuts was obtained with a 9-day storage period at 1.7° C. Further storage resulted in decreased desirability of the aroma and flavor scores and the development of "gaminess" in the lean and rancidity of the fat.

Diet of animal. Barbella, Hankins, and Alexander (6) studied the influence of retarded growth in lambs on flavor and other characteristics of the meat. They reported that meat from lambs fed a well-balanced ration was more desirable in flavor than meat from lambs given only roughage.

Carrick and Hauge (17) were among the first to report that cod liver oil, fed in sufficient quantity to chickens, imparts a "fishy" taste to the flesh of chickens. They observed that cooked meat from chickens fed diets containing 2 per cent of cod liver oil up to the time of slaughter showed no unusual taste when the meat was served warm. However, a "fishy" taste was noted when the chicken was served cold. According to Marble and co-workers (61), only 1 per cent of a poultry grade cod liver oil in the diet of turkeys produced an off flavor and odor in turkey meat.

It has been established that the firmness of pork fat is largely dependent upon the amount of unsaturated fatty acids in the fat tissue. Carbohydrate feeds produce firm fat; whereas feeds with high oil content such as soybeans and peanuts produce soft and oily pork. Brady and co-workers (12) showed that both the quantity of soybeans and the length of time it is fed to hogs affect the degree of firmness of th

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of the pork fat. The Hawaii Agricultural Experiment Station (48) reported a commercial feed for hogs which was very effective for the production of soft pork. There is a demand for soft pork by a segment of the population in Hawaii.

Freezing and wrap. In the study by Palmer and co-workers (67), cited previously, deterioration of pork during freezer storage was reported. Ground pork was stored for periods of 3, 6, and 9 months at -18° C and -12° C. Ground pork was also stored with fluctuating temperatures of -12° C one week and -18° C the following week. These storage temperatures were alternated at weekly intervals for periods of 3, 6, and 9 months. Pork chops were stored for periods of 3, 6, 9, and 12 months at -18° C. Pork roasts were stored for 6 and 12 months at -18° C. Palmer and co-workers reported that deterioration of pork in storage was progressive and became more pronounced with time under all storage conditions. Palatability scores were highest for those samples of ground pork, prepared from firm carcasses, which had been wrapped in superior packaging materials and stored at -18° C. Meat packaged in waxed paper had more than five times greater dehydration loss than that packaged in laminated paper. A severe freezer burn was noted on the cuts wrapped with waxed paper.

Hiner, Gaddis, and Hankins (49) compared the effect of different methods of protection on the palatability of freezer-stored meats. They observed that desiccation of exposed frozen meat was retarded by a high fat content and by a low storage temperature of -17.8° C.

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Cellophane and lard-coating were equally satisfactory in protecting frozen cuts from moisture loss. Vacuum packing resulted in no moisture loss. They reported that more desiccation occurred in the exposed frozen meat than in cellophane wrapped meats or in cuts that were coated with lard. The development of undesirable flavor was not attributable to fat oxidation alone but appeared to be related to moisture loss, also. Cellophane wrapping and lard dipping gave a small amount of protection against oxidation. The original quality of meat declined rapidly in all types of protection studied except vacuum packing.

In their study concerning the effect of four different packaging materials on frozen meats, Simpson and Chang (81) found that aluminum foil and glassine-laminated paper was more effective than polyethylene-coated paper or butcher wrap in retarding rancidity development at storage temperaturs of 0° F, -20° F, -30° F, and -40° F.

Appearance and texture

Crist and Seaton (31), from their experiments to determine the reliability of organoleptic tests, reported that appearance ranked first in importance according to the judges' scores. Their results justified the familiar saying that people buy and eat with their eyes.

Raw meat. From a study of the factors influencing the tenderness and texture of beef, Brady (11) concluded that texture is dependent upon the sise of the bundle of muscle fibers. He observed that meats with finer texture consisted of larger bundles of muscle fibers. Shea and

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and co-workers (79) presented an improved technique for the induction of marbling by mechanically introducing fat into the vascular systems of beef. They found that the vascularly injected meat appeared well-marbled but had a veal-like pallor.

Size of animal. Paul and McClean (70) studied the effect of varied internal temperatures on veal roasts from calves of three different weights. They found that the roasts from the large animals gave the best results for texture. The judges' scores for texture and color showed that the extent of the variation induced by the increase in internal temperature was less for roasts from large animals than for the roasts from small animals.

Grade. According to Satorius and Child (77), the judges' scores showed no significant difference between medium and good grades in the external appearance of longissimus dorsi and adductor muscles cooked to 58° C at 150° C oven temperature. However, they reported a significant difference was found between the two grades in the external appearance of the raw muscles.

Day (35), from her study with the longissimus dorsi of beef from U. S. Good, U. S. Commerical, and U. S. Utility grades, reported that the analysis of the taste panel scores indicated little difference between grades in appearance and texture.

Cuts and muscles. Satorius and Child (77) reported from their study, cited previously, that the adductor muscle was graded lower in texture than the longissimus dorsi muscle.

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Cooking time. In her study with beef rounds, Aldrich (1) found that the average appearance scores for cuts of both Good and Choice grades cooked the additional hour after they had reached 90° C internal temperature were lower than the average scores for comparable cuts cooked only to 90° C internal temperature. The cuts cooked the additional hour showed a marked darkening of large areas on the surface of the sliced muscles. Large areas of the slices also became highly iridescent after exposure to air.

Tenderness and shear force

Tenderness and flavor in meat are two qualities desired more than any others, according to Deatherage and Rieman (36). They further commented that meat which has good flavor is still undesirable if it is tough. Factors which affect the tenderness of meat have been the subject of many investigations.

Degree of internal temperature. By means of a modified New York testing laboratory penetrometer, Noble, Halliday, and Klaas (65) determined the tenderness of beef cooked to 61° and 75° C internal temperature at an oven temperature of 149° C. They concluded from the penetrometer readings that toughening occurred during heating from 61° to 75° C. Paul and McClean (70) reported that with each rise in internal temperature of the veal roasts, there was improved tenderness according to the taste panel scores.

<u>Oven temperature</u>. Cover (29) cooked paired beef roasts to an internal temperature of 80° C at oven temperatures of 125° C and 225° C. She reported that well done round-bone chuck, rib, and rump roasts were more tender when cooked at 125° C than when cooked at 225° C. However, she found no significant difference in tenderness of medium-rare rib and chuck roasts of beef cooked at these two temperatures. She reasoned that the difference in cooking time required by the different cuts may have had more influence on tenderness than did the oven temperatures. Cover's data (28), from the study of the use of metal skewers in meat roasting, gave further support to the theory that longer, slower cooking increases tenderness in meat and shorter, faster cooking increases its toughness. The same investigator (27) then studied the effect of oven temperatures of 80° C and 125° C on tenderness of beef. From the results of this experiment, Cover concluded that 80° C oven temperature was not desirable for roasting meats. Although roasts cooked at this low temperature were more tender, the meat was dry, mealy, and flavorless.

Cline and co-workers (26), from investigations based on different methods of cooking and their effect on the quality and palatability of beef, concluded from the judges' scores that low oven temperatures were correlated with increased tenderness. Latzke (54) also reported that cooking meat at low oven temperatures resulted in more tender roasts than cooking meats at high oven temperatures. Child and Satorius (22) cooked semitendinosus and longissimus dorsi muscles of beef to an internal temperature of 58° C at oven temperatures of 125°, 150°, 175°, and 200° C. From their findings, it appeared that only at the very extreme ends of the oven temperature range was the shear force of the roasts affected. A significantly greater number of pounds of force was required to shear the ribs roasted at 200° C than to shear meat cooked at 150° C. Fewer pounds of force were required to shear meat cooked at 125° C oven temperature than meat cooked at 150° C.

Cooking. Ramsbottom, Strandine, and Koonz (76), from their study with representative beef muscles, observed that most muscles were made less tender by cooking, some did not change significantly, and other muscles became more tender. They concluded that since connective and fatty tissues were made more tender by cooking, the decreased tenderness of certain cooked muscles might be associated with factors such as coagulation and denaturation of muscle proteins together with varying degrees of shrinkage and hardening of the muscle fibers.

Bard and Tischer (7) studied the changes in beef shoulder clod of Canner and Cutter grades during heat processing. They found that the tenderness of beef, measured by the pounds of force required to shear the meat, decreased as the temperature of processing was raised from 225° to 255° F.

Diet of animal. Black, Warner and Wilson (9) studied the effect of grade and feeding of grain supplement to steers on the quality of beef. They found from the judges' scores and mechanical shear tests that the meat from steers fed the grain supplement was more tender than the meat from steers fed only on grass. Barbella, Hankins, and Alexander (6) also noted that meat from well-fed lambs was more tender than meat from poorly fed animals.

Age, sex, and grade. The observations of MacKintosh and co-workers (58) indicated that meat from mature steers was less tender than that from yearling cattle. From their experiments, Satorius and Child (77) concluded that meat from steers was more tender than that from cows.

Lowe and co-workers (56) compared the effect on palatability of three grades of prime ribs of beef which had been stored at -17.8° C temperature. They cooked 35 prime ribs at oven temperatures of 120°C, 150° C, and 175° C to internal temperatures of 58° C and 75° C. According to the palatability scores, tenderness was influenced by the carcass grade. These investigators reported that roasts from Commercial grade carcasses had lower tenderness scores than those from Choice and Good grade carcasses.

Animal and muscle variations. In their study, previously cited, Noble, Halliday, and Klaas (65) found that the differences between tenderness averages for corresponding left and right wholesale rib cuts were very small when the cuts were cooked in the same manner. They also observed that the rib cuts were one and one-half times more tender than the first round cuts from the same animal.

According to Ramsbottom and Strandine (75), the individual muscles within a carcass varied markedly in tenderness. They reported that the longissimus dorsi (eye muscle) and the psoas major (tenderloin) averaged higher in tenderness than any other muscles with the exception of the internal oblique (the cut surface between the sirloin and the short loin).

From the studies by Lowe and co-workers (56), it appeared that tenderness was the palatability factor most often affected by animal and muscle variations.

Aging and ripening. Aging and ripening appear to have a marked influence on the tenderness of beef. Deatherage and Rieman (36) stated that meat may be tenderized during ripening by hanging at refrigerator temperatures of 0.6 to 1.1° C for periods of time varying from 3 to 6 weeks. The disadvantages of this method, they mentioned, were the danger of the development of off-flavors, the high losses due to shrinkage and trimming, and the high cost of storage. The Tenderay process was developed to circumvent these difficulties. Deatherage and Rieman (36) reported the results of experiments with the Tenderay process on 82 beef carcasses. The U. S. Commercial carcasses showed slightly greater improvement than did those of U.S.Good. For the whole group, Tenderayed beef scored 2.5 points higher in tenderness than the unprocessed meat from a possible total score of 10 points.

Freezing. The effect of different freezing temperatures on the tenderness of beef steaks was studied by Hankins and Hiner (45). Their results showed that the control steaks stored at 34° F had higher shear readings and were less tender than meats frozen at +20° F, -10° F, and -40° F. Storage temperatures of -10° F and -40° F had significantly greater tenderizing effect than the storage temperature of +20° F. No significant difference was found between meats frozen at the two lowest temperatures, -10° F and -40° F.

Paul and Child (68) reported that there was no significant difference in the tenderness of meat which was not frozen and meat which was frozen at -0.4° F. According to Ramsbottom (73), freezer storage at - 10° F or lower for seven years did not significantly change the tenderness of beef steaks.

Dahlinger (33) compared the tenderness of beef rounds which were precooked and frozen with similar cuts which were freshly frozen and then roasted the day they were served. All cuts were stored for 25 days at -10° F. According to the analysis of the shear force averages, the roasts which were freshly frozen and then cooked were significantly more tender than comparable cuts which were precooked and then frozen. The taste panel scores indicated a preference for roasts which were precooked and frozen, but the differences were not statistically significant.

Juiciness and press fluid

Latzke (54), from her studies in standardizing methods of roasting beef in experimental cookery, commented that the quality and palatability of a roast are largely determined by juiciness. This factor can be measured to some extent by the amount of cooking losses in meat. Studies (26,70) have shown that there is correlation between juiciness and cooking weight losses.

Degree of internal temperature. According to Child and Fogarty (21), semitendinosus beef muscles cooked to 58° C internal temperature at 150° C oven temperature contained approximately 11 per cent more press fluid than similar muscles cooked to 75° C. They also observed than an inverse relationship existed between the percentage of press fluid and the total cooking losses in muscles heated to 75° C. No relationship was observed between the percentage of press fluid and the total cooking losses in muscles heated to 58° C.

From their experiments on beef ribs and rounds cooked at 149°C, Noble and co-workers (65) reported that the ribs cooked to 61° C yielded more juice than those heated to 75° C when samples were subjected to a pressure of 380 pounds per square inch.

Exterior temperature. Child and Satorius (22) reported that oven temperatures of 125°, 150°, 175°, and 200° C did not affect the press fluid of beef muscles cooked to an internal temperature of 58° C. From the studies of Cline and co-workers (26), it appeared that high oven temperatures decreased the juiciness of roasts. They cooked beef at oven temperatures of 110°, 163°, 191°, 218°, and 260° C to an internal temperature of 57° C.

Siemers and Hanning (80) studied the effect of temperature, length of cooking, and fat content on the juiciness of meat. To simulate the braising of meat, they cooked blended samples of lean beef and suet in closed graduated centrifugal tubes. The temperatures used were 70°, 80°, 90°, and 98° C. Cooking periods were 5, 10, 20, and 30 minutes. The increased temperature of braising and length of cooking time significantly increased the loss of juice.

Effect of cut and boning. Child and Esteros (20) used the pressometer to determine the amount of press fluid in samples of standing and rolled rib roasts of beef. They concluded that the standing rib roasts had a larger quantity of juice than the corresponding rolled roasts. There was also a slight tendency for the standing roasts to have a richer quality of juice than the rolled roasts according to the judges' scores. Noble, Halliday, and Klaas (65) observed that the rounds yielded more juice than the standing rib roasts when both meats were cooked to 61° C at an oven temperature of 149° C.

Method of cooking. According to Harrison (46), the judges found no significant differences in juiciness of meats cooked in air, steam, water, or fat. There was no significant difference in the amount of press fluid at the center of the roasts attributable to cooking mediums; but there was a highly significant difference in the amount of press fluid from samples one-half inch below the surface of the roasts which was attributable to different cooking mediums. Meats cooked in air had the most press fluid. When fat, water, or steam was used as the cooking medium, less press fluid was found in the meat. The cuts cooked in steam contained the smallest amount of press fluid.

Grade. Vail and O'Neill (89) reported that results of their press fluid tests with cooked rolled rib, top round, and clod cuts were unexpected. The cuts from U. S. Choice grade yielded appreciably less press fluid than did the cuts from U. S. Good grade. However, the palatability scores showed the roasts prepared from U. S. Choice grade to be higher in juiciness than similar cuts from U. S. Good grade.

According to Aldrich (1), the amounts of press fluid found in U. S. Choice rounds was slightly higher than that found in U. S. Good rounds. Day (35), from her experiments with the longissimus dorsi of three grades of beef, concluded that there was little difference in average scores for juiciness of U. S. Utility, U. S. Commercial, and U. S. Good grade cuts. She reported a positive correlation, significant at the 5 per cent probability level, between press fluid tests and juiciness scores.

Method of cooking. Freeman (40) reported that the pressurecooked pot roasts yielded significantly greater amount of press fluid than pot roasts cooked by the conventional method.

Methods of Evaluating Palatability of Meats

Subjective method

Subjective methods of scoring food depend upon the sensory organs. These tests are subjective because the qualitative and quantitative aspects of the characteristics under study are based on the opinions of the judges. Lowe and Stewart (57) commented that these tests are inherently associated with acceptability, since a large part of the acceptability of food is related to sensory perception. The problems involved in the subjective method of testing are discussed by several investigators (10, 51, 66). Boggs and Hanson (10) have observed that each judge tends to weigh the various factors by his own standards. The psychological and physiological factors have also been shown to influence the judges' scoring (32,57).

Lowe and Stewart (57) stated that there is much confusion among food research workers regarding the use of subjective tests. Some investigators consider all subjective tests, only in terms of preference. According to Lowe and Stewart (57), this is not necessarily valid. They classify subjective tests into two categories: preference or acceptance tests and difference or psychometric tests.

The triangle test, based on three samples two of which are duplicates, has been widely used. The taste panel is asked to select the odd sample. This test determines whether the difference between the duplicates and the odd sample is great enough to be detected by the panel members. Davis and Hanson (34) stated that considerable information is lost in the use of the triangle test if intensity designation is not made or if it is utilized only for those judgments in which the odd sample is correct. They presented a new method of evaluating the results of three sample tests in which designation of intensity is required. All judgments are evaluated in terms of an I-value which is directly related to the probability of chance occurrence of the judgment. The inclusion of partially correct judgments provides for increased efficiency by reducing the number of trials necessary to detect a difference at a given level of significance.

There have been extensive studies to discover the best methods for the treatment of food products in order to give them good quality. The need for technical criteria and a flavor standard to determine the final quality of these products is generally recognized. Sjostrom and Cairncross (82) presented the flavor-profile method, a descriptive rather than a measuring device, for testing food products. According to this concept, flavor consists of a number of indistinguishable components which combine to produce a blend of few recognizable flavors. These components give a product character and individuality. Each member of the taste panel records the intensity of detectable flavor notes in the order of their appearance.

An Acceptance Testing Methodology Symposium was held in 1953 at Chicago under the joint sponsorhsip of the National Research Council and the Quartermaster Food and Container Institute. Proceedings of this conference have not yet been published. However, according to a recent abstract (72) of the symposium, some new concepts were introduced.

Dr. H. Schlosberg, Brown University, reported that apparently the best or only way to obtain more stable and sensitive measurements of responses is to increase panel size. His conclusion was based on an extensive study of the problem of selecting and training panels. When panel members had immediate knowledge of the results of their efforts, the performance of scoring appeared to improve. Dr. Carl Pfaffmann, also of Brown University, attributed this improvement to the increased interest of the panel members. Dr. L. L. Thurstone, Psychometric

Laboratory, University of North Carolina, presented evidence that a "rational zero point" can be established. This is the point at which the individual neither likes nor dislikes the food.

Research workers continue to depend upon the judgment of taste panels for quality scoring. Overman and Li (66) emphasized the need for comparing the reliability of the judgments of the taste panel members. They suggested a method for measuring the consistency and discriminating ability of each member of the taste panel. Even with its shortcomings, the subjective method is considered an important method in determining palatability.

Objective method

Halliday (44) stated that subjective tests with their carefully planned score cards have their value but indicated that they should not be used as the sole criteria. Objective tests can be reproduced and are more applicable to the needs of the control laboratory (57).

In 1934, Child and Baldelli (19) discussed the development of a method for objective evaluation of juiciness in meats. Techniques for use of the pressometer to analyze press fluid content in meats were presented. Studies (20,35) have shown that there is correlation between pressometer readings and juiciness scores by the judging committee. A method for mechanical determination of juiciness in meats by means of a hydraulic press was described by Tanner, Clark, and Hankins (87). However, their findings showed no close correlation between results obtained by the hydraulic press method and the results of the taste panel scores for juiciness of beef cooked to 58° C internal temperature.

A number of mechanical devices for measuring the tenderness of meats have been invented. Bratzler (14) studied the Warner shearing machine and standardized the size and shape of the opening and the type of cutting edge. The Warner-Bratzler shearing apparatus has been widely used for tenderness determinations. A high degree of correlation between taste panel scores for tenderness and shear force readings has been established by several investigators (1, 9, 78). The penetrometer has also been used to measure the tenderness of meat and other products. Other methods have been devised to determine the tenderness of meats by chemical analysis.

The shortometer for testing tenderness of baked products and the Munsell system of rotation to study the preservation of green color in cooked vegetables are further examples of objective testing for foods. These objective tests show that the research worker is not entirely dependent upon subjective tests for evaluating the quality of cooked food.

Objective and subjective methods

Although numerous methods have been tried in the laboratory, the type of test most widely applicable to all foods of all classes is the subjective-objective approach. Dove (37) commented, "The use of these two terms in combination now becomes necessary since the trend in research has been to depend solely upon the objective approach". He added that the subjective-objective approach is the first step to be taken in reorientation before food acceptance tests can be developed. Lowe and Stewart (57) stated that the objective tests for organoleptic qualities must measure those characteristics which are correlated with acceptability. Halliday (44) also recommended the use of combined methods of subjective and objective approaches in food testing. Examples of the combined uses of these methods are shown by the work done on tenderness and juiciness by various investigators.

Cost of Edible Portion

In 1917, Van Arsdale and Monroe (90) commented on the importance to the housewives of distinguishing between the original cost of the meat and its actual cost after elimination of waste and loss in cooking. Their experiments included steaks, chops, fowl, and the commonly called "cheaper" cuts of meat. They gave the cost per pound as purchased for pot roast of beef as \$ 0.26 and cost per pound of edible portion as \$ 0.485. Fuel cost of \$ 0.02 was included in the final cost.

Cline and Nesbitt (25), in 1936, conducted experiments on cooking losses and yields of prime ribs, chucks, top rounds, and heels of rounds cooked to three stages of doneness. Yields were based on the number of 100 gram servings obtainable from a pound of uncooked meat. Portion costs of meats at the well done stage, including the cost of gas for cooking, were heel of round \$ 0.062, chuck \$ 0.067, prime ribs \$ 0.089, and top round \$ 0.106.

Factors which affect the palatability and cost of roast beef served in institutions were studied by Vail and O'Neill in 1937 (89). They cooked rolled rib roasts, top round, and clod at a constant oven temperature of 149° C to an internal temperature of 68° C. A summary of their results showed that the cost of a 70 gram cooked portion from ribs was about 180 per cent greater than a similar serving from either the round or clod, regardless of grade. They concluded that if cost is important, the top clod of U. S. Prime, U. S. Choice, or U. S. Good should be served because of the great difference in cost and slight difference in palatability as compared with similar data for rib roasts.

According to the results reported by Dunnigan (38), in 1943, the cost per pound of edible cooked meat for the U. S. Choice bone-in sirloin butts was $ 0.531 and for boneless roasts, $0.419. For similar cuts of U. S. Utility grade, the cost per pound of edible cooked meat were $ 0.526 and $0.352, respectively. Brown (15), in 1948, compared the losses of the cuts attributable to oven roasting and slicing. She reported a 7 per cent increase in the yield but a 15 per cent increase in the price of rounds over chucks. She concluded from her results that the chuck cuts appeared to be more economical than the cuts from the round when cooked under the conditions and at the prices mentioned in the study.

From her research on the effect of the extent of cooking for the muscles of beef rounds, Aldrich (1), in 1951, reported that the edible portion cost showed an increase of 5.04 per cent for U. S. Choice grade during the additional hour of cooking after the internal temperature had reached 90° C. She found the cost per 2.5 ounce portion of edible meat for U. S. Choice rounds cooked to 90° C to be $0.2343 and for U. S. Good $0.2229. After the additional hour of cooking the edible portion cost for U. S. Choice rounds was $0.2461 and U. S. Good grade, $0.2406.

Day (35), in 1953, reported the cost for 2.5 ounces of cooked portion of the longissimus dorsi of beef to be $ 0.5644 for U. S. Good, $ 0.4475 for U. S. Commercial, and $ 0.3288 for U. S. Utility grade.

METHOD OF PROCEDURE

Preparation of Cuts

Dissection of carcass

Three sides of beef carcasses of each grade, Choice, Good, and Commercial, were purchased from Armour and Company in Chicago. The storage period for the sides of beef varied from 2 to 7 days from delivery to cutting date. During this period, the meat was held at 1.7° C. After storage, the half carcasses were cut into quarters between the twelfth and thirteenth ribs. The forequarter and hindquarter were divided into wholesale cuts. Each wholesale cut was then divided, boned, and trimmed into retail cuts. The percentage yields of the edible meat, bone, and fat were determined. The edible meat was divided into tender cuts for dry roasting and less tender cuts suitable for pot roasts, stew meat, and ground beef.

Division into oven-ready cuts

For this study, oven-ready roasts were prepared from the ribs, sirloin, short loin, and round. The boned rib was rolled and tied and divided into three cuts of about equal size. The tenderloin was removed from the sirloin and the remaining sirloin butt was divided into two roasts. The tenderloin was removed from the short loin and the strip loin was left whole for roasting. From the round, the top round was removed and divided into three roasts. The center portion was the largest of the three oven-ready roasts from the top round. The beef cuts used in this study are identified in Figure 1.

Freezing and storage of cuts

The oven-ready roasts were individually wrapped with freezer paper, tied securely, and labeled. The cuts were frozen at -12.2° C and were stored at the same temperature until defrosting just prior to cooking. The length of storage for the frozen cuts varied from 11 to 13 weeks.

Cooking of Cuts

Defrosting of cuts

The frozen cuts were unwrapped and weighed on a Torsion balance. They were defrosted in a refrigerator at 5° C for 40 to 55 hours, depending upon the size and weight of the cut, to an internal temperature of approximately 0° C.

The defrosted cuts were weighed again just prior to roasting. A thermometer was placed so that the bulb would be as near the center of the cut as possible. Each cut, with the exception of the strip loin, was placed on a trivet in a 9 x 14 inch aluminum pan for cooking. The strip loin was placed on a trivet in a 11 x 18 inch pan of 18 gauge stainless steel.

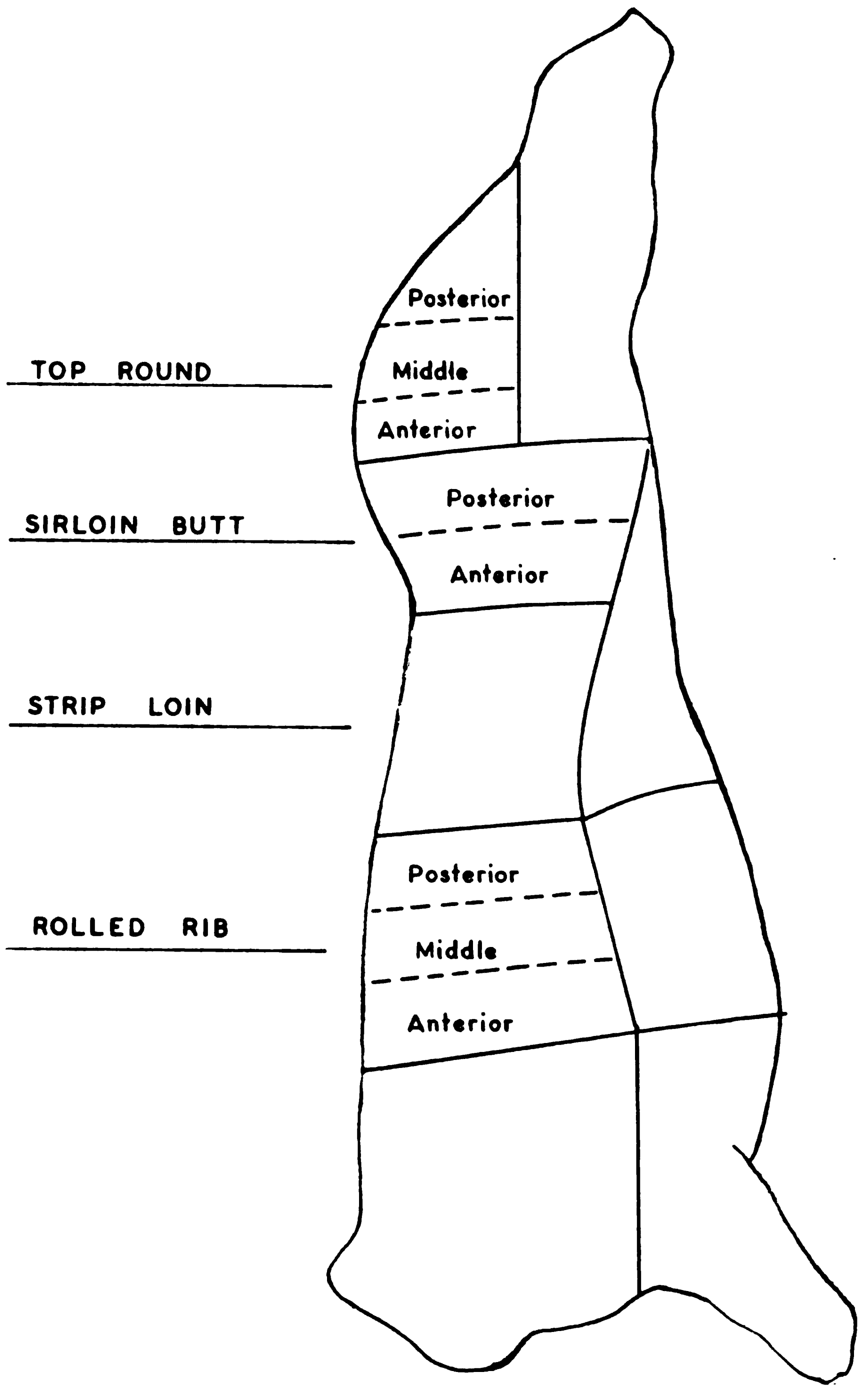

Figure 1. Beef chart identifying tender cuts used in study.

Roasting process

The meat was cooked in thermostatically controlled Hot Point Electric ovens, built with open fire-brick bottoms. A Precision oven thermometer was used to double check the oven temperature. Each cut was cooked without a cover at a constant oven temperature of 150° C. The roasts were weighed during the cooking period at the following specified internal temperatures: 50° C, 60° C, 70° C, 80° C, and 90° C. Four cuts were roasted simultaneously, two cuts in each of the two ovens.

Temperatures of the roasts were recorded at 15 minute intervals until the internal temperature of the roasts neared 50° C. The temperatures were then checked every 3 to 5 minutes. The oven temperatures were checked at 30 minute intervals. Since the oven doors were not equipped with glass windows, it was necessary to open the doors to check the temperatures of the roasts.

When each roast reached 50° C internal temperature, it was removed from the oven. The cooked roast and the drippings were weighed and recorded. The roast was then placed in the original pan and returned to the oven. A stop watch was used to determine the number of minutes the roast remained out of the oven so that total cooking time could be figured. The internal temperature of the meat was again recorded at 15 minute intervals until it neared the next specified internal temperature and was then checked at 3 to 5 minute intervals. For the 10 degree rise between 70° and 80° C and between 80° and 90° C, the internal temperatures were checked at 20 minute intervals. The roasts were removed from the oven at 60° C, 70° C, 80° C, and 90° C and the same procedure was followed as described for the roast at 50° C internal temperature.

Volatile losses were calculated by subtracting the sum of the weight of the drippings and the cooked weight of each roast from the defrosted weight of the roast.

Preparation of Samples

The roasts were allowed to cool at room temperature for approximately 30 minutes, before samples were removed for the taste panel judges. It was necessary to slice the samples from the larger roasts shortly after their removal from the oven because of the complication of extremely long cooking periods which delayed setting up samples. In preparing the samples for scoring, a layer of cooked meat about 1.0 to 1.5 inches thick, was removed from the outside of the cooked roasts. The muscles were then separated, and a cut was made with a sharp knife across the grain to produce a straight edge for machine slicing. Another cut, parallel to the first, was made 2.5 inches from the trimmed edge. A cylinder was removed from the 2.5 inch portion of roast for the shear force tests and the remainder was sliced into samples for palatability scoring by the taste panel.

Samples for shear force readings

From the center of the 2.5 inch section of roast, a sample was obtained for testing tenderness on the Warner-Bratzler shear apparatus.

Occasionally, it was necessary to obtain a sample from nearer the edge to avoid visible strips of connective tissue. This sample was cut parallel with the direction of the muscle fibers. A one-inch metal core with a sharp edge was used with a gentle, rotating motion along the grain of the meat. The samples were placed in individual polyethylene bags and stored overnight. Shear tests were run the following morning.

Samples for palatability scoring

After the cylinders had been removed from the 2.5 inch portion of roast, samples for scoring were cut from this section with a General Slicing Machine, Model 225. These slices were approximately 0.25 inch thick. Each judge was identified by letter and received a sample of meat in the same order of slicing for all tests. On a few occasions, it was necessary to freeze some samples in polyethylene bags because the judges were unable to be present for the scoring at the regular time. As soon as was practicable, these slices were thawed at room temperature for an hour and then were scored.

Tests and Records

Shear force tests

Tenderness was objectively measured on the Warner-Bratzler shear machine. This shearing apparatus measures the pounds of force required for the blade to cut through a sample of meat one-half or one inch in diameter. Five tests were made on a one-inch cylinder from each roast.

Subjective tests

Each of seven judges scored a sample from each roast. The rating was based on a scale ranging from 0 to 10 for aroma, flavor, appearance, texture, tenderness, and juiciness. The score sheets also included descriptive terms for each palatability factor to be checked by the taste panel members. A copy of the score card may be found in the Appendix.

Cost for edible portion

The cost per pound of the individual uncooked, oven-ready cuts from each side of beef was based on the total purchase value of the half carcass, the weights of edible meat from each animal, and on cost factors which were assigned arbitrarily. The cost per pound of ground beef was assigned a value of X, stew meat 1.28 X, pot roasts 1.44 X, and dry roasts 1.67 X, based on the relative value of each of the four classifications on the market at the time of this study.

The following steps illustrate the manner in which the price per pound of the individual uncooked, oven-ready cuts from each half carcass was computed.

1. The weights of edible meat of each classification obtained from animal A of Commercial grade were tabulated as shown in Table 1.

2. The total weights of ground beef, stew meats, pot roasts, and dry roasts of animal A were multiplied by their respective factors.

41.125	x	X	=	41.125 X
85.375	x	1.28 X	=	109.28 X
26.5	x	1.44 X	=	38.160 X
67.875	x	1.67 X	=	113.35125X
		Total		301.91625X

3. The cost per pound of ground beef or the X value for animal A was calculated by dividing the total purchase value of the half carcass ($ 95.04) by the total of the four products obtained in step 2 (301.91625 X).

4. The costs per pound of stew meat, pot roasts, and dry roasts for animal A were calculated by multiplying the respective factors by the cost of ground beef per pound.

Ground beef:	X	=	$ 0.3148
Stew meat:	1.28 x 0.3148	=	0.4029
Pot roasts:	1.44 x 0.3148	=	0.4532
Dry roasts:	1.67 x 0.3148	=	0.5257

Table 1. Distribution of weight of edible meat from animal A of Commercial grade.

Wholesale Cut	Ground Beef	Stew Meat	Pot Roasts	Dry Roasts
	lbs.	lbs.	lbs.	lbs.
Round	13.25		26.5	17.75
Loin end	1.0			19.75
Flank	7.25			
Short loin	7.25			11.25
Rib	1.5			19.125
Plate	1.5	13.25		
Chuck	1.75	65.50		
Shank	7.625	6.625		
Total	41.125	85.375	26.5	67.875

The average cost per pound of the individual uncooked, oven-ready cuts from each of the three grades was figured by dividing the total raw weight cost of the oven-ready cuts from the three sides of each grade by the total weight of the oven-ready cuts for that particular grade. See Table 2. In this study, the average costs per pound of the individual, uncooked oven-ready cuts do not include the labor costs for cutting and handling the meat or the storage cost.

The total cost, $ 95.0554, was divided by the total weight, 172 pounds 9 ounces, to obtain the average cost per pound of all cuts to be used for roasting from the three carcasses. The average cost per pound of uncooked roasts from three Commercial grade carcasses was $ 0.5508. The average costs per pound of uncooked roasts from three Good and three Choice grade carcasses, calculated as previously described, were $ 0.6599 and $ 0.7161, respectively.

Table 2. Weight and cost of oven-ready cuts from three animals of Commercial grade.

Animal	Cut	Weight lbs.	oz.	Cost/lb.	Total Cost
A:	Sirloin butt	17		$ 0.5257	$ 8.9369
	Top round	17	12	0.5257	9.3331
	Strip loin	9		0.5257	4.7313
	Rolled rib	19	2	0.5257	10.0540
B:	Sirloin butt	17		0.5567	9.4639
	Top round	14	8	0.5567	8.0721
	Strip loin	8	12	0.5567	4.5232
	Rolled rib	16	13	0.5567	9.3595
C:	Sirloin butt	16	3	0.5743	9.2965
	Top round	14	10	0.5743	8.3991
	Strip loin	7	11	0.5743	4.4149
	Rolled rib	14	12	0.5743	8.4709
	Total	172	9		$95.0554

The average cost per pound of the individual cooked roasts for each of the three grades at specified internal temperatures was found by dividing the raw weight cost of the roast by the cooked weight.

The average portion cost of the cooked roasts was based on 2.5-ounce portions. Since the strip loin had an extremely large amount of fat covering, the average portion cost of this roast was based on 4-ounce portions.

RESULTS AND DISCUSSION

Cooking Weight Losses

Total losses

The total cooking weight losses of all cuts showed an increase with each rise in internal temperature, as was expected. Tables 3, 4, 5, and 6 list the average percentage total cooking weight losses of the cuts from Commercial, Good, and Choice grade carcasses at internal temperatures of 50° C, 60° C, 70° C, 80° C, and 90° C. Total losses for each of the cuts from the three grades at the different internal temperatures may be found in the Appendix. There was no significant difference in total losses attributable to grade at any of the internal temperatures. However, highly significant differences were found among the cuts for all the grades.

The strip loin had consistently lower total cooking weight losses at each of the internal temperatures studied than any of the other cuts. Differences in total losses were significant at the 1 per cent level of probability between the strip loin and all other cuts, with the exception of the posterior round cut at 50° C internal temperature. The decreased total losses of strip loin were attributed to the protection from evaporation afforded by the greater quantity of external fat and to the large proportion of exposed surface area to weight of the roast, which considerably shortened the cooking period of the strip loins. The total cooking weight losses of all cuts at each of

Table 3. Average percentages of cooking losses from sirloin butt roasts of three grades of beef at specified internal temperatures.

Portion of Sirloin Butt	Internal Temp. °C	Total Losses			Dripping Losses			Volatile Losses		
		Grade			Grade			Grade		
		Comm.	Good	Choice	Comm.	Good	Choice	Comm.	Good	Choice
Anterior	50	8.4	9.6	9.7	2.7	3.0	2.7	5.7	6.6	7.0
Posterior		9.1	9.1	9.4	1.7	1.5	2.2	7.4	7.6	7.2
Average		8.8	9.4	9.5	2.2	2.3	2.4	7.6	7.1	7.1
Anterior	60	12.8	14.8	15.2	3.5	4.6	4.2	9.3	10.2	11.0
Posterior		12.7	12.2	12.3	2.5	2.2	2.7	10.2	10.0	9.6
Average		12.7	13.5	13.8	3.0	3.4	3.5	9.7	10.1	10.3
Anterior	70	20.6	24.4	24.8	5.2	7.4	6.0	15.4	17.0	18.8
Posterior		19.4	17.6	19.1	4.1	3.4	5.0	15.3	14.2	14.1
Average		19.9	21.0	21.9	4.6	5.4	5.5	15.3	15.6	16.4
Anterior	80	30.3	34.3	35.3	6.5	8.3	5.8	23.8	26.0	29.5
Posterior		27.2	26.0	28.1	5.5	5.1	7.2	21.7	20.9	20.9
Average		28.6	30.1	31.7	6.0	6.7	6.5	22.6	23.4	25.2
Anterior	90	38.8	39.8	40.1	6.3	7.8	6.6	32.5	32.0	33.5
Posterior		34.2	34.6	36.3	7.6	7.3	9.0	26.6	27.3	27.3
Average		36.4	37.2	38.2	6.9	7.6	7.8	29.5	29.6	30.4

Table 4. Average percentages of cooking losses from top round roasts of three grades of beef at specified internal temperatures.

Portion of Top Round	Internal Temp. °C	Total Losses			Dripping Losses			Volatile Losses		
		Grade			Grade			Grade		
		Comm.	Good	Choice	Comm.	Good	Choice	Comm.	Good	Choice
Anterior	50	9.9	7.3	7.4	2.0	1.0	1.0	7.9	6.3	6.4
Middle		9.2	10.3	10.3	1.1	1.5	1.9	8.1	8.8	8.4
Posterior		3.9	6.7	6.9	1.8	1.7	1.4	2.1	5.0	5.5
Average		7.6	8.1	8.1	1.6	1.4	1.4	6.0	6.7	6.7
Anterior	60	14.8	11.0	11.5	2.6	1.2	1.6	12.2	9.8	9.9
Middle		15.6	17.8	16.3	1.9	2.7	2.4	13.7	15.1	13.9
Posterior		9.8	12.4	10.7	2.9	3.1	2.0	6.9	9.3	8.7
Average		13.3	13.7	12.8	2.4	2.3	2.0	10.9	11.4	10.8
Anterior	70	24.2	20.4	18.7	3.9	2.6	2.8	20.3	17.8	15.9
Middle		25.9	29.7	27.1	2.3	3.4	3.1	23.6	26.3	24.0
Posterior		17.7	22.9	19.7	3.7	5.7	3.6	14.0	17.2	16.1
Average		22.4	24.3	21.7	3.3	3.8	3.1	19.1	20.5	18.6
Anterior	80	36.2	30.7	29.9	4.1	3.1	3.2	32.1	27.6	26.7
Middle		36.1	38.1	36.1	2.5	3.3	2.7	33.6	34.8	33.4
Posterior		27.5	32.3	30.4	4.7	6.8	5.4	22.8	25.5	25.0
Average		33.0	33.6	32.0	3.8	4.3	3.7	29.2	29.3	28.3
Anterior	90	41.7	39.0	37.9	5.1	3.1	4.2	36.6	35.9	33.7
Middle		41.4	42.9	41.4	3.0	3.7	3.8	38.4	39.2	37.6
Posterior		35.2	38.4	37.9	4.6	6.8	5.6	30.6	31.6	32.3
Average		39.2	40.1	39.0	4.2	4.5	4.5	35.0	35.6	34.5

Table 5. Average percentages of cooking losses from strip loin roasts of three grades of beef at specified internal temperatures. This cut was cooked as a single roast.

Internal Temp. °C	Total Losses			Dripping Losses			Volatile Losses		
	Grade			Grade			Grade		
	Comm.	Good	Choice	Comm.	Good	Choice	Comm.	Good	Choice
50	4.8	4.3	4.5	2.6	2.4	2.4	2.2	1.9	2.1
60	6.8	7.1	6.9	3.1	3.1	2.9	3.7	4.0	4.0
70	10.1	10.3	9.5	4.1	4.1	3.5	6.0	6.2	6.0
80	15.2	16.0	14.0	5.9	6.5	4.9	9.3	9.5	9.1
90	24.2	28.0	23.4	8.1	11.6	9.0	16.1	16.4	14.4

Table 6. Average percentages of cooking losses from rolled rib roasts of three grades of beef at specified internal temperatures.

Portion of Rolled Rib	Internal Temp. °C	Total Losses			Dripping Losses			Volatile Losses		
		Grade			Grade			Grade		
		Comm.	Good	Choice	Comm.	Good	Choice	Comm.	Good	Choice
Anterior	50	12.2	11.6	14.3	2.0	2.1	2.7	10.2	9.5	11.6
Middle		11.0	9.8	11.0	2.1	1.7	2.1	8.9	8.1	8.9
Posterior		8.2	9.9	8.8	1.7	2.3	2.3	6.5	7.6	6.5
Average		10.4	10.4	11.3	1.9	2.0	2.3	8.5	8.4	9.0
Anterior	60	18.0	16.7	19.8	2.7	2.8	3.5	15.3	13.9	16.3
Middle		17.0	14.8	15.3	3.2	2.4	3.1	13.8	12.4	12.2
Posterior		12.3	14.8	12.5	2.5	3.8	3.2	9.8	11.0	9.3
Average		15.7	15.4	15.8	2.8	3.0	3.2	12.9	12.4	12.6
Anterior	70	26.7	25.9	28.2	3.7	3.9	5.6	23.0	22.0	22.6
Middle		25.5	23.6	23.0	5.0	4.4	5.6	20.5	19.2	17.4
Posterior		19.5	22.0	18.6	4.3	6.2	5.2	15.2	15.8	13.4
Average		23.7	23.8	23.2	4.3	4.8	5.4	19.4	19.0	17.8
Anterior	80	34.1	33.8	36.3	5.8	6.3	8.9	28.3	27.5	27.4
Middle		33.3	32.2	30.7	7.7	7.7	8.8	25.6	24.5	21.9
Posterior		27.9	29.6	27.0	6.8	9.2	9.0	21.1	20.4	18.0
Average		31.5	31.8	31.3	6.8	7.7	8.9	24.7	24.1	22.4
Anterior	90	40.4	40.7	43.8	8.4	9.2	12.5	32.0	31.5	31.3
Middle		39.4	39.5	39.0	9.9	11.5	13.3	29.5	28.0	25.7
Posterior		34.9	36.9	35.0	9.7	12.1	13.3	25.2	24.8	21.7
Average		38.0	39.0	39.2	9.4	10.9	13.0	28.6	28.1	26.2

the specified internal temperatures are shown graphically in Figures 2, 3, 4, 5, and 6.

The cuts are coded in the following manner for the graphs: sirloin butt, anterior, SBa; sirloin butt, posterior, SBp; round, anterior, Ra; round, middle, Rm; round, posterior, Rp; strip loin, SL; rolled rib, anterior, RRa; rolled rib, middle, RRm; rolled rib, posterior, RRp.

Average total cooking weight losses of the posterior round were the second lowest among the 9 cuts at internal temperatures of 50° and 60° C. However, at internal temperatures of 70°, 80°, and 90° C, the average total cooking weight losses of the posterior sirloin butt were the second lowest.

The highest total cooking weight losses of the tender cuts studied were found in the anterior portion cut of the rolled rib at 50° and 60° C internal temperatures. With progressive increase in internal temperatures, 70° , 80° , and 90° C, the center portion cut of the top round showed the highest total loss, which was significantly higher than losses of the posterior sirloin butt, posterior round, posterior rolled rib, and strip loin cuts.

The analyses of variance of total cooking weight losses at each of the internal temperatures appear in Table 7.

No significant difference in total losses attributable to grade was found. Average total cooking weight losses of sirloin butt roasts, as shown in Table 3, increased slightly with each increase in grade. The average total losses of the other cuts from the three grades showed no consistent pattern in their cooking weight losses.

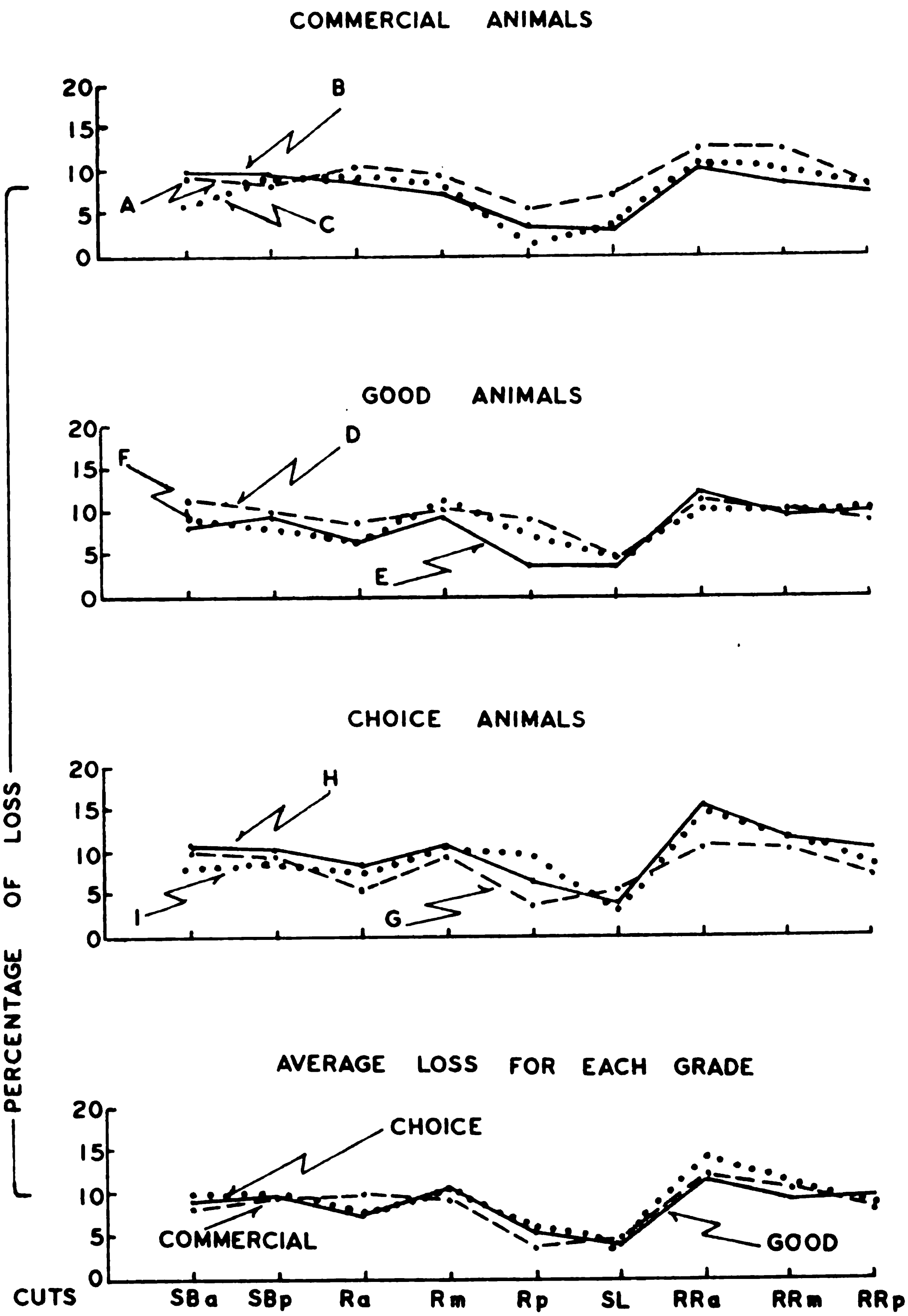

Figure 2. Total losses of beef roasts from Commercial, Good, and Choice grades at 50° C internal temperature.

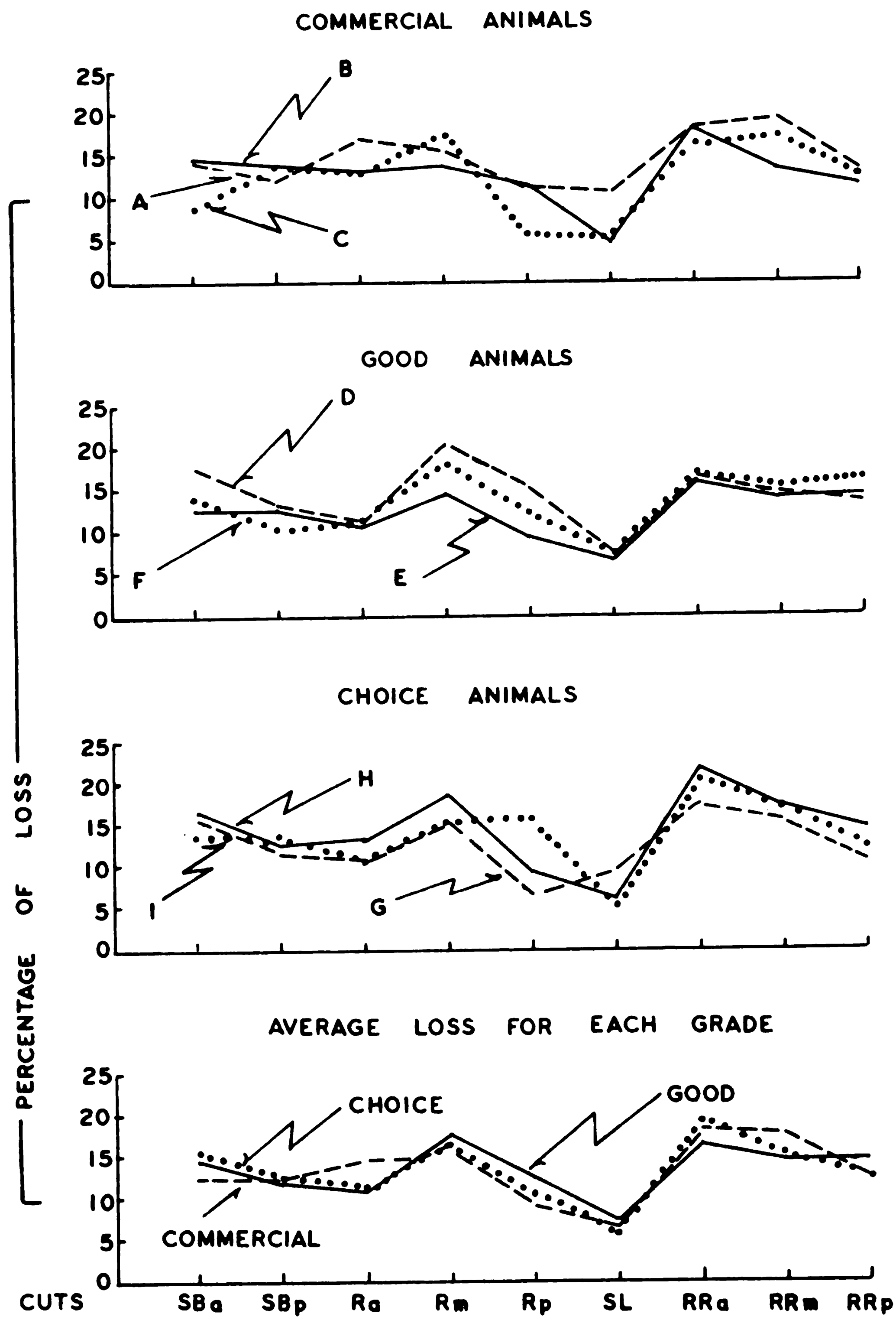

Figure 3. Total losses of beef roasts from Commercial, Good, and Choice grades at 60° C internal temperature.

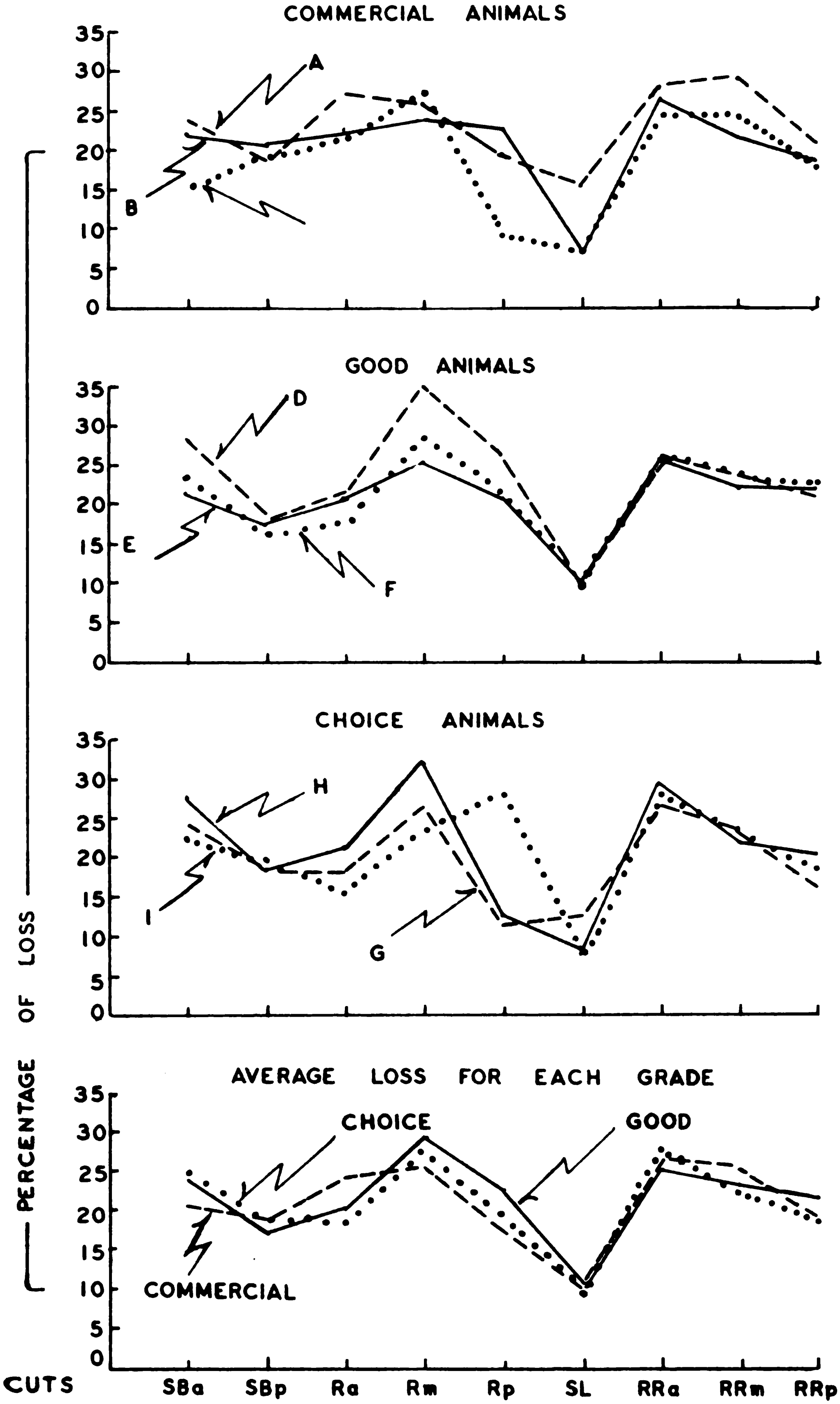

Figure 4. Total losses of beef roasts from Commercial, Good, and Choice grades at 70° C internal temperature.

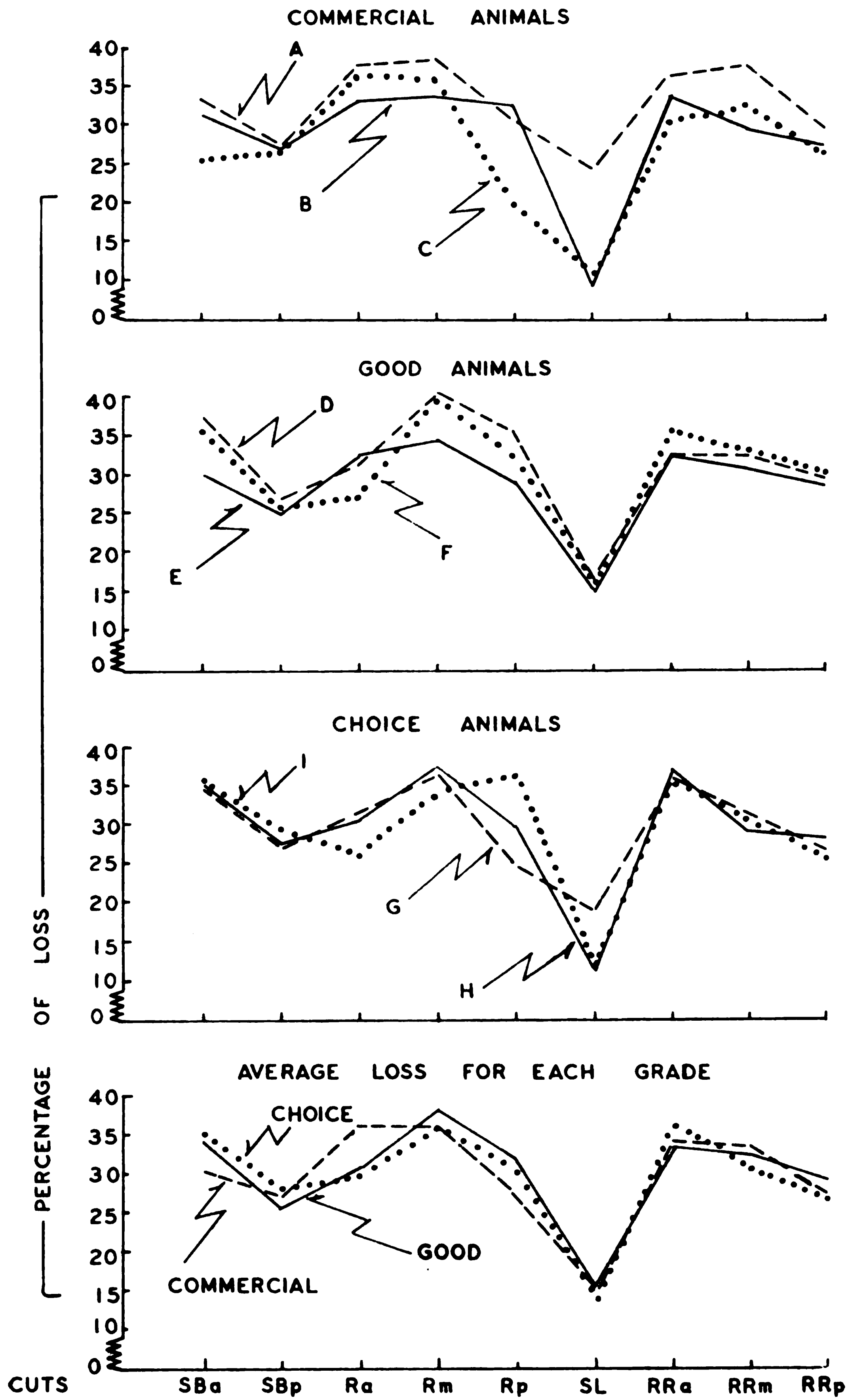

Figure 5. Total losses of beef roasts from Commercial, Good, and Choice grades at 80° C internal temperature.

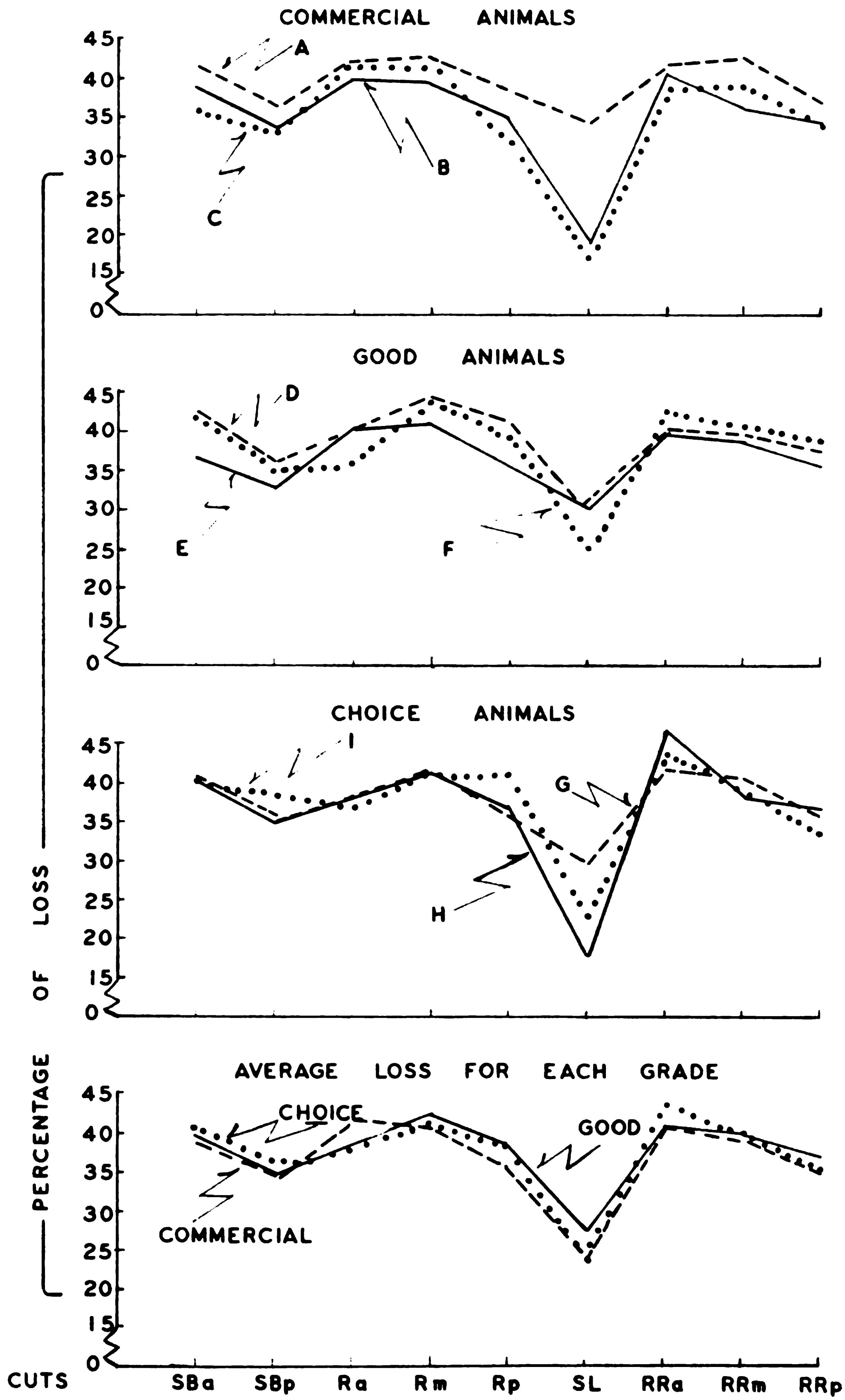

Figure 6. Total losses of beef roasts from Commerical, Good, and Choice grades at 90° C internal temperature.

Table 7. Analyses of variance of total cooking weight losses at specified internal temperatures.

Source of Variance	D.F.	M. S. Values for Specified Internal Temperatures				
		50° C	60° C	70° C	80°C	90° C
Total	80					
Grade	2	2.83	0.71	8.66	4.63	9.85
Cut	8	53.74**	100.03**	250.91**	361.41**	237.74**
Interaction (GxC)	16	3.03	4.44	11.07	14.02	6.70
Error	54	2.09	5.07	11.46	10.89	8.97

Although a number of studies (5, 3[illegible], 47, 88) have shown that cuts with higher fat content usually have greater total cooking weight losses than similar cuts with lower fat content, this relationship was not evident from the results of this experiment. However, the three half-carcasses of Commercial grade, from which the roasts for this investigation were obtained, appeared to be top Commercial grade. In addition, animals B and C of Commercial grade appeared to be of higher quality than animals E and F of Good grade when the carcasses had been cut. Animals A, B, and C were Commercial grade; animals D, E, and F were Good grade; animals G, H, and I were Choice grade.

It is generally recognized that rolled rib roasts have greater total cooking weight losses than comparable standing rib roasts (4,20).

** Significant at the 1% level of probability

Boned roasts have also been shown by investigators to lose more weight than bone-in roasts when both are cooked under the same conditions (56).

In general, as shown in Tables 4 and 6, the rolled rib cuts had higher average total cooking weight losses than the round cuts at the lower internal temperatures of 50° , 60° , and 70° C; but at 80° and 90° C internal temperatures, the round cuts had higher losses than the rolled rib cuts. This may be attributed to the presence of certain muscles in the round which appeared to conduct heat very slowly, after the roasts reached 70° C internal temperature. For many of the round cuts, the cooking time for the 10 degree rise between 70° and 80° C was as long as 3 hours; the internal temperature remained at 70° C for one-half hour in a few of the roasts from the top round. For the 10 degree rise between 80° and 90° C, the cooking period for the round cuts averaged approximately 3 hours. Such lengthy cooking periods resulted in extremely heavy cooking losses in these cuts.

The average total cooking weight losses for sirloin butts of Commercial grade varied from 12.7 per cent at 60° C internal temperature (rare) to 28.6 per cent at 80° C (well done). There was an increase of 7.8 per cent in total losses for the cooking time of these roasts between 80° C and 90° C internal temperature. The average total cooking weight losses for sirloin butts of Good grade varied from 13.5 per cent at 60° C to 30.1 per cent at 80° C; there was an increase of 7.1 per cent for the additional 10 degree rise to 90° C. The average total cooking weight losses for sirloin butts of Choice grade varied from 13.8 per cent at 60° C to 31.7 per cent at 80° C; an additional

6.5 per cent loss was noted for the 10 degree rise from 80° C to 90° C internal temperature.

For top round roasts of Commercial, Good, and Choice grades, the average total cooking weight losses were 13.3 per cent, 13.7 per cent, and 12.8 per cent, respectively, at 60° C internal temperature; average losses at 80° C for the same grades were 33.0 per cent, 33.6 per cent, and 32.0 per cent. The increased losses noted for the additional 10 degree rise from 80° to 90° C for Commercial, Good, and Choice grades were 6.2 per cent, 6.5 per cent, and 7 per cent, respectively.

The average total cooking weight losses of strip loin of Commercial grade varied from 6.8 per cent at 60° C to 15.2 per cent at 80° C; there was an increase of 9 per cent for the cuts to reach 90° C internal temperature from 80° C. For comparable cuts of Good grade, the average total cooking weight losses varied from 7.1 per cent at 60° C to 16.0 per cent at 80°C; there was an increase of 12 per cent for the final 10 degree rise. For strip loins of Choice grade, the average total losses varied from 6.9 per cent at 60° C to 14.0 per cent at 80° C; an increase of 9.4 per cent was observed for the last 10 degree rise.

The average total cooking weight losses of rolled rib roasts for Commercial, Good, and Choice grades at 60° C internal temperature were 15.7 per cent, 15.4 per cent, and 15.8 per cent, respectively; at 80° C the total losses were 31.5 per cent, 31.8 per cent, and 31.3 per cent, respectively. The increased losses attributable to the 10 degree rise between 80° and 90° C were for Commercial, Good, and Choice grades 6.5 per cent, 7.2 per cent, and 7.9 per cent, respectively.

No significant difference in total cooking weight losses attributable to animal variations was found.

Dripping losses

The average percentage dripping losses of sirloin butt, top round, strip loin, and rolled rib roasts at the different internal temperatures are listed in Tables 3, 4, 5, and 6, respectively. Dripping losses for each of the cuts from the three grades may be found in the Appendix. There were significant differences in dripping losses attributable to cuts at each of the internal temperatures studied; but the differences in dripping losses attributable to grade were significant only at 90° C internal temperature. Table 8 shows the analyses of variance of dripping losses at 50°, 60°, 70°, 80°, and 90° C.

Table 8. Analyses of variance of dripping losses at specified internal temperatures.

Source of Variance	D.F.	M. S. Values for Specified Internal Temperatures				
		50° C	60° C	70° C	80° C	90° C
Total	80					
Grade	2	0.14	0.17	2.34	4.57	17.89*
Cut	8	1.99**	3.55**	9.38**	31.59**	83.70**
Interaction (G x C)	16	0.31	0.75	2.10	3.03	4.30
Error	54	0.39	0.86	1.52	2.79	3.64

*Significant at the 5% level of probability
**Significant at the 1% level of probability

Analysis of variance showed the average dripping losses at 90° C internal temperature for Good and Choice grades to be significantly higher than those for Commercial grade. There was no significant difference between the average dripping losses of Choice and Good roasts cooked to 90° C internal temperature.

Total round roasts, including anterior, center, and posterior cuts, showed the lowest average dripping losses of the cuts studied. At 50° and 60° C internal temperatures, the lowest dripping loss was found in the anterior round; at 70°, 80°, and 90° C, the lowest dripping loss was found in the center portion of the top round.

The anterior portion of the sirloin butt showed the highest dripping losses of all the cuts at 50°, 60°, and 70° C, but the posterior rib roasts had the highest average dripping losses at 80° and 90° C internal temperatures. The next highest dripping losses were found in the strip loin at 50° C, in the posterior rolled rib at 60° and 70° C, and in the center rolled rib cuts at 80° and 90° C. The dripping losses of the cuts are illustrated graphically in Figures 7 and 8.

These results indicate that the cuts with increased fat content generally had higher dripping losses than cuts with decreased fat content. Mention should be made of the strip loin cuts, which had the greatest amount of external fat among the cuts used in this study. Because of the very short cooking period required for the strip loin roasts, they did not show an extremely high dripping loss even though these cuts had a heavy fat covering. Explanation of the comparatively short cooking time required for the strip loins was given previously in the discussion.

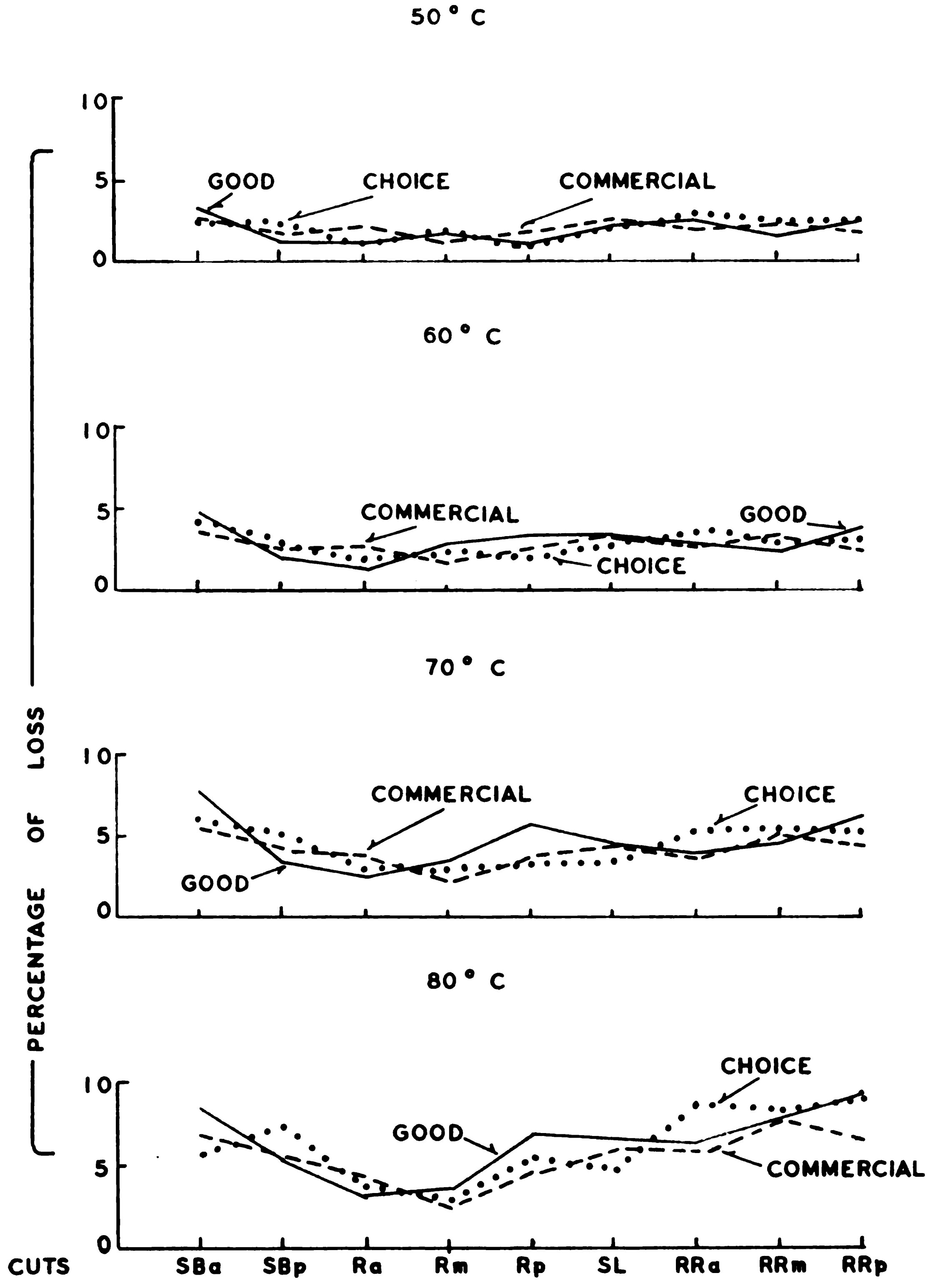

Figure 7. Dripping losses of beef roasts from Commercial, Good, and Choice grades at 50°, 60°, 70°, and 80° C internal temperatures.

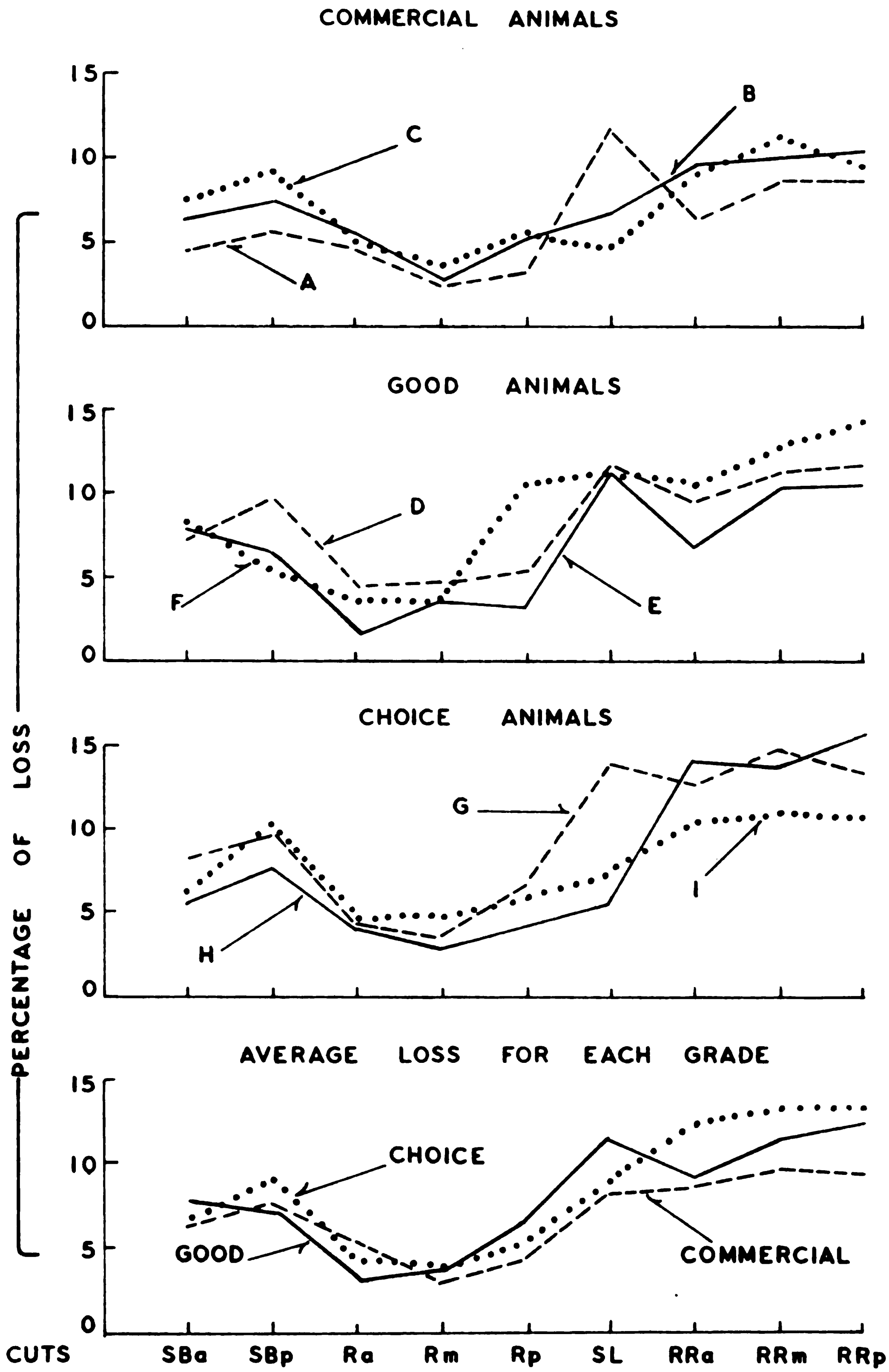

Figure 8. Dripping losses of beef roasts from Commercial, Good, and Choice grades at 90° C internal temperature.

Volatile losses

The average percentage volatile losses for the roasts from the three grades at each of the internal temperatures are listed in Tables 3, 4, 5, and 6. The volatile losses for each of the cuts from the three grades may be found in the Appendix. There was no significant difference in volatile losses attributable to grade, but there were highly significant differences attributable to cuts at each of the internal temperatures studied.

The strip loin showed the lowest volatile loss and was significantly lower than any of the other cuts. Volatile loss of posterior round was the next lowest at 50° and 60° C, that of posterior sirloin butt at 70° C, and volatile loss of posterior rolled rib at 80° and 90° C.

The anterior portion of the rolled rib had the highest volatile loss of all the cuts at 50° and 60° C; the center portion of the top round had the highest volatile loss at 70°, 80°, and 90° C. The next highest volatile loss was found in the center rolled rib at 50° C, in the center round at 60° C, in the anterior rolled rib at 70° C, and in the anterior round at 80° and 90° C internal temperatures. The average volatile losses of the cuts for each grade at 50°, 60°, 70°, and 80° C are shown graphically in Figure 9. The volatile losses of each cut for the three grades and the average volatile losses of each cut for each of the three grades at 90° C are shown in Figure 10.

These results indicate that comparable cuts in this study showed similar trends in their total cooking weight and volatile

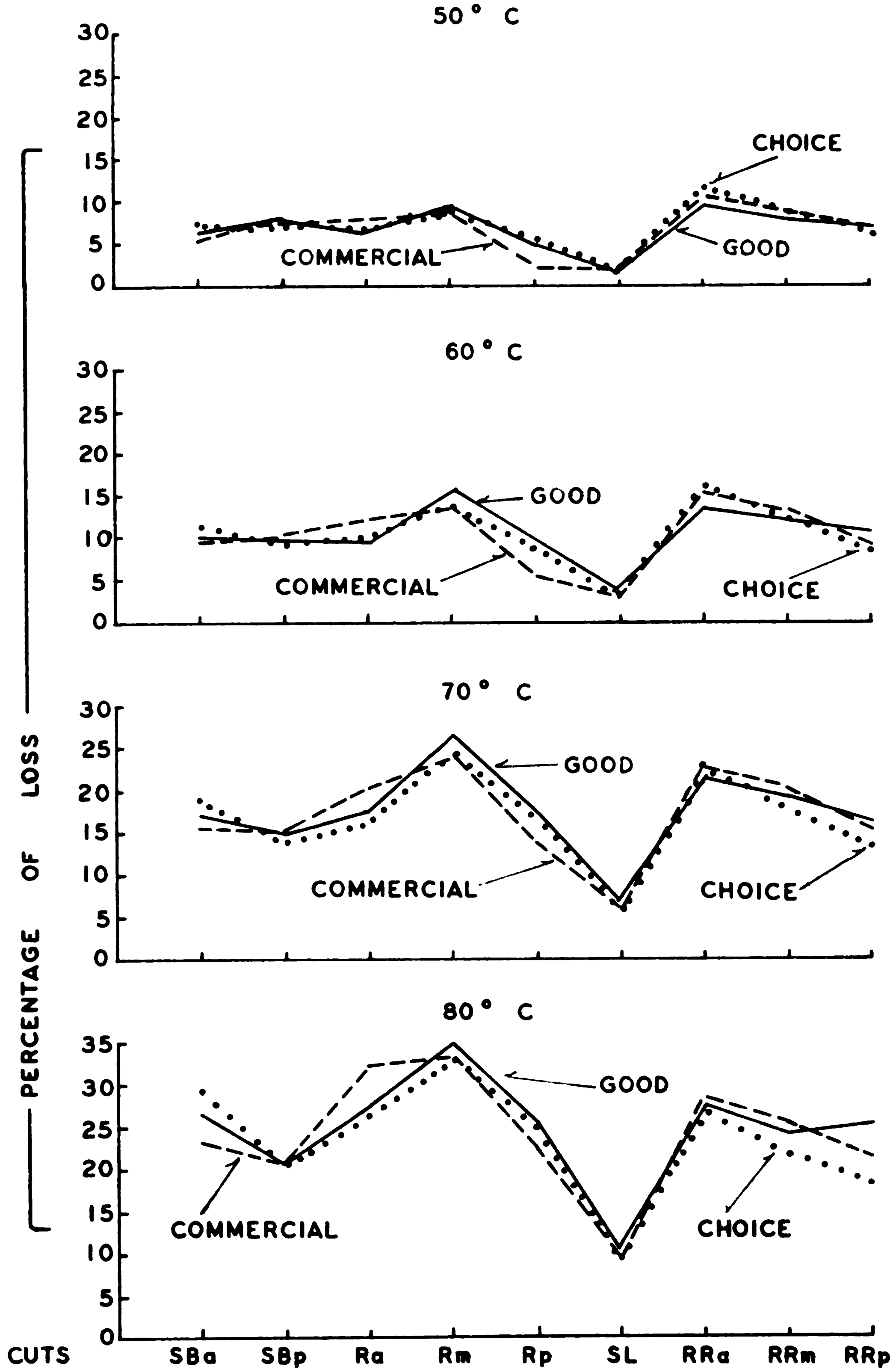

Figure 9. Volatile losses of beef roasts from Commercial, Good, and Choice grades at 50°, 60°, 70°, and 80° C internal temperatures.

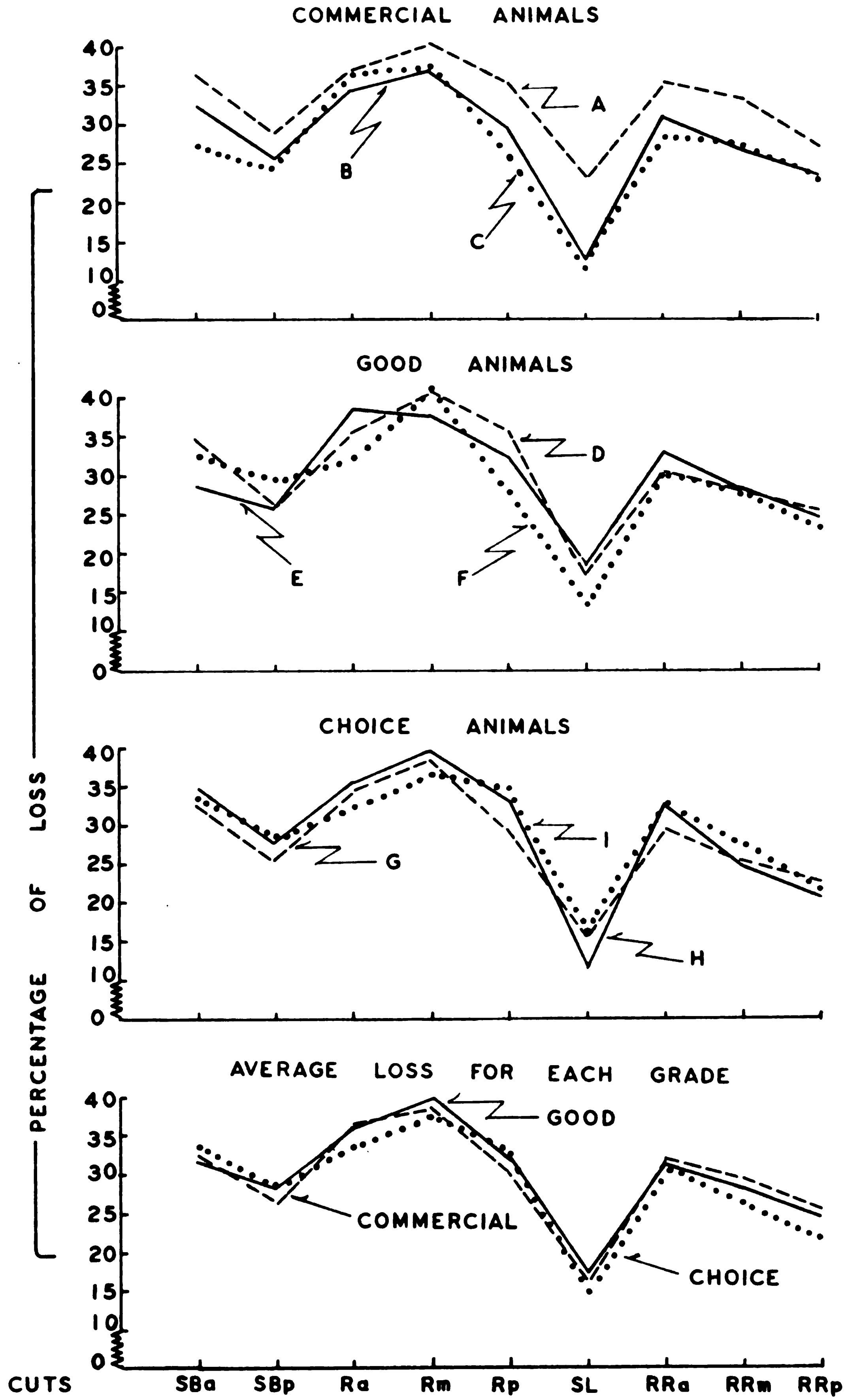

Figure 10. Volatile losses of beef roasts from Commercial, Good, and Choice grades at 90° C internal temperature.

losses. The analyses of variance of volatile losses at the different internal temperatures are shown in Table 9.

Table 9. Analyses of variance of volatile losses at specified internal temperatures.

		M. S. Values for Specified Internal Temperatures				
Source of Variance	D.F.	50° C	60° C	70° C	80° C	90° C
Total	80					
Grade	2	1.97	0.24	5.37	2.48	8.61
Cut	8	54.93**	101.23**	256.52**	428.93**	365.82**
Interaction (G x C)	16	2.26	2.93	5.86	9.55	25.82**
Error	54	1.33	2.65	8.82	10.28	7.81

The analyses of variance of the volatile losses showed interaction between grade and cut only at 90° C internal temperature. This might be attributed to the extremely long cooking period required for some of the roasts to reach 90° C internal temperature; this was noted particularly for the cuts from the top round and the rolled rib.

Palatability Factors

Since the principle objective of this study was concerned with following the subsequent cooking loss-s of each cut through the specified series of internal temperatures, results of the palatability scoring were obtained only for cuts cooked to 90° C internal temperature. Overcooking of roast meats is a real problem in quantity preparation, and it was thought that judging samples from roasts cooked to 90° C internal temperature might furnish data which would show whether similar cuts of different grades were affected in the same way by overoooking.

** Significant at the 1% level of probability.

Aroma and flavor

Table 10 lists the average aroma and flavor scores of all cuts from the three grades cooked to 90° C internal temperature. The average aroma and flavor scores of roasts from Commercial grade were significantly higher than those from roasts of Good and Choice grades. The aroma and flavor averages of the samples from Good and Choice grades were not significantly different.

The investigator observed strong, pungent odors in a few of the roasts during the cooking periods between 70° and 80° C and between 80° and 90° C. This strong aroma was attributed to the breakdown of the fats in the drippings. According to the judges' descriptive terms for aroma, there was no correlation between the odor of the cooked meat samples and the strong odors of the same roasts during cooking. The taste panel members usually described the aroma as mild or faint for samples from roasts which had strong odors during cooking.

The analyses of variance of aroma and flavor scores appear in Table 11.

The analyses of variance of aroma scores showed a significant difference attributable to grade but no significant difference attributable to cut. There were significant differences in flavor scores attributable to both grade and cut.

The strip loin had significantly higher flavor averages than any of the other cuts. The anterior portion of the top round had the next highest flavor average but was significantly higher only

Table 10. **Average aroma, flavor, and juiciness scores of Commercial, Good, and Choice cuts cooked to 90° C internal temperature.**

Cut	Average Aroma Scores			Average Flavor Scores			Average Juiciness Scores		
	Grade			Grade			Grade		
	Comm.	Good	Choice	Comm.	Good	Choice	Comm.	Good	Choice
Sirloin butt, anterior	5.7	4.9	5.2	4.7	3.9	4.1	3.8	3.2	3.0
Sirloin butt, posterior	5.1	4.9	5.1	4.6	4.7	4.0	4.2	4.9	3.5
Average	5.4	4.9	5.2	4.7	4.3	4.1	4.0	4.1	3.3
Top round, anterior	5.6	5.0	4.8	4.6	5.1	4.6	4.2	4.9	4.4
Top round, middle	5.5	4.6	4.2	5.3	3.4	3.5	4.0	2.5	2.8
Top round, posterior	5.9	4.7	4.4	4.9	4.0	4.5	4.0	3.4	3.9
Average	5.7	4.8	4.5	5.0	4.1	4.2	4.1	3.6	3.7
Strip loin	5.4	4.9	5.4	6.6	4.8	6.0	6.5	5.0	5.4
Rolled rib, anterior	5.4	5.2	5.0	4.1	3.9	3.6	3.4	3.5	3.1
Rolled rib, middle	5.7	4.7	4.1	4.6	4.2	4.1	3.3	3.1	3.3
Rolled rib, posterior	6.3	5.1	5.5	5.3	4.1	4.6	3.5	3.7	4.0
Average	5.8	5.0	4.9	4.6	4.0	4.1	3.4	3.5	3.5

Table 11. Analyses of variance of aroma and flavor scores.

Source of Variance	D. F.	M. S. Values	
		Aroma	Flavor
Total	80		
Grade	2	4.92**	4.32**
Cut	8	0.59	2.88**
Interaction (G x C)	16	0.33	0.62
Error	54	0.44	0.81

when compared with the anterior portion of the rolled rib roast which had the lowest flavor score of all the cuts. The flavor of many samples from top round, sirloin butt, and rolled rib roasts was described by the judges as slightly acid, rancid, bitter, old, and mild but peculiar. The fairly low flavor scores for all samples of all grades of these cuts were attributed to undersirable changes which occurred during the long cooking period required for roasts from top round, sirloin butt, and rolled rib to reach 90° C internal temperature. The average aroma and flavor scores of the cuts from the three grades are shown graphically in Figure 11.

Juiciness

The average juiciness scores are listed in Table 10 and are illustrated graphically in Figure 11. The analysis of variance of juiciness scores, Table 12, showed no significant difference attributable to grade but a highly significant difference attributable to cut.

** Significant at the 1% level of probability.

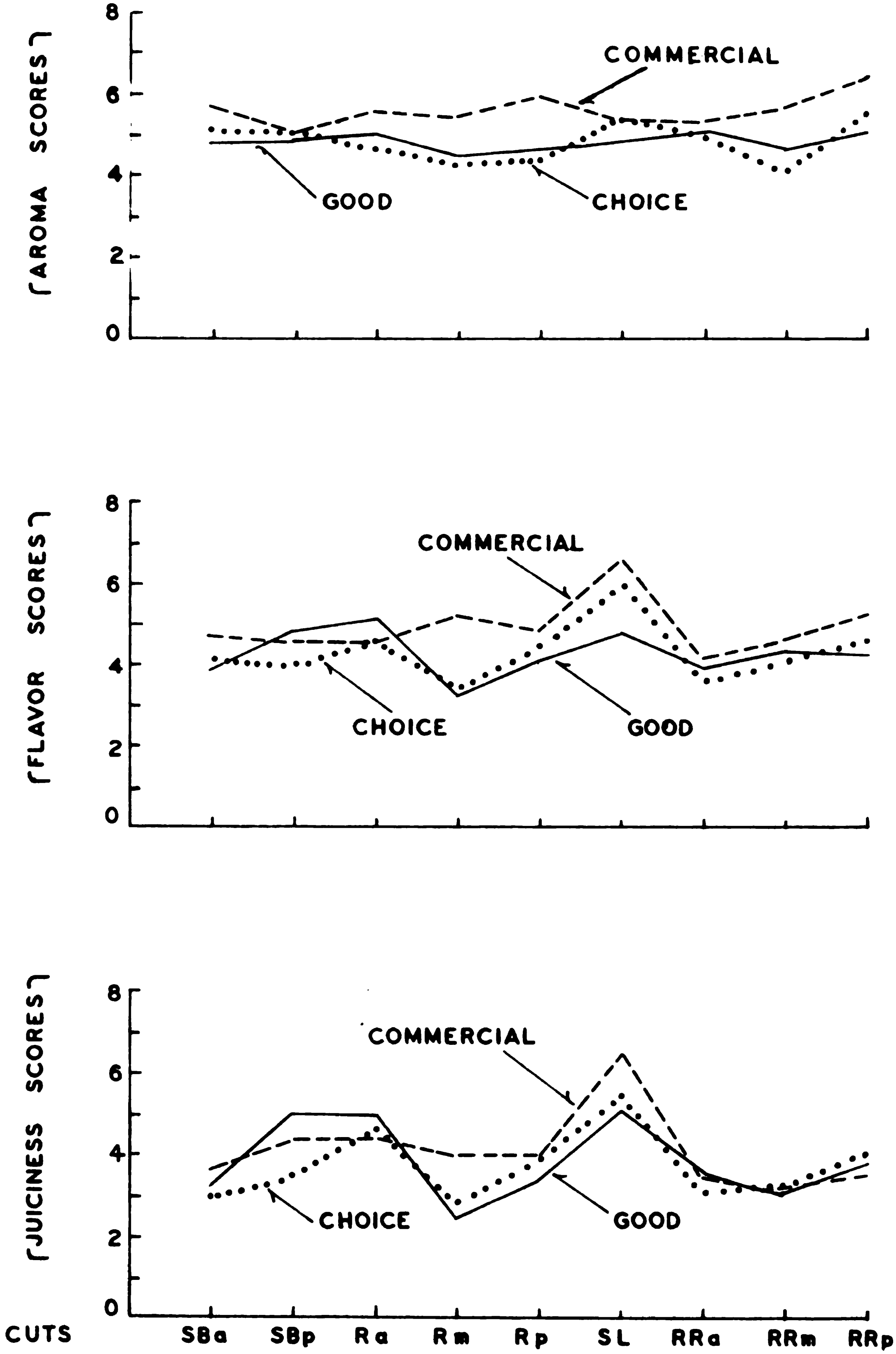

Figure 11. Average aroma, flavor, and juiciness scores of beef roasts from Commercial, Good, and Choice Grades cooked to 90° C internal temperature.

Table 12. Analysis of variance of juiciness scores.

Source of Variance	D. F.	M. S.
Total	80	
Grade	2	1.11
Cut	8	5.78**
Interaction (G x C)	16	0.70
Error	54	0.85

Results of other studies (26, 65, 70) have shown that extended cooking decreases the juiciness of meat. The average scores for juiciness indicated that a similar conclusion could be made from the results of this investigation. The judges consistently rated the strip loin highest in juiciness of all the cuts. Analysis of the data also showed the strip loin to be significantly higher in juiciness than any of the other cuts. The center round showed the lowest average score for juiciness of all the cuts. Although no statistical correlation was calculated, there was a trend suggesting a probable negative correlation between the average juiciness scores of the taste panel and the total cooking weight losses in this study.

Appearance and texture

The average scores for appearance and texture of the cuts cooked to 90° C are listed in Table 13. There were significant differences in appearance scores attributable to both grade and cut. The analysis of data showed a significant difference in texture scores

**Significant at the 1% level of probability.

Table 13. Average appearance and texture scores of Commercial, Good, and Choice cuts cooked to 90° C internal temperature.

Cut	Average Appearance Scores			Average Texture Scores		
	Grade			Grade		
	Comm.	Good	Choice	Comm.	Good	Choice
Sirloin butt, anterior	5.0	4.6	3.7	5.0	5.2	4.7
Sirloin butt, posterior	4.1	5.4	3.3	4.9	5.5	4.7
Average	4.5	5.0	3.5	4.9	5.4	4.7
Top round, anterior	4.4	5.6	4.9	4.8	5.7	5.7
Top round, middle	5.0	3.8	3.5	5.2	4.0	4.1
Top round, posterior	5.2	4.9	4.5	5.9	4.8	5.6
Average	4.9	4.8	4.3	5.3	4.8	5.1
Strip loin	5.9	5.2	5.2	6.1	5.8	5.7
Rolled rib, anterior	3.7	3.9	3.1	4.3	4.4	4.3
Rolled rib, middle	4.4	4.0	3.3	4.4	4.6	4.2
Rolled rib, posterior	4.5	4.8	4.2	5.0	5.1	5.7
Average	4.2	4.2	3.5	4.6	4.7	4.7

attributable to cut but no significant difference attributable to grade. The analyses of variance of appearance and texture scores appear in Table 14.

Table 14. Analyses of variance of appearance and texture scores.

Source of Variance	D. F.	M. S. Values	
		Appearance	Texture
Total	80		
Grade	2	4.65**	0.08
Cut	8	2.96**	2.54**
Interaction (G x C)	16	0.72	0.57
Error	54	0.70	0.63

The average appearance scores for samples from Commercial and Good grade roasts were significantly higher than scores for samples from comparable cuts of Choice grade roasts. There was no significant difference between the appearance averages of samples from Commercial and Good grade roasts.

Samples from the strip loin were scored highest in appearance, and the averages were significantly higher than those of samples from the sirloin butts, center portion of the top round, and the rolled rib roasts. The anterior portion of the rolled rib roasts showed the lowest score for appearance of all the cuts. In general, the judges scored samples from the rolled rib roasts, including anterior, center, and posterior cuts, lower in appearance than the other cuts. Because of the long cooking period necessary for this

**Significant at the 1% level of probability.

blocky cut, the rolled rib roasts shrank greatly in size; they also appeared charred and hard on the external surface. The surface fat from the roasts had melted until only a thin layer of charred fat was visible on the outside of the roasts. These dry roasts were very difficult to slice; therefore, the majority of the samples from the rib roasts were crumbly. Many of the samples from the top round, sirloin butt, and rolled rib roasts were described as iridescent in appearance by the judges.

The taste panel members scored the strip loin highest in texture of all the cuts. The analysis of data of texture scores showed the strip loin to have significantly higher texture averages than the anterior and posterior sirloin butts, center round, and anterior and center rolled rib cuts. The anterior portion of the rolled rib roasts showed the lowest texture average and was significantly lower than posterior rolled rib, strip loin, and anterior and posterior round cuts. Graphic illustrations of the appearance and texture scores of the roasts from the three grades are presented in Figure 12.

Rib roasts are considered to have finer texture than roasts from rounds (77). In this study, because of the extremely long cooking periods involved, this finding was not observed. The texture of the majority of the samples from the rolled rib roasts was described with such terms as crumbly, powdery, and separation of fiber. This powdery quality and separation of fiber were also noted in roasts from the top round but apparently not to the same extent as in the rib roasts.

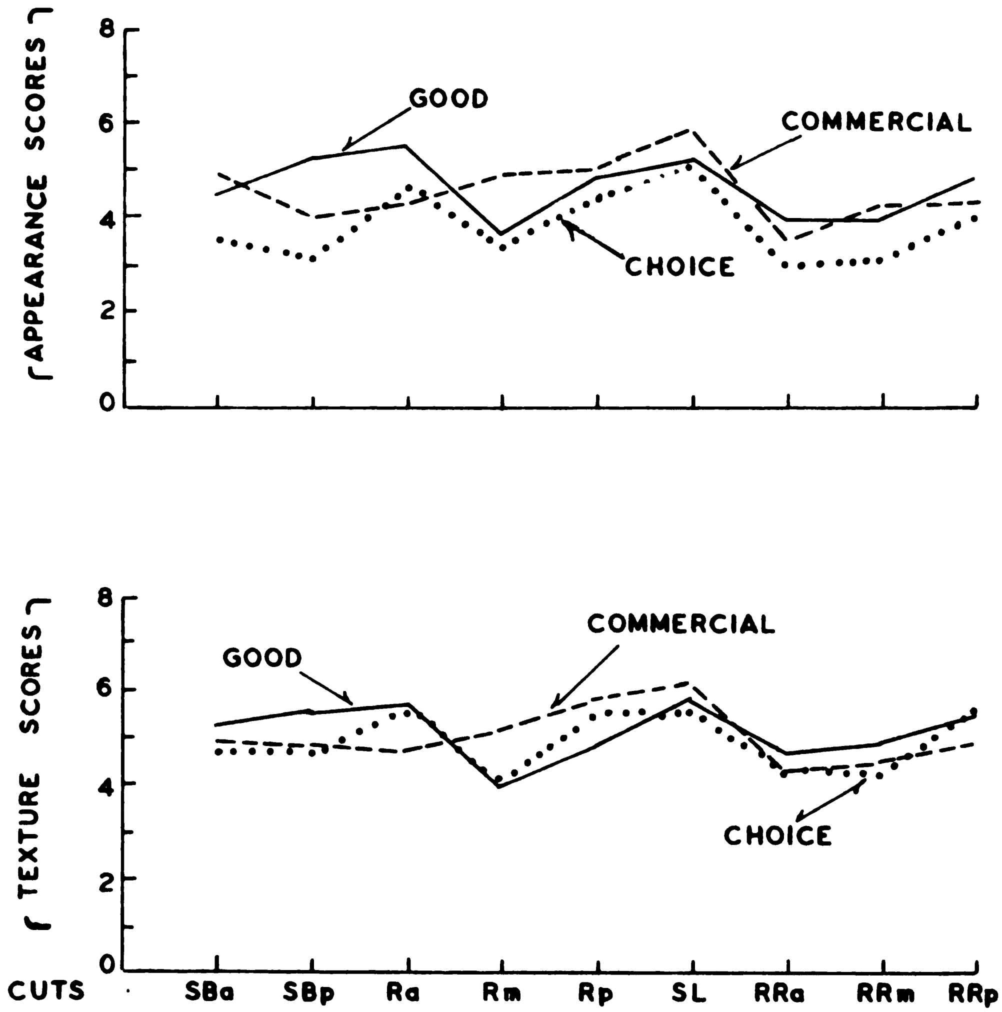

Figure 12. Average appearance and texture scores of beef roasts from Commercial, Good, and Choice grades cooked to 90° C internal temperature.

Tenderness and shear force

The tenderness of cooked meat has been studied by many investigators. According to a number of findings (1, 70), the tenderness of cooked meat is increased with extended cooking. Since the palatability scoring in this experiment concerned roasts cooked to 90° C internal temperature, tenderness might be expected to score higher than that reported in many meat cookery studies. The results of this experiment showed that tenderness scored higher than any of the other palatability factors. The average scores for tenderenss and shear force readings are listed in Table 15.

The average tenderness scores for samples from Choice grade roasts were significantly higher than those from Commercial and Good grade roasts. No significant difference in tenderness was found between the average scores of samples from Commercial and Good grade roasts.

The analysis of data of shear force readings also showed the cuts from Choice grade to be significantly more tender than those from Commercial and Good grades. The shear force averages of samples from Choice grade roasts were significantly lower than those from samples of Commercial and Good grade roasts. No significant difference was found between the average shear force readings for samples from Commercial and Good grades. The analyses of variance of tenderness scores and shear force readings appear in Table 16.

The analyses of tenderness scores and shear force readings also revealed significant differences attributable to cuts. The

Table 15. Average tenderness scores and shear force readings of Commercial, Good, and Choice cuts cooked to 90° C internal temperature.

Cut	Average Tenderness Scores			Average Shear Force Readings		
	Grade			Grade		
	Comm.	Good	Choice	Comm.	Good	Choice
Sirloin butt, anterior	5.5	5.5	7.1	16.1	15.4	10.2
Sirloin butt, posterior	6.6	6.4	7.6	10.0	10.2	9.0
Average	6.0	6.0	7.3	13.1	12.8	9.6
Top round, anterior	5.6	7.0	7.5	14.4	12.5	10.7
Top round, middle	5.7	5.2	5.6	14.7	18.3	14.9
Top round, posterior	6.7	4.9	7.9	11.0	13.2	9.7
Average	6.0	5.7	7.0	13.4	14.7	11.8
Strip loin	5.9	6.6	7.6	13.7	12.2	8.7
Rolled rib, anterior	7.0	6.9	7.2	10.2	12.5	10.2
Rolled rib, middle	6.5	6.1	7.1	12.7	11.3	8.5
Rolled rib, posterior	7.3	6.7	7.8	10.3	10.7	7.1
Average	7.0	6.6	7.3	11.0	11.5	8.6

Table 16. Analyses of variance of tenderness scores and shear force readings.

Source of Variance	D. F.	M. S. Values	
		Tenderness	Shear Force
Total	80		
Grade	2	9.63**	73.22**
Cut	8	2.55*	39.27**
Interaction (G x C)	16	0.98	5.15
Error	54	1.15	11.30

center cut of the top round averaged highest in shear force and was significantly higher than any of the other cuts. The average tenderness score of the center cut of the top round was significantly lower than any of the other cuts with the exception of anterior sirloin butt and posterior round. The shear force averages of samples from the posterior rib roast were the lowest among the 9 cuts. The average tenderness score of the posterior cut of the rolled rib was the highest but was significantly higher only when compared with the anterior sirloin butt and center round. The results indicated a probable high negative correlation between the tenderness scores of the judges and the shear force tests. The tenderness and shear force averages are shown graphically in Figure 13.

Edible Portion Cost

Although the cost per pound of raw meats is important to the food service operator, the edible portion cost of cooked meats is a more

* Significant at the 5% level of probability.
** Significant at the 1% level of probability.

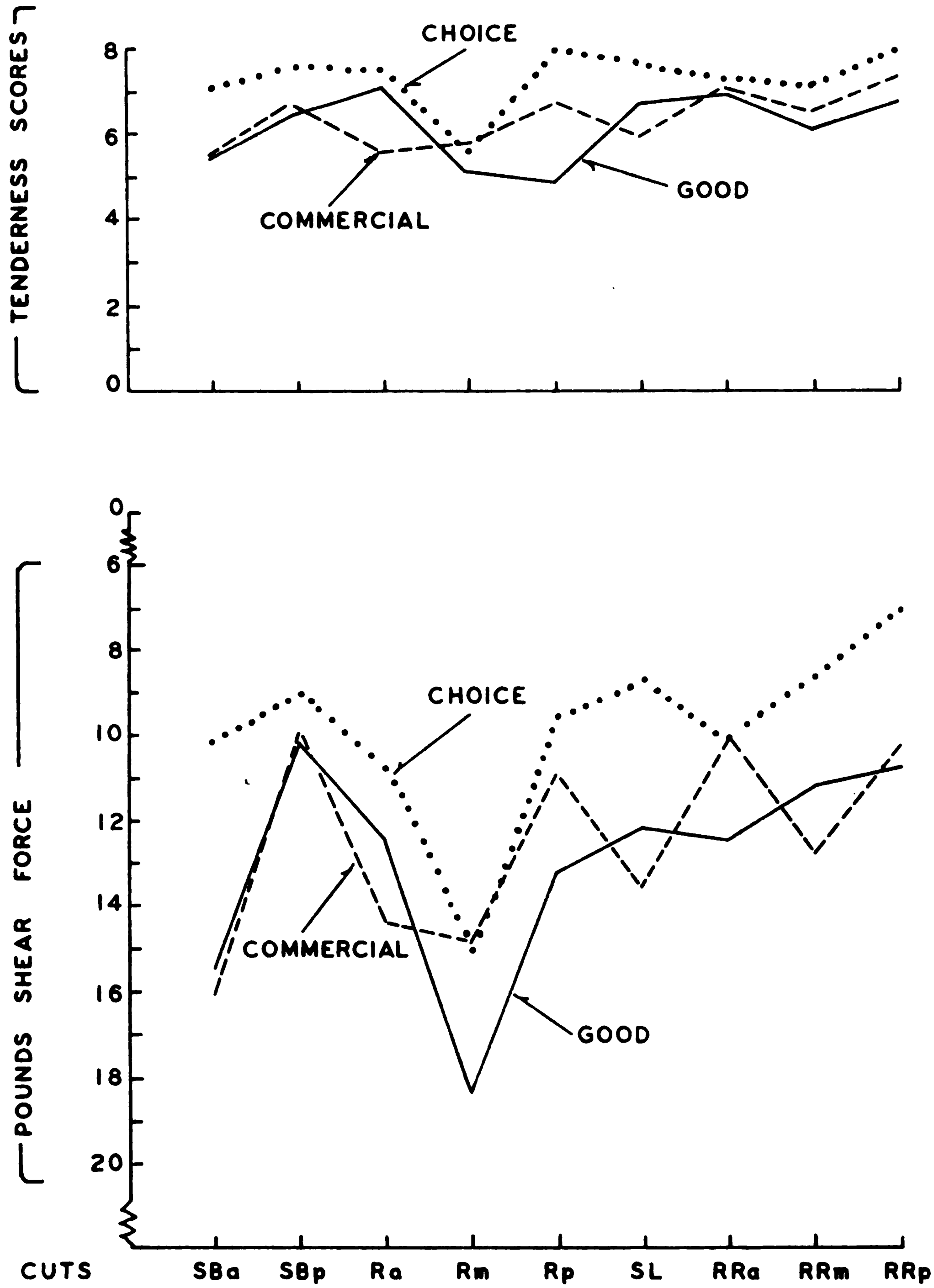

Figure 13. Average tenderness scores and shear force readings of beef roasts from Commercial, Good, and Choice grades cooked to 90° C internal temperature.

reliable basis for cost control. Many meat cookery studies include fuel costs in the actual portion cost of cooked meats. However, in this experiment, the edible portion costs are based only on the total cooking weight losses at the different internal temperatures and the costs per pound of oven-ready cuts. The average costs per pound of uncooked roasts were \$ 0.5508, \$ 0.6599, and \$ 0.7161, for Commercial, Good, and Choice grades, respectively.

The methods for computing the cost per pound and also the actual portion cost of cooked meats have been presented previously in the Method of Procedure.

Because the total cooking weight losses increased with each rise in internal temperature of the meat, the cost per pound of cooked meat would be expected to increase accordingly. The costs per pound of cooked Commercial, Good, and Choice beef cuts at internal temperatures of 50°, 60°, 70°, 80°, and 90° C appear in Table 17 and are shown graphically in Figure 14. The increased costs which were found with rise in the internal temperature of the meat, particularly from the well done stage to 90° C, emphasize the importance of the extent of cooking meats in relation to food budget control.

Anterior sirloin butt roasts of Commercial grade showed an increase of \$ 0.11 per pound from the well done stage to 90° C internal temperature; there was an increase of \$ 0.09 per pound for similar cuts of Good grade and \$ 0.08 for cuts of Choice grade. An increase of \$ 0.08 per pound was noted in the posterior sirloin butt roasts of Commercial grade, \$0.12 in comparable roasts of Good grade, and \$ 0.12

Table 17. Cost per pound of cooked Commercial, Good, and Choice beef cuts at internal temperatures of 50°, 60°, 70°, 80°, and 90° C.

	50° C	60° C	70° C	80° C	90° C
Sir.butt, anterior					
Comm.	$ 0.6027	$ 0.6324	$ 0.6949	$ 0.7917	$ 0.9018
Good	.7276	.7719	.8699	1.0009	1.0930
Choice	.7930	.8439	.9514	1.1063	1.1943
Sir.butt,posterior					
Comm.	.6074	.6323	.6850	.7577	.8380
Good	.7244	.7495	.7985	.8895	1.0058
Choice	.7898	.8160	.8844	.9954	1.1241
Top round,anterior					
Comm.	.6104	.6455	.7257	.8264	.9424
Good	.7125	.7428	.8298	.9537	1.0841
Choice	.7745	.8095	.8814	1.0227	1.1530
Top round,middle					
Comm.	.6061	.6517	.7425	.8605	.9391
Good	.7368	.8034	.9392	1.0668	1.1570
Choice	.7986	.8552	.9832	1.1202	1.2228
Top round,posterior					
Comm.	.5724	.6097	.6679	.7594	.8484
Good	.7083	.7546	.8565	.9760	1.0726
Choice	.7695	.8026	.891[illegible]	1.0292	1.1553
Strip Loin					
Comm.	.5789	.5908	.6127	.6495	.7267
Good	.6903	.7116	.7368	.7870	.9178
Choice	.7504	.7695	.7915	.8328	.9346
Rolled rib,anterior					
Comm.	.6265	.6711	.7504	.8338	.9218
Good	.7463	.7923	.8930	1.0002	1.1159
Choice	.8352	.8930	.9969	1.1245	1.2740
Rolled rib,middle					
Comm.	.6177	.6625	.7383	.8238	.9075
Good	.7316	.7750	.8647	.9742	1.0910
Choice	.8047	.8450	.9296	1.0330	1.1739
Rolled rib,posterior					
Comm.	.5996	.6276	.6833	.7627	.8458
Good	.7329	.7748	.8452	.9377	1.0458
Choice	.7855	.8179	.8800	.9815	1.1020

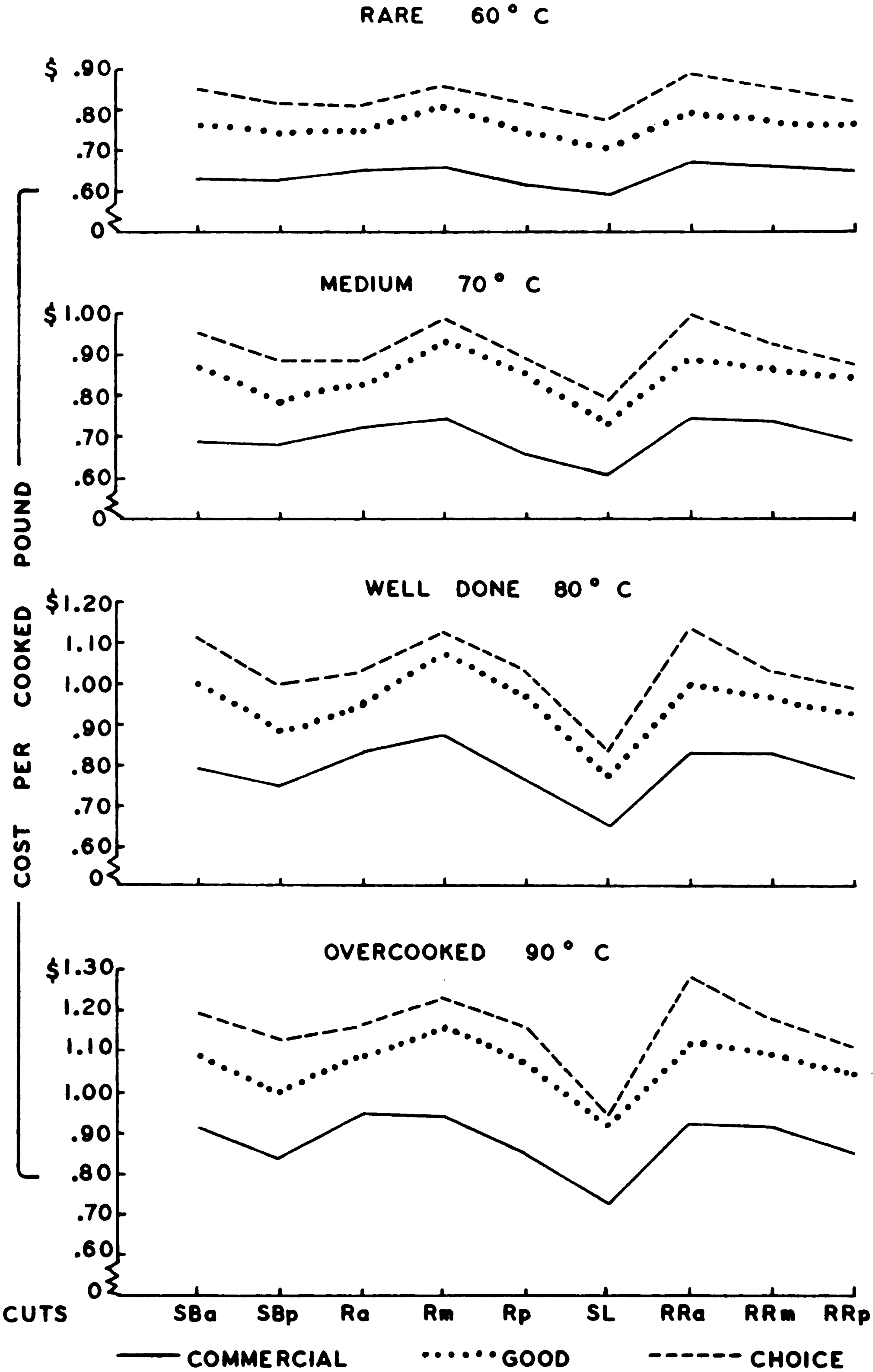

Figure 14. Cost per pound of cooked Commercial, Good, and Choice beef cuts at 60°, 70°, 80°, and 90° C internal temperatures. Costs per pound of raw meat were $0.5508 for Commercial, $0.6599 for Good, and $0.7161 for Choice.

in roasts of Choice grade. The costs per pound of cooked posterior sirloin butt were lower than those of cooked anterior sirloin butt for all three grades.

For the additional cooking period from 80° to 90° C internal temperature, the anterior portion of the top round showed increases of \$ 0.08, \$ 0.13, and \$ 0.13 per pound for Commercial, Good, and Choice grades, respectively. The increases in cost per pound of center round were \$ 0.08, \$ 0.09, and \$ 0.10 for Commercial, Good, and Choice grades, respectively; for the posterior sirloin butt of Commercial, Good, and Choice grades, the increases were \$ 0.09, \$0.09, and \$ 0.13, respectively. The costs per pound of the cooked center round cut were higher than those of anterior and posterior round cuts from Good and Choice grades. The costs per pound of cooked anterior and center round cuts from Commercial grade were approximately the same at 80° C internal temperature; the costs of these two cuts were also comparable at 90° C internal temperature.

An increase of \$ 0.08 per pound was noted in the cost of strip loin from Commercial grade during the cooking interval between 80° C and 90° C. Increases of \$ 0.13 and \$ 0.10 per pound were found for the strip loins of Good and Choice grades during the final 10 degree temperature rise.

The anterior portion of the rolled rib roasts of Commercial, Good, and Choice grades showed increases of \$ 0.09, \$ 0.12, and \$ 0.15 per pound, respectively, for the cooking period between 80° C and 90° C internal temperature; increases of \$ 0.09, \$ 0.12, and

$ 0.14 per pound were noted in the center cut of the rolled rib roasts for Commercial, Good, and Choice grades, respectively. From the well done stage to 90° C, the increases in cost per pound of posterior rolled rib of Commercial, Good, and Choice grades were $ 0.09, $ 0.11, and $ 0.12, respectively. The costs per pound of the cooked anterior rolled rib cut were higher than those of cooked posterior and center rolled rib cuts for each of the three grades.

The costs for 2.5-ounce portions of cooked top round, sirloin butt, and rolled rib roasts and 4-ounce portions of cooked strip loin at the different internal temperatures appear in Table 18.

The roasts in this study were cut from carcass and a single basic cost was established for all cuts suitable for roasting. When the costs per pound of cooked roasts at 80° C internal temperature (well done) were compared, it appeared that sirloin butt would be the most economical to prepare among the tender cuts of the same grade. However, when primal cuts or fabricated meats are used, this cost relationship might not always be true because of the variation in market prices. The strip loin had the lowest total cooking weight loss and consequently the lowest cost per cooked pound.

However, the edible portion cost for strip loin was higher than that for any of the other cuts because it was necessary to make allowance for the large amount of external fat in the strip loin so that the portion of edible lean meat would be comparable to the portion from other cuts.

Table 18. Cost per portion of cooked Commercial, Good, and Choice beef cuts at internal temperatures of 50°, 60°, 70°, 80°, and 90° C. All costs are based on 2.5-ounce portions of cooked weight, with the exception of strip loin which is based on 4-ounce portions.

	50° C	60° C	70° C	80° C	90° C
Sir.butt, anterior					
Comm.	$ 0.0942	$ 0.0988	$ 0.1086	$ 0.1237	$ 0.1409
Good	.1137	.1206	.1359	.1564	.1708
Choice	.1239	.1319	.1487	.1729	.1866
Sir.butt,posterior					
Comm.	.0949	.0988	.1070	.1184	.1309
Good	.1132	.1171	.1248	.1390	.1572
Choice	.1234	.1275	.1382	.1555	.1756
Top round,anterior					
Comm.	.0954	.1009	.1134	.1348	.1473
Good	.1113	.1161	.1297	.1490	.1694
Choice	.1210	.1265	.1377	.1598	.1802
Top round,middle					
Comm.	.0947	.1020	.1160	.1345	.1467
Good	.1151	.1255	.1468	.1667	.1808
Choice	.1248	.1336	.1536	.1750	.1911
Top round,posterior					
Comm.	.0894	.0953	.1044	.1187	.1326
Good	.1107	.1179	.1338	.1525	.1676
Choice	.1202	.1254	.1393	.1608	.1805
Strip loin					
Comm.	.1447	.1477	.1532	.1624	.1817
Good	.1726	.1779	.1842	.1968	.2295
Choice	.1876	.1924	.1979	.2082	.2337
Rolled rib,anterior					
Comm.	.0979	.1049	.1173	.1303	.1440
Good	.1166	.1238	.1395	.1563	.1744
Choice	.1305	.1395	.1558	.1757	.1991
Rolled rib,middle					
Comm.	.0965	.1035	.1154	.1287	.1418
Good	.1143	.1211	.1351	.1522	.1705
Choice	.1257	.1320	.1453	.1614	.1834
Rolled rib,posterior					
Comm.	.0937	.0981	.1068	.1192	.1322
Good	.1145	.1211	.1321	.1465	.1634
Choice	.1227	.1278	.1375	.1534	.1722

SUMMARY AND CONCLUSIONS

The primary objective of this study was to determine the effect of five different internal temperatures on the cooking weight losses of roasts prepared from the tender cuts of Commercial, Good, and Choice grade beef carcasses.

The total cooking weight losses of all cuts increased with each rise in the internal temperature of the meat, as was expected. There was no significant difference in total losses attributable to grade at any of the internal temperatures. However, highly significant differences were found among the cuts for all the grades. The cooking weight losses of the strip loin at each of the internal temperatures were significantly lower than those of any of the other cuts with the exception of the posterior round cut at 50° C internal temperature. The highest total cooking weight losses of the tender cuts were found in the anterior portion of the rolled rib at 50° and 60° C internal temperatures and in the center cut of the top round at 70°, 80°, and 90° C.

In general, at 50°, 60°, and 70° C internal temperatures, the average total cooking weight losses of the rolled rib roasts were higher than those of the top round cuts; but at 80° and 90° C, the round cuts showed higher cooking losses than the rolled rib cuts.

No significant difference in total cooking weight losses attributable to animal variations was found.

There were significant differences in dripping losses attributable to cuts at each of the internal temperatures studied; but the differences in dripping losses attributable to grade were significant only at 90° C internal temperature. The average dripping losses at 90° C for Good and Choice grades were significantly higher than those for Commercial grade. There was no significant difference between the average dripping losses of Good and Choice grade roasts cooked to 90°C internal temperature.

Total round roasts, including anterior, center, and posterior cuts, showed the lowest average dripping losses of the cuts studied. The anterior portion of the sirloin butt had the highest dripping losses at 50°, 60°, and 70° C; but the posterior rib roasts had the highest average dripping losses at 80° and 90° C internal temperatures.

No significant difference in volatile losses attributable to grade was found; but highly significant differences at each of the internal temperatures attributable to cuts were found. The strip loin consistently showed the lowest volatile loss of all the cuts. The average volatile losses of the anterior rolled rib were the highest of all cuts at 50° and 60° C; however, the average losses of the center round cut were the highest of all the cuts at internal temperatures of 70°, 80°, and 90° C.

The second objective of this study was to compare the effect of the degree of internal temperature on the edible portion cost of the roasts.

Since the total cooking weight losses of the cuts increased with each rise in internal temperature, the costs per pound of cooked meat increased proportionately. The increase in cost for the additional cooking period from the well done stage to 90° C varied from $ 0.08 to $ 0.12 per pound in the sirloin butt roasts. For the roasts from top round, the increases in cost for this additional cooking period ranged from $ 0.08 to $ 0.13 per pound. The strip loin roasts for Commercial, Good, and Choice grades showed increases of $ 0.08, $ 0.13, and $ 0.10 per pound for the 10 degree rise between 80° and 90° C. The costs per pound of cooked rolled rib roasts showed increases of $ 0.09 to $ 0.15 per pound for the extended cooking from 80° to 90° C internal temperature.

The third objective was the comparison of the palatability of all cuts of the three grades, cooked to a final internal temperature of 90° C.

From the results of the palatability scoring, it appeared that the roasts from Commercial grade averaged somewhat higher than those from Good and Choice grades. Statistical analysis showed the average aroma and flavor scores of roasts from Commercial grade to be significantly higher than those from Good and Choice grade roasts. The average appearance scores for samples from Commercial and Good grade roasts were significantly higher than scores for samples from comparable cuts of Choice grade roasts. No significant differences in juiciness and texture scores attributable to grade were found. The average tenderness scores for samples from Choice grade roasts were significantly higher than those from Commercial and Good grade roasts. The results of the shear force readings and tenderness scores indicated a probable high negative correlation.

The average flavor and juiciness scores of the strip loin were significantly higher than those of any of the other cuts. The strip loin also scored highest in appearance and texture of all the cuts, and the posterior cut of the rolled rib roast scored highest in tenderness of all the cuts.

The lowest average flavor, appearance, and texture scores of all cuts were found in the anterior portion of the rolled rib roasts. The center cut of the top round averaged lower in juiciness and tenderness than did any of the other cuts. No significant difference in aroma scores attributable to cuts was found.

The following conclusions were drawn from the results of this investigation.

The increased total cooking weight losses and the corresponding increased costs per pound of the cooked roasts point out the importance of the extent of cooking in meats, particularly in relation to food budget control. Over-cooking of meats from the well done stage to 90° C internal temperature resulted in fairly low palatability scores in addition to the increased total weight losses and increased costs per edible portion.

The tender cuts of Commercial grade compared favorably in palatability factors, except for tenderness, with similar cuts of Good and

Choice grades. The cuts from Choice grade were appreciably more tender than those of Good and Commercial grades; but this quality alone did not make the roasts from Choice grade more acceptable than roasts from Good and Commercial grades. Since no significant differences in total cooking weight losses among the three grades were found, it appeared that tender cuts of Commercial grade might be more economical to purchase than oven-ready cuts from Good and Choice grades.

On the basis of total cooking weight losses and costs per edible portion of meats at 80° C internal temperature found in this study, it appeared that sirloin butt cuts would be the most economical of the tender cuts to prepare. The roasts in this investigation were cut from carcass and a single basic cost was established for all cuts suitable for roasting. However, when primal cuts or fabricated meats are used,.this cost relationship might not always be true because of variation in market prices. Further studies on tender cuts of beef from the three grades cooked to an internal temperature of 80° C would provide data for comparison with the results of this study.

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APPENDICES

Appendix A. Cooking Losses

Table 19. Percentage of total cooking losses of roasts cooked to 50° C internal temperature.

CUT	CARCASS GRADE											
	COMMERCIAL				GOOD				CHOICE			
	Animal Code				Animal Code				Animal Code			
	A	B	C	Av.	D	E	F	Av.	G	H	I	Av.
Sirloin butt, anterior	9.3	9.8	6.2	8.4	11.6	8.6	8.7	9.6	10.0	10.5	8.6	9.7
Sirloin butt, posterior	8.6	9.6	9.2	9.1	9.9	9.7	8.0	9.1	9.1	10.0	8.9	9.4
Average	8.9	9.7	7.8	8.8	10.7	9.1	8.3	9.4	9.6	10.3	8.8	9.5
Top round, anterior	10.6	9.0	9.7	9.9	8.4	6.7	6.7	7.3	5.9	8.5	7.8	7.4
Top round, middle	9.6	8.5	9.6	9.2	10.2	9.1	11.6	10.3	9.5	10.7	10.7	10.3
Top round, posterior	6.6	3.4	1.2	3.9	9.0	3.7	7.1	6.7	3.8	6.7	9.9	6.9
Average	9.1	7.1	7.5	7.6	9.3	6.7	8.8	8.1	6.8	8.9	9.7	8.1
Strip loin (whole)	7.1	3.1	3.9	4.5	4.5	3.5	4.9	4.3	5.7	4.1	3.8	4.5
Rolled rib, anterior	12.9	11.9	11.7	12.2	11.5	11.9	11.3	11.6	11.9	15.6	14.9	14.3
Rolled rib, middle	12.5	8.9	11.2	11.0	10.1	9.6	9.8	9.8	10.2	11.3	11.6	11.0
Rolled rib, posterior	8.6	7.8	8.2	8.2	9.3	9.9	10.5	9.9	7.1	10.3	8.9	8.8
Average	11.5	9.7	10.3	10.4	10.3	10.6	10.5	10.4	9.8	12.4	11.9	11.3

Table 20. Percentage of total cooking losses of roasts cooked to 60° C internal temperature.

CUT	CARCASS GRADE											
	COMMERCIAL				GOOD				CHOICE			
	Animal Code				Animal Code				Animal Code			
	A	B	C	Av.	D	E	F	Av.	G	H	I	Av.
Sirloin butt, anterior	14.6	14.6	8.8	12.8	17.9	12.7	13.7	14.8	15.3	16.8	13.5	15.2
Sirloin butt, posterior	12.1	13.8	12.1	12.7	13.3	12.6	10.9	12.2	11.6	12.5	12.8	12.3
Average	13.4	14.2	10.6	12.7	15.3	12.6	12.2	13.5	13.4	14.5	13.1	13.8
Top round, anterior	17.3	13.3	13.1	14.5	11.9	10.5	10.[illegible]	11.0	10.5	13.2	10.6	11.5
Top round, middle	15.4	13.6	17.7	15.6	20.7	14.5	18.4	17.8	15.2	18.7	15.1	16.3
Top round, posterior	11.4	11.5	5.9	9.8	15.4	9.5	12.2	12.4	6.6	9.5	15.7	10.7
Average	14.9	12.9	13.2	13.3	16.4	11.8	14.3	13.7	11.3	14.4	14.2	12.8
Strip loin (whole)	10.4	4.4	5.1	6.8	7.3	6.8	7.3	7.1	9.3	5.9	5.4	6.9
Rolled rib, anterior	18.8	18.5	16.5	18.0	16.6	16.3	17.0	16.7	17.3	21.4	20.5	19.8
Rolled rib, middle	19.9	13.4	17.1	17.0	14.9	14.3	15.2	14.8	15.3	15.3	15.2	15.3
Rolled rib, posterior	13.3	11.5	12.1	12.3	13.7	14.4	16.1	14.8	10.6	14.3	12.2	12.5
Average	17.5	14.7	15.1	15.7	15.1	15.1	16.2	15.4	14.4	17.1	16.1	15.8

Table 21. Percentage of total cooking losses of roasts cooked to 70° C internal temperature.

CUT	CARCASS GRADE											
	COMMERCIAL				GOOD				CHOICE			
	Animal Code				Animal Code				Animal Code			
	A	B	C	Av.	D	E	F	Av.	G	H	I	Av.
Sirloin butt, anterior	23.6	22.0	15.5	20.6	28.3	21.1	23.8	24.4	24.2	27.4	22.8	24.8
Sirloin butt, posterior	18.3	20.6	19.1	19.4	18.8	17.9	16.3	17.6	18.9	18.4	19.8	19.1
Average	21.1	21.2	17.5	19.9	23.0	19.5	19.5	21.0	21.6	22.6	21.2	21.9
Top round, anterior	27.2	22.7	22.0	24.2	21.8	20.9	18.0	20.4	18.4	21.4	15.8	18.7
Top round, middle	25.9	24.4	27.3	25.9	35.5	25.2	28.9	29.7	26.1	32.1	23.7	27.1
Top round, posterior	19.7	22.8	9.3	17.7	26.1	20.7	21.8	22.9	11.5	17.9	28.7	19.7
Average	24.7	23.4	21.0	22.4	28.3	22.5	23.8	24.3	19.5	24.8	23.4	21.7
Strip loin (whole)	15.9	6.5	6.9	10.1	10.7	9.9	10.4	10.3	12.8	8.0	7.5	9.5
Rolled rib, anterior	28.3	27.0	24.2	26.7	25.3	25.7	26.6	25.9	26.3	29.6	28.4	28.2
Rolled rib, middle	29.3	21.8	24.4	25.5	24.4	22.7	23.8	23.6	23.4	22.3	23.3	23.0
Rolled rib, posterior	21.0	18.9	18.4	19.5	21.3	21.9	22.5	22.0	16.5	20.5	18.5	18.6
Average	26.5	22.8	22.2	23.7	23.6	23.6	24.4	23.8	22.1	24.2	23.6	23.2

Table 22. Percentage of total cooking losses of roasts cooked to 80° C internal temperature.

CUT	CARCASS GRADE											
	COMMERCIAL				GOOD				CHOICE			
	Animal Code				Animal Code				Animal Code			
	A	B	C	Av.	D	E	F	Av.	G	H	I	Av.
Sirloin butt, anterior	33.5	31.3	25.5	30.3	37.4	30.1	35.4	34.3	34.7	35.5	35.8	35.3
Sirloin butt, posterior	27.9	27.1	26.6	27.2	27.2	25.4	25.5	26.0	27.2	27.6	29.3	28.1
Average	30.8	28.9	26.1	28.6	31.7	27.7	29.7	30.1	31.0	31.3	32.3	31.7
Top round, anterior	37.7	33.2	36.9	36.2	31.6	32.5	27.4	30.7	31.8	31.4	26.3	29.9
Top round, middle	38.4	33.7	35.6	36.1	40.7	34.5	39.3	38.1	36.7	37.4	34.3	36.1
Top round, posterior	30.1	32.1	19.3	27.5	35.5	29.0	32.2	32.3	24.9	29.2	36.5	30.4
Average	36.0	33.1	32.0	33.0	36.3	32.2	34.0	33.6	31.7	33.2	33.0	32.0
Strip loin (whole)	24.6	9.6	10.2	15.2	16.8	15.5	15.9	16.0	19.1	11.2	11.5	14.0
Rolled rib, anterior	36.3	33.8	31.3	34.1	32.9	32.6	35.7	33.8	35.1	37.1	36.7	36.3
Rolled rib, middle	36.9	29.7	32.2	33.3	32.7	30.8	33.1	32.2	31.9	29.8	30.3	30.7
Rolled rib, posterior	29.8	27.4	26.3	27.9	29.8	28.5	30.4	29.6	26.7	28.5	25.7	27.0
Average	34.6	30.4	29.8	31.5	31.8	30.7	33.2	31.8	31.3	31.9	31.1	31.3

Table 23. Percentage of total cooking losses of roasts cooked to 90° C internal temperature.

CUT	CARCASS GRADE											
	COMMERCIAL				GOOD				CHOICE			
	Animal Code				Animal Code				Animal Code			
	A	B	C	Av.	D	E	F	Av.	G	H	I	Av.
Sirloin butt, anterior	41.5	38.7	35.7	38.8	42.1	36.5	41.0	39.8	40.5	39.7	40.1	40.1
Sirloin butt, posterior	35.6	33.4	33.7	34.2	35.9	32.7	34.9	34.6	35.4	35.1	38.3	36.3
Average	38.7	35.7	34.6	36.4	38.7	34.5	37.5	37.2	37.9	37.3	39.1	38.2
Top round, anterior	42.5	39.9	42.0	41.7	40.5	40.3	35.8	39.0	38.5	38.2	36.8	37.9
Top round, middle	42.9	39.4	41.7	41.4	44.8	40.5	43.5	42.9	41.8	41.4	41.0	41.4
Top round, posterior	38.2	35.0	31.7	35.2	41.1	35.1	38.7	38.4	35.9	36.7	41.0	37.9
Average	41.6	38.3	39.3	39.2	42.3	38.8	39.9	40.1	39.1	39.1	40.0	39.0
Strip loin (whole)	34.9	19.5	16.8	24.2	29.4	29.8	24.7	28.0	29.5	17.6	22.9	23.4
Rolled rib, anterior	41.8	40.5	38.2	40.4	40.1	39.6	42.2	40.7	41.7	46.2	43.2	43.8
Rolled rib, middle	42.8	36.0	38.5	39.4	39.9	38.2	40.4	39.5	40.4	38.1	38.5	39.0
Rolled rib, posterior	36.9	34.4	33.4	34.9	37.4	35.1	38.1	36.9	35.8	36.0	33.1	35.0
Average	40.6	37.1	36.6	38.0	39.1	37.7	40.3	39.0	39.3	40.2	38.4	39.2

Table 24. **Percentage of dripping losses of roasts cooked to 50° C internal temperature.**

CUT	CARCASS GRADE											
	COMMERCIAL				GOOD				CHOICE			
	Animal Code				Animal Code				Animal Code			
	A	B	C	Av.	D	E	F	Av.	G	H	I	Av.
Sirloin butt, anterior	3.5	1.9	2.6	2.7	3.2	2.7	3.2	3.0	2.8	2.8	2.5	2.7
Sirloin butt, posterior	1.5	1.9	1.7	1.7	1.9	1.7	1.1	1.5	2.6	1.9	2.1	2.2
Average	2.5	1.9	2.1	2.2	2.5	2.2	2.0	2.3	2.7	2.3	2.2	2.4
Top round, anterior	2.7	1.9	0.9	2.0	1.4	0.5	1.1	1.0	0.6	1.0	1.5	1.0
Top round, middle	1.6	0.6	1.2	1.1	1.1	1.2	2.2	1.5	1.3	2.6	1.9	1.9
Top round, posterior	2.0	2.4	0.9	1.8	1.9	0.9	2.3	1.7	1.1	0.9	2.1	1.4
Average	2.1	1.5	1.0	1.6	1.5	0.9	2.0	1.4	1.0	1.6	1.9	1.4
Strip loin (whole)	3.9	1.5	2.2	2.6	2.2	2.7	2.3	2.4	3.4	1.9	1.8	2.4
Rolled rib, anterior	2.6	1.5	2.0	2.0	2.4	1.5	2.3	2.1	1.9	3.6	2.3	2.7
Rolled rib, middle	2.6	1.3	2.3	2.1	2.2	1.2	1.8	1.7	2.1	2.4	1.9	2.1
Rolled rib, posterior	2.1	1.4	1.7	1.7	1.9	2.3	2.9	2.3	1.8	3.2	1.9	2.3
Average	2.5	1.4	2.0	1.9	2.2	1.7	2.3	2.0	1.9	3.0	2.0	2.3

Table 25. Percentage of dripping losses of roasts cooked to 60° C internal temperature.

CUT	CARCASS GRADE											
	COMMERCIAL				GOOD				CHOICE			
	Animal Code				Animal Code				Animal Code			
	A	B	C	Av.	D	E	F	Av.	G	H	I	Av.
Sirloin butt, anterior	4.9	2.6	2.7	3.5	4.8	3.9	4.9	4.6	4.2	4.6	3.8	4.2
Sirloin butt, posterior	2.4	2.9	2.4	2.5	2.5	2.3	1.8	2.2	2.9	2.3	3.1	2.7
Average	3.7	2.8	2.5	3.0	3.5	3.1	3.1	3.4	3.5	3.4	3.4	3.5
Top round, anterior	3.9	2.3	1.3	2.6	1.7	0.6	1.4	1.2	1.4	1.7	1.7	1.6
Top round, middle	2.2	1.1	2.2	1.9	2.7	2.1	3.4	2.7	1.9	2.7	2.6	2.4
Top round, posterior	2.7	4.6	1.1	2.9	3.7	1.5	3.8	3.1	1.3	1.7	2.9	2.0
Average	2.8	2.5	1.6	2.4	2.8	1.5	3.1	2.3	1.6	2.1	2.5	2.0
Strip loin (whole)	5.1	1.8	2.2	3.1	2.9	3.6	2.8	3.1	4.3	2.4	1.9	2.9
Rolled rib, anterior	3.5	2.2	2.3	2.7	3.2	1.5	3.6	2.8	2.8	4.3	3.4	3.5
Rolled rib, middle	4.1	1.8	3.5	3.2	2.7	1.7	2.9	2.4	3.9	2.9	2.5	3.1
Rolled rib, posterior	3.1	2.1	2.3	2.5	3.1	3.2	4.9	3.8	2.4	4.3	2.6	3.2
Average	3.6	2.1	2.6	2.8	3.0	2.1	3.8	3.0	3.0	3.9	2.8	3.2

Table 26. **Percentage of dripping losses of roasts cooked to 70° C internal temperature.**

CUT	CARCASS GRADE											
	COMMERCIAL				GOOD				CHOICE			
	Animal Code				Animal Code				Animal Code			
	A	B	C	Av.	D	E	F	Av.	G	H	I	Av.
Sirloin butt, anterior	6.7	4.2	4.4	5.2	6.4	6.7	9.0	7.4	6.7	5.3	5.9	6.0
Sirloin butt, posterior	3.6	4.3	4.3	4.1	4.2	3.3	2.7	3.4	5.2	3.9	5.7	5.0
Average	5.2	4.2	4.4	4.6	5.2	5.0	5.4	5.4	6.0	4.6	5.8	5.5
Top round, anterior	4.8	4.3	2.6	3.9	3.2	1.9	2.7	2.6	2.8	3.0	2.4	2.8
Top round, middle	2.8	1.8	2.3	2.3	3.3	2.9	4.1	3.4	3.1	2.4	3.7	3.1
Top round, posterior	4.3	4.8	1.7	3.7	5.9	3.1	7.7	5.7	2.6	3.9	4.2	3.6
Average	3.8	3.4	2.2	3.3	4.2	2.6	5.1	3.8	2.9	3.0	3.6	3.1
Strip loin (whole)	7.4	2.3	2.2	4.1	4.0	4.3	3.9	4.1	5.1	2.9	2.5	3.5
Rolled rib, anterior	4.0	3.7	3.4	3.7	4.3	2.3	4.9	3.9	5.2	6.5	4.9	5.6
Rolled rib, middle	5.8	3.6	5.6	5.0	4.6	3.2	5.4	4.4	7.1	4.7	4.9	5.6
Rolled rib, posterior	4.6	3.9	4.3	4.3	5.3	5.2	7.8	6.2	3.9	7.1	4.5	5.2
Average	4.8	3.7	4.4	4.3	4.7	3.5	6.0	4.8	5.4	6.1	4.8	5.4

Table 27. Percentage of dripping losses of roasts cooked to 80° C internal temperature.

CUT	CARCASS GRADE											
	COMMERCIAL				GOOD				CHOICE			
	Animal Code				Animal Code				Animal Code			
	A	B	C	Av.	D	E	F	Av.	G	H	I	Av.
Sirloin butt, anterior	6.4	5.7	7.4	6.5	6.5	8.6	9.8	8.3	7.3	4.7	5.3	5.8
Sirloin butt, posterior	4.3	5.8	6.4	5.5	6.7	4.6	4.1	5.1	7.3	5.8	8.4	7.2
Average	5.4	5.7	6.8	6.0	6.6	6.5	6.6	6.7	7.3	5.2	7.0	6.5
Top round, anterior	4.7	4.5	3.3	4.1	3.9	2.1	3.3	3.1	3.1	2.9	3.7	3.2
Top round, middle	2.2	2.4	2.9	2.5	4.1	2.9	2.9	3.3	3.2	0.5	3.9	2.7
Top round, posterior	3.9	5.0	5.2	4.7	5.3	3.4	10.9	6.8	6.2	4.7	5.3	5.4
Average	3.4	3.8	3.6	3.8	4.5	2.9	6.0	4.3	4.1	2.4	4.3	3.7
Strip loin (whole)	10.4	3.7	2.9	5.9	6.5	6.3	6.7	6.5	7.3	3.7	3.7	4.9
Rolled rib, anterior	5.0	6.5	6.2	5.8	6.5	4.2	8.3	6.3	9.1	9.8	7.9	8.9
Rolled rib, middle	7.8	6.7	8.8	7.7	7.6	6.2	9.3	7.7	10.9	7.9	7.4	8.8
Rolled rib, posterior	6.4	7.0	7.1	6.8	8.6	7.6	11.3	9.2	8.5	11.4	6.9	9.0
Average	6.3	6.7	7.3	6.8	7.5	5.9	9.5	7.7	9.5	9.7	7.4	8.9

Table 28. Percentage of dripping losses of roasts cooked to 90° C internal temperature.

CUT	CARCASS GRADE											
	COMMERCIAL				GOOD				CHOICE			
	Animal Code				Animal Code				Animal Code			
	A	B	C	Av.	D	E	F	Av.	G	H	I	Av.
Sirloin butt, anterior	4.6	6.6	7.9	6.3	7.2	7.8	8.4	7.8	8.1	5.5	6.3	6.6
Sirloin butt, posterior	5.6	7.6	9.3	7.6	9.8	6.6	5.6	7.3	9.6	7.5	10.1	9.0
Average	5.1	7.2	8.7	6.9	8.6	7.2	6.8	7.6	8.8	6.6	8.3	7.8
Top round, anterior	4.6	5.6	5.2	5.1	4.5	1.4	3.7	3.1	4.2	3.9	4.7	4.2
Top round, middle	2.4	2.9	3.7	3.0	4.6	3.2	3.2	3.7	3.7	2.8	4.9	3.8
Top round, posterior	3.1	5.2	5.5	4.6	5.4	3.1	10.9	6.8	6.6	4.0	6.0	5.6
Average	3.3	4.3	4.7	4.2	4.9	2.7	6.2	4.5	4.8	3.5	5.2	4.5
Strip loin (whole)	11.8	6.9	4.9	8.1	11.9	11.4	11.6	11.6	13.9	5.8	7.1	9.0
Rolled rib, anterior	6.6	9.7	9.3	8.4	9.6	7.0	10.7	9.2	12.6	14.0	10.8	12.5
Rolled rib, middle	8.8	9.9	11.3	9.9	11.2	10.2	12.9	11.5	14.9	13.8	11.0	13.3
Rolled rib, posterior	8.9	10.5	9.8	9.7	11.9	10.3	14.1	12.1	13.3	15.5	10.8	13.3
Average	8.0	10.0	10.1	9.4	10.8	9.1	12.5	10.9	13.6	14.4	10.8	13.0

Table 29. **Percentages of volatile losses of roasts cooked to 50° C internal temperature.**

CUT	CARCASS GRADE											
	COMMERCIAL				GOOD				CHOICE			
	Animal Code				Animal Code				Animal Code			
	A	B	C	Av.	D	E	F	Av.	G	H	I	Av.
Sirloin butt, anterior	5.8	7.9	3.5	[illegible].7	9.4	5.9	5.5	6.6	7.2	7.7	6.2	7.0
Sirloin butt, posterior	7.0	7.7	7.5	7.4	8.1	7.9	6.9	7.6	6.5	8.2	6.9	7.2
Average	6.4	7.8	5.7	6.6	8.2	6.9	6.3	7.1	6.9	8.0	6.6	7.1
Top round, anterior	7.7	7.1	8.8	7.9	6.9	6.2	5.6	6.3	5.3	7.5	6.3	6.4
Top round, middle	7.9	7.9	8.4	8.1	9.1	7.9	9.4	8.8	8.2	8.1	8.8	8.4
Top round, posterior	4.6	1.0	0.3	2.1	7.1	2.8	4.9	5.0	2.7	5.8	7.8	5.5
Average	7.0	5.6	6.5	6.0	7.8	5.8	6.8	6.7	5.8	7.3	7.8	6.7
Strip loin (whole)	3.2	1.6	1.7	2.2	2.3	0.9	2.6	1.9	2.3	2.1	1.9	2.1
Rolled rib, anterior	10.3	10.5	9.7	10.2	9.1	10.4	8.9	9.5	9.9	12.1	12.6	11.6
Rolled rib, middle	9.9	7.7	8.9	8.9	7.9	8.4	8.0	8.1	8.1	8.9	9.7	8.9
Rolled rib, posterior	6.6	6.4	6.5	6.5	7.5	7.7	7.6	7.6	5.4	7.1	6.9	6.5
Average	9.0	8.3	8.3	8.5	8.1	8.9	8.2	8.4	7.9	9.4	9.9	9.0

Table 30. Percentage of volatile losses of roasts cooked to 60° C internal temperature.

CUT	CARCASS GRADE											
	COMMERCIAL				GOOD				CHOICE			
	Animal Code				Animal Code				Animal Code			
	A	B	C	Av.	D	E	F	Av.	G	H	I	Av.
Sirloin butt, anterior	9.7	11.9	6.1	9.3	13.0	6.8	8.8	10.2	11.1	12.2	9.8	11.0
Sirloin butt, posterior	9.7	10.9	9.8	10.2	10.8	10.2	9.2	10.0	8.7	10.2	9.7	9.6
Average	9.7	11.4	8.1	9.7	11.8	9.5	9.1	10.1	9.9	11.1	9.7	10.3
Top round, anterior	13.4	11.1	11.8	12.2	10.2	9.9	9.3	9.8	9.1	11.5	8.9	9.9
Top round, middle	13.2	12.4	15.5	13.7	18.0	12.5	14.9	15.1	13.6	15.9	12.4	13.9
Top round, posterior	8.7	6.9	4.8	6.9	11.7	7.9	8.4	9.3	5.2	7.8	12.7	8.7
Average	12.1	10.4	11.6	10.9	13.6	10.3	11.2	11.4	9.7	12.3	11.7	10.8
Strip loin (whole)	5.3	2.6	2.8	3.7	4.4	3.2	4.5	4.0	4.9	3.5	3.5	4.0
Rolled rib, anterior	15.3	16.3	14.2	15.3	13.4	14.8	13.4	13.9	14.4	17.1	17.1	16.3
Rolled rib, middle	15.8	11.6	13.6	13.8	12.2	12.6	12.3	12.4	11.4	12.4	12.7	12.2
Rolled rib, posterior	10.2	9.4	9.8	9.8	10.6	11.3	11.2	11.0	8.2	10.0	9.6	9.3
Average	13.9	12.6	12.5	12.9	12.1	13.0	12.4	12.4	11.4	13.2	13.3	12.6

Table 31. Percentage of volatile losses of roasts cooked to 70° C internal temperature.

CUT	CARCASS GRADE											
	COMMERCIAL				GOOD				CHOICE			
	Animal Code				Animal Code				Animal Code			
	A	B	C	Av.	D	E	F	Av.	G	H	I	Av.
Sirloin butt, anterior	16.9	17.9	11.0	15.4	21.9	14.4	14.8	17.0	17.5	22.1	16.8	18.8
Sirloin butt, posterior	14.8	16.4	14.8	15.3	14.6	14.6	13.6	14.2	13.8	14.5	14.1	14.1
Average	15.9	17.0	13.1	15.2	17.8	14.5	14.1	15.6	15.6	18.0	15.4	16.4
Top round, anterior	22.4	18.4	19.4	20.3	18.6	19.1	15.3	17.8	15.6	18.4	13.5	15.9
Top round, middle	23.1	22.6	24.9	23.6	32.2	23.3	24.9	26.3	23.0	29.7	19.9	24.0
Top round, posterior	15.4	17.9	7.7	14.0	20.1	17.6	14.1	17.2	8.9	14.0	24.5	16.1
Average	20.9	20.0	18.8	19.1	24.1	19.9	18.7	20.5	16.6	21.8	19.8	18.6
Strip loin (whole)	8.6	4.2	4.7	6.0	6.7	5.5	6.5	6.2	7.7	5.1	4.9	6.0
Rolled rib, anterior	24.3	23.3	20.8	23.0	20.9	23.4	21.7	22.0	21.1	23.1	23.5	22.6
Rolled rib, middle	23.6	18.2	18.7	20.5	19.8	19.5	18.4	19.2	16.3	17.6	18.4	17.4
Rolled rib, posterior	16.4	15.0	14.1	19.2	16.1	16.7	14.6	15.8	12.6	13.5	14.1	13.4
Average	21.7	19.1	17.8	19.4	18.9	20.1	18.4	19.0	16.7	18.1	18.8	17.8

Table 32. Percentage **of volatile** losses of roasts cooked to 80° C internal temperature.

CUT	CARCASS GRADE											
	COMMERCIAL				GOOD				CHOICE			
	Animal Code				Animal Code				Animal Code			
	A	B	C	Av.	D	E	F	Av.	G	H	I	Av.
Sirloin butt, anterior	27.0	25.6	18.1	23.8	30.9	21.6	25.5	26.0	27.4	30.8	30.4	29.5
Sirloin butt, posterior	23.7	21.3	20.2	21.7	20.5	20.8	21.4	20.9	19.9	21.9	20.9	20.9
Average	25.4	23.2	19.3	22.6	25.1	21.2	23.2	23.4	23.7	26.1	25.3	25.2
Top round, anterior	33.0	28.7	33.7	32.1	27.6	30.4	24.1	27.6	28.7	28.4	22.5	26.7
Top round, middle	36.2	31.3	32.7	33.6	36.6	31.5	36.3	34.8	33.5	36.8	30.3	33.4
Top round, posterior	26.1	27.1	14.1	22.8	30.1	25.6	21.4	25.5	18.7	24.5	31.3	25.0
Average	32.6	29.3	28.4	29.2	31.8	29.3	28.0	29.3	27.6	30.8	28.7	28.3
Strip loin (whole)	14.2	5.9	7.2	9.3	10.3	9.2	9.2	9.5	11.8	7.6	7.8	9.1
Rolled rib, anterior	31.3	27.3	25.2	28.3	26.4	28.4	27.4	27.5	25.9	27.3	28.8	27.4
Rolled rib, middle	29.2	22.9	23.3	25.6	25.2	24.6	23.8	24.5	20.9	21.9	22.8	21.9
Rolled rib, posterior	23.4	20.3	19.2	21.1	21.2	20.9	19.1	20.4	18.3	17.1	18.8	18.0
Average	28.3	23.7	22.5	24.7	24.3	24.8	23.7	24.1	21.8	22.2	23.7	22.4

Table 33. Percentage of volatile losses of roasts cooked to 90° C internal temperature.

CUT	CARCASS GRADE											
	COMMERCIAL				GOOD				CHOICE			
	Animal Code				Animal Code				Animal Code			
	A	B	C	Av.	D	E	F	Av.	G	H	I	Av.
Sirloin butt, anterior	36.9	32.1	27.7	32.5	34.9	28.7	32.6	32.0	32.4	34.2	33.8	33.5
Sirloin butt, posterior	29.9	25.8	24.4	26.6	26.2	26.1	29.3	27.3	25.8	27.7	28.2	27.3
Average	33.6	28.5	25.9	29.5	30.1	27.3	30.7	29.6	29.1	30.7	30.8	30.4
Top round, anterior	37.9	34.4	36.9	36.6	35.9	38.9	32.0	35.9	34.3	34.4	32.1	33.7
Top round, middle	40.5	36.6	37.9	38.4	40.2	37.3	40.3	39.2	38.1	38.6	36.2	37.6
Top round, posterior	35.1	29.8	26.2	30.6	35.7	31.9	27.7	31.6	29.3	32.6	34.9	32.3
Average	38.3	34.0	34.6	35.0	37.4	36.1	33.7	35.6	34.3	35.6	34.8	34.5
Strip loin (whole)	23.1	12.5	11.9	16.1	17.5	18.4	13.0	16.4	15.6	11.8	15.8	14.4
Rolled rib, anterior	35.2	30.8	28.9	32.0	30.5	32.5	31.5	31.5	29.1	32.1	32.4	31.3
Rolled rib, middle	33.9	26.1	27.2	29.5	28.7	28.0	27.4	28.0	25.5	24.4	27.4	25.7
Rolled rib, posterior	27.9	23.8	23.5	25.2	25.5	24.8	23.9	24.8	22.5	20.5	22.3	21.7
Average	32.6	27.1	26.5	28.6	28.3	28.6	27.8	28.1	25.7	25.8	27.6	26.2

Appendix B. Palatability Scores

Table 34. **Average aroma scores of roasts cooked to 90° C internal temperature.**

CUT	CARCASS GRADE											
	COMMERCIAL				GOOD				CHOICE			
	Animal Code				Animal Code				Animal Code			
	A	B	C	Av.	D	E	F	Av.	G	H	I	Av.
Sirloin butt, anterior	5.7	6.4	5.1	5.7	5.3	4.5	5.0	4.9	5.1	6.1	4.4	5.2
Sirloin butt, posterior	4.7	5.6	5.0	5.1	5.8	4.7	4.1	4.9	4.4	5.7	5.3	5.1
Average	5.2	6.0	5.1	5.4	5.6	4.6	4.6	4.9	4.8	5.9	4.9	5.2
Top round, anterior	4.7	5.4	6.7	5.6	5.3	4.6	5.1	5.0	4.4	5.3	4.7	4.8
Top round, middle	4.6	5.1	6.7	5.5	5.6	3.9	4.4	4.6	3.7	4.7	4.1	4.2
Top round, posterior	4.6	7.1	6.0	5.9	5.6	3.7	4.7	4.7	4.0	4.6	4.7	4.4
Average	4.6	5.9	6.5	5.7	5.5	4.1	4.7	4.8	4.0	4.9	4.5	4.5
Strip loin (whole)	5.7	5.0	5.4	5.4	4.4	5.1	5.1	4.9	5.9	5.0	5.3	5.4
Rolled rib, anterior	4.9	6.0	5.3	5.4	5.3	5.3	4.9	5.2	5.4	4.6	5.1	5.0
Rolled rib, middle	5.4	5.4	6.3	5.7	5.1	4.1	5.0	4.7	3.6	4.3	4.3	4.1
Rolled rib, posterior	6.1	6.7	5.9	6.3	5.3	5.7	4.4	5.1	4.7	6.1	5.6	5.5
Average	5.5	6.0	5.8	5.8	5.2	5.0	4.8	5.0	4.6	5.0	5.0	4.9

Table 35. Average flavor scores of roasts cooked to 90° C internal temperature.

CUT	CARCASS GRADE											
	COMMERCIAL				GOOD				CHOICE			
	Animal Code				Animal Code				Animal Code			
	A	B	C	Av.	D	E	F	Av.	G	H	I	Av.
Sirloin butt, anterior	3.7	5.6	4.9	4.7	3.7	4.0	3.9	3.9	3.6	4.7	4.0	4.1
Sirloin butt, posterior	3.7	5.4	4.6	4.6	4.7	4.8	4.6	4.7	4.4	4.6	3.0	4.0
Average	3.7	5.5	4.8	4.7	4.2	4.4	4.3	4.3	4.0	4.7	3.5	4.1
Top round, anterior	3.0	5.2	5.6	4.6	4.9	5.4	4.9	5.1	4.4	5.6	3.9	4.6
Top round, middle	3.9	5.4	6.7	5.3	3.7	3.1	3.3	3.4	2.7	4.6	3.3	3.5
Top round, posterior	3.4	5.4	5.9	4.9	4.7	3.7	3.6	4.0	4.0	4.7	4.7	4.5
Average	3.4	5.4	6.1	5.0	4.4	4.1	3.9	4.1	3.7	5.0	4.0	4.2
Strip loin (whole)	5.1	6.9	7.7	6.6	4.4	5.0	5.1	4.8	4.9	6.3	6.9	6.0
Rolled rib, anterior	3.4	4.4	4.4	4.1	3.6	3.9	4.1	3.9	3.3	3.9	3.6	3.6
Rolled rib, middle	4.0	5.1	4.6	4.6	4.3	4.1	4.1	4.2	3.1	3.6	5.6	4.1
Rolled rib, posterior	3.9	5.6	6.4	5.3	4.9	4.3	3.0	4.1	2.7	5.3	5.9	4.6
Average	3.8	5.0	5.1	4.6	4.3	4.1	3.7	4.0	3.0	4.3	5.0	4.1

Table 36. Average juiciness scores of roasts cooked to 90° C internal temperature.

CUT	CARCASS GRADE											
	COMMERCIAL				GOOD				CHOICE			
	Animal Code				Animal Code				Animal Code			
	A	B	C	Av.	D	E	F	Av.	G	H	I	Av.
Sirloin butt, anterior	3.0	4.1	4.3	3.8	3.2	3.5	3.0	3.2	3.0	3.6	2.4	3.0
Sirloin butt, posterior	5.0	4.4	3.1	4.2	5.2	5.2	4.3	4.9	4.1	4.9	1.6	3.5
Average	4.0	4.3	3.7	4.0	4.1	4.4	3.7	4.1	3.6	4.3	2.0	3.3
Top round, anterior	4.4	4.6	3.7	4.2	4.1	5.6	4.9	4.9	3.3	6.0	4.0	4.4
Top round, middle	3.4	3.4	5.3	4.0	2.1	2.4	3.0	2.5	2.1	3.4	2.9	2.8
Top round, posterior	2.9	4.0	5.1	4.0	3.4	3.0	3.7	3.4	3.9	4.4	3.3	3.9
Average	3.6	4.0	4.7	4.1	3.2	3.7	3.9	3.6	3.1	4.6	3.4	3.7
Strip loin (whole)	4.4	7.4	7.6	6.5	4.3	4.7	5.9	5.0	3.7	6.1	6.4	5.4
Rolled rib, anterior	2.3	4.4	3.4	3.4	3.3	2.9	4.4	3.5	3.3	2.6	3.3	3.1
Rolled rib, middle	2.6	4.0	3.3	3.3	3.4	3.0	3.0	3.1	2.9	3.6	3.3	3.3
Rolled rib, posterior	2.0	4.6	4.0	3.5	3.6	3.9	3.7	3.7	3.0	4.0	5.1	4.0
Average	2.3	4.3	3.6	3.4	3.4	3.3	3.7	3.5	3.1	3.4	3.9	3.5

Table 37. Average appearance scores of roasts cooked to 90° C internal temperature.

CUT	CARCASS GRADE											
	COMMERCIAL				GOOD				CHOICE			
	Animal Code				Animal Code				Animal Code			
	A	B	C	Av.	D	E	F	Av.	G	H	I	Av.
Sirloin butt, anterior	4.0	5.3	5.6	5.0	4.8	5.7	3.3	4.6	4.0	3.9	3.3	3.7
Sirloin butt, posterior	2.9	5.3	4.1	4.1	5.2	6.2	4.9	5.4	3.9	3.1	2.9	3.3
Average	3.5	5.3	4.9	4.5	5.0	6.0	4.1	5.0	4.0	3.5	3.1	3.5
Top round, anterior	3.7	5.0	4.6	4.4	5.0	6.6	5.3	5.6	5.3	4.9	4.4	4.9
Top round, middle	3.4	5.3	6.4	5.0	4.0	3.6	3.7	3.8	2.7	4.0	3.9	3.5
Top round, posterior	4.0	5.4	6.1	5.2	5.4	4.9	5.3	4.9	4.4	5.1	3.9	4.5
Average	3.7	5.2	5.7	4.9	4.8	5.0	4.4	4.8	4.1	4.7	4.1	4.3
Strip loin (whole)	4.4	6.7	6.7	5.9	5.1	5.0	5.4	5.2	5.6	5.0	5.1	5.2
Rolled rib, anterior	2.9	4.1	4.0	3.7	3.7	4.3	3.7	3.9	3.7	2.4	3.3	3.1
Rolled rib, middle	3.4	5.3	4.6	4.4	4.7	3.9	3.4	4.0	3.1	3.1	3.7	3.3
Rolled rib, posterior	2.6	5.7	5.1	4.5	5.1	5.3	4.1	4.8	3.3	5.1	4.1	4.2
Average	3.0	5.0	4.6	4.2	4.5	4.5	3.7	4.2	3.4	3.5	3.7	3.5

Table 38. Average texture scores of roasts cooked to 90° C internal temperature.

CUT	CARCASS GRADE											
	COMMERCIAL				GOOD				CHOICE			
	Animal Code				Animal Code				Animal Code			
	A	B	C	Av.	D	E	F	Av.	G	H	I	Av.
Sirloin butt, anterior	4.0	5.7	5.3	5.0	4.2	6.3	5.1	5.2	4.7	4.7	4.6	4.7
Sirloin butt, posterior	4.7	5.3	4.6	4.9	4.8	6.0	5.6	5.5	5.0	4.9	4.1	4.7
Average	4.4	5.5	5.0	4.9	4.5	6.2	5.4	5.4	4.9	4.8	4.4	4.7
Top round, anterior	4.6	5.1	4.6	4.8	5.3	6.6	5.1	5.7	6.1	5.3	5.7	5.7
Top round, middle	3.9	5.9	5.7	5.2	3.6	4.3	4.0	4.0	3.7	4.6	4.1	4.1
Top round, posterior	5.3	6.0	6.4	5.9	5.4	4.6	4.3	4.8	5.3	6.6	4.9	5.6
Average	4.6	5.7	5.6	5.3	4.8	5.2	4.5	4.8	5.0	5.5	4.9	5.1
Strip loin (whole)	3.7	7.1	7.6	6.1	4.9	5.7	6.7	5.8	5.1	5.9	6.1	5.7
Rolled rib, anterior	4.3	4.4	4.3	4.3	4.6	4.7	3.9	4.4	3.6	4.6	4.6	4.3
Rolled rib, middle	3.6	5.3	4.3	4.4	5.3	4.3	4.3	4.6	3.4	3.9	5.3	4.2
Rolled rib, posterior	4.3	5.3	5.3	5.0	5.4	5.6	4.3	5.1	4.3	6.6	6.1	5.7
Average	4.1	5.0	4.6	4.6	5.1	4.9	4.2	4.7	3.8	5.0	5.3	4.7

Table 39. Average tenderness scores of roasts cooked to 90° C internal temperature.

CUT	CARCASS GRADE											
	COMMERCIAL				GOOD				CHOICE			
	Animal Code				Animal Code				Animal Code			
	A	B	C	Av.	D	E	F	Av.	G	H	I	Av.
Sirloin butt, anterior	4.9	6.3	5.3	5.5	3.2	6.7	6.6	5.5	5.3	8.2	7.9	7.1
Sirloin butt, posterior	6.7	6.0	7.0	6.6	7.2	6.3	5.7	6.4	6.7	7.9	8.0	7.6
Average	5.8	6.2	6.2	6.0	5.2	6.5	6.2	6.0	6.0	8.1	8.0	7.3
Top round, anterior	6.6	5.4	4.7	5.6	6.9	7.0	7.0	7.0	8.1	6.9	7.4	7.5
Top round, middle	5.1	5.6	6.3	5.7	3.3	5.0	7.3	5.2	5.9	5.6	5.3	5.6
Top round, posterior	6.6	7.4	6.0	6.7	4.6	6.7	3.3	4.9	7.7	8.0	7.9	7.9
Average	6.1	6.1	5.7	6.0	4.9	6.2	5.9	5.7	7.2	6.8	6.9	7.0
Strip loin (whole)	3.9	6.7	7.1	5.9	5.9	7.0	6.9	6.6	7.4	7.3	8.0	7.6
Rolled rib, anterior	5.9	6.9	8.3	7.0	6.4	7.1	7.1	6.9	7.0	8.0	6.6	7.2
Rolled rib, middle	4.1	6.7	8.7	6.5	5.3	6.7	6.3	6.1	5.6	7.7	7.9	7.1
Rolled rib, posterior	7.0	7.0	8.0	7.3	6.6	6.7	6.9	6.7	7.7	7.7	7.9	7.8
Average	5.7	6.9	8.3	7.0	6.1	6.8	6.8	6.6	6.8	7.8	7.5	7.3

Table 40. Average shear force readings of roasts cooked to 90° C internal temperature.

CUT	CARCASS GRADE											
	COMMERCIAL				GOOD				CHOICE			
	Animal Code				Animal Code				Animal Code			
	A	B	C	Av.	D	E	F	Av.	G	H	I	Av.
Sirloin butt, anterior	17.8	17.1	13.5	16.1	23.4	13.1	9.9	15.4	13.5	6.2	11.0	10.2
Sirloin butt, posterior	11.7	9.1	9.2	10.0	8.0	10.0	12.5	10.2	7.7	12.1	7.4	9.0
Average	14.7	13.1	11.3	13.1	15.7	11.5	11.2	12.8	10.6	9.2	9.2	9.6
Top round, anterior	13.3	15.7	14.3	14.4	12.2	12.2	13.1	12.5	11.4	10.5	10.2	10.7
Top round, middle	17.7	15.4	11.1	14.7	27.9	16.7	10.5	18.3	12.0	17.1	15.7	14.9
Top round, posterior	12.9	7.4	12.8	11.0	14.2	7.8	17.7	13.2	11.8	8.9	8.6	9.7
Average	14.6	12.8	12.7	13.4	18.1	12.2	13.7	14.7	11.7	12.1	11.5	11.8
Strip loin (whole)	13.9	12.7	14.5	13.7	13.3	11.5	11.7	12.2	9.1	9.4	7.6	8.7
Rolled rib, anterior	12.9	10.9	6.9	10.2	15.7	8.6	13.2	12.5	12.4	7.8	10.5	10.2
Rolled rib, middle	18.8	11.8	7.5	12.7	14.7	8.5	10.7	11.3	8.9	7.2	9.4	8.5
Rolled rib, posterior	13.1	8.9	8.9	10.3	12.9	9.7	9.4	10.7	8.6	5.7	7.1	7.1
Average	14.9	10.5	7.7	11.0	14.4	8.9	11.1	11.5	9.9	6.9	9.0	8.6

SCORE CARD FOR MEAT

Sample No. ____________ Scorer ____________

Animal No. ____________ Date ____________

FACTOR	10	9	8	7	6	5	4	3	2	1	0	CHECK MOST DESCRIPTIVE TERM
	Extremely Good	Very Good	Good	Medium Range Plus		Minus	Fair	Poor	Very Poor	Extremely Poor	Unacceptable	
Aroma												___mild ___sharp ___strong ___faint ___foreign
Appearance												___light brown ___dark brown ___red and brown ___light grey ___irridescent
Flavor												___mild ___mellowed ___rich ___strong ___old ___rancid ___bitter ___acid ___salty ___sweet
Texture	Extremely fine, no stringy-ness	Very Fine	Find	Medium Fineness Plus		Minus	Fair	Coarse & stringy	Very coarse stringy	Extremely coarse stringy		___powdery ___gelatinous ___separation of fiber
Tenderness	Extremely tender	Very Tender	Tender	Medium Tenderness Plus		Minus	Fair	Tough	Very Tough	Extremely tough		___No. of chews
Juiciness	Extremely Juicy	Very Juicy	Juicy	Medium Juiciness Plus		Minus	Fair	Dry	Very Dry	Extremely Dry		

(7398)