LONGISSIMUS DORSI OF THREE GRADES OF BEEF: COMPARISON OF COOKING WEIGHT LOSSES, PALATABILITY AND EDIBLE PORTION

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LONGISSIMUS DORSI OF THREE GRADES OF BEEF: COMPARISON OF COOKING WEIGHT LOSSES, PALATABILITY AND EDIBLE PORTION

By

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INTRODUCTION

The primary aim in institutional food service is to provide foods of the highest quality in conformity with budget allowances. Because the largest part of the food dollar is spent for meat, procuring and serving meat of satisfactory quality as economically as possible is of utmost importance.

One of the most difficult problems in satisfying customers is the standardization of the serving portion. Many people who would be willing to accept broken pieces or chunks of meat at home demand well-cut, unbroken slices when they eat in a commercial food establishment and complain about variation of size, shape, weight and appearance of portions.[1] The use of the longissimus dorsi of beef, because of its relative uniformity in size and shape, might offer a partial solution to this serving problem.

The longissimus dorsi of beef is reputed to be one of the more tender muscles of the carcass. Portions of this muscle of several U.S. grades are available from many of the meat packing companies. Since U.S. Good grade has been widely accepted as satisfactory for roasts in large quantity food service, the longissimus dorsi of this grade was used in this study as a basis for comparison with lower grades.

This study was planned to obtain information about the cooking weight losses, palatability and the edible portion cost of the longissimus dorsi of U.S. Good, Commercial and Utility grades of beef.

It is hoped that the results of this study may be sufficiently interesting and encouraging to stimulate further study of a similar nature using even lower grades of beef. The information gained from this study may also be of interest and of value to those who are confronted with the challenge of serving uniform portions of palatable meat at moderate cost.

REVIEW OF LITERATURE

Palatability Factors

Extensive research has shown that many factors influence the palatability of meat. Some of the important factors are market class or age and sex, care and diet of the animal. Methods of processing and cooking have also been found to influence the palatability of meats.

Aroma and flavor

Branaman, Hankins and Alexander (10), from their study of the relation of the degree of finish in cattle to meat flavors, reported increases in scores for intensity and desirability of the lean and juice of meat with increased fatness.

From a study of the influence of retarded growth on flavor and other characteristics of lamb, Barbella, Hankins and Alexander (5) pointed out that the lean meat from well-fed animals was strikingly superior in flavor to meat from poorly fed animals. Barbella and co-workers (6) used 728 beef rib roasts to study the relationships of flavor and juiciness of beef to fatness and other factors. They reported a range of fat percentages from 7.5 to 57.5 in these roasts. They considered fatness, age, breeding and sex of the animal as important factors influencing the flavor of meat.

Deatherage and Rieman (29), in their report of the Tenderay process, stated that there was danger of inducing off-flavors in ripening meats.

The effect of storage conditions on the palatability of beef was studied by Griswold and Wharton (34). They found that meat aged 37 days had somewhat stronger aroma and flavor than meat aged 9 days. Paired rounds of Good grade steer were stored at 17° C (35° F) and checked at intervals up to 18 days in a study by Paul, Lowe and McClurg (52) to determine changes in the histological structure and palatability of beef during storage. They reported improvement in aroma and flavor to the 9th day but found decreases in scores for these characteristics with further aging of the meat. The decreases in aroma and flavor scores were attributed to the development of gaminess in the lean and rancidity in the fat. From another similar study by Hanson, Stewart and Lowe (39), in which broilers were stored for a period of 118 hours, no change in aroma and flavor was reported at the end of 18 hours of storage. They observed decreases in scores for aroma and flavor after 40 hours and found

aroma and flavor of the broilers to be undesirable after 90 hours of storage.

Harrison (41), from the study of the histological, physical, and organoleptic changes in beef during aging, observed that the greatest improvement in palatability occurred during the first 10 days of ripening at a temperature of 34° to 36° F. The beef developed a musty odor and a high flavor between 20 and 30 days of storage.

When meats were cooked with skewers, either covered or uncovered, no difference in the taste of the interior of the roasts was noted by Morgan and Nelson (47).

Lowe (45) stated that the flavor of fat was primarily responsible for differences in flavor noted between the species, pork, lamb, beef, chicken and turkey.

Bull (13) pointed out that, although bull and stag beef does not have the extremely disagreeable odor and flavor found in boar meat, these animals constitute the least desirable class of beef. The meat from bull and stag beef has a sweetish taste.

Appearance and texture

Although appearance is not necessarily a guide to quality in meat, Hankins (36) commented that it is always a psychological factor. In some cases, appearance is

associated with characteristics of quality which are of real importance in judging quality of meat. He suggested that color is usually outstanding among the factors contributing to appearance of meats.

Bull (13) pointed out that judging the quality of any kind of meat by observation takes more experience than most consumer-buyers have. He continued that meats which are graded according to specifications and stamped with the grade name give the benefit of expert and unprejudiced judgment to the inexperienced buyer. Standards for market classes and grades of livestock are included in his book, Meat for the Table. These standards have also been described in government publications

Brady (9), from his study of the factors influencing the texture and tenderness of beef, reported that texture was dependent on the size of the fiber bundles in the muscles. He observed that the larger fiber bundles seemed to be characteristic of finer texture. Grindley and Sprague (33), in their study of a precise method for roasting beef, described in detail the characteristics of beef roasted to three stages of doneness. They attributed the differences in appearance of samples at varying degrees of doneness to changes in color and texture.

Descriptive terms of rose red, light pink and brownish grey were used by them to indicate the progressive stages of doneness. They pointed out that the texture became more compact and the appearance less moist as internal temperatures of the roasts increased.

From the results of work done with pork loins, Clark (18) found that roasts which were seared had a better general appearance than those which were cooked by constant oven temperature. She used an oven temperature of 482° F (250° C) for 30 minutes to sear and 320° F (160° C) to finish the roasts cooked by the searing method. An oven temperature of 320° F (160° C) was used throughout for roasts cooked by constant temperature method.

The effect of cold storage and freezing on the longissimus dorsi of beef was studied by Orr (50). She reported little or no difference between scores for appearance of steaks kept in cold storage or in frozen storage. The temperature used for the cold storage treatment was 7.8° C (46° F). For the freezing treatment the muscles were frozen at -26° C (-15° F) and stored at 0° C (32° F) in this investigation. Orr pointed out that judges described the appearance of cooked samples from frozen steaks as dark and dry on

the surface. Aldrich (1), from her investigation of the effect of the extent of cooking on U.S. Choice and U.S. Good pot roasts, concluded that appearance of the Choice cuts was scored slightly higher than of the Good cuts from roasts held an hour at 150° C after they reached 90° C internal temperature.

For studies on veal, Paul and McLean (53) used two pairs of legs from U.S. Good carcasses which weighed 50, 125 and 200 pounds. Roasts from these legs were cooked by constant oven temperature of 163° C (325° F) to internal temperatures of 71°, 77°, 82° and 88° C (160°, 170°, 180° and 190° F). These workers found that small roasts were quite pink at the lower internal temperatures and that the medium and large size roasts turned greyish brown at the higher internal temperatures. They indicated that both pink and brown are undesirable in the appearance of roast veal.

Morgan and Nelson (47) reported that meat from skewered roasts was more appetizing and juicy in appearance than meat from roasts cooked without the use of skewers. They found no difference in the appearance of the interiors of roasts cooked well done in covered pans and those cooked well done in uncovered pans. In some cases, they noted charring of the outer fat when the roasts were cooked uncovered.

"People buy with their eyes", stated Crist and Seaton (26). These workers emphasized that frequently the appearance of a food will be the determining factor in its acceptability even though other characteristics of quality and palatability are satisfactory. Appearance alone may be cause for rejection of food by the consumer, they concluded.

Tenderness and shear force

Tenderness is one of the most important of the palatability factors. Deatherage and Rieman (29) stated that consumers desired flavor and tenderness in meat more than any other qualities. They pointed out that although meat may have good flavor, it is still undesirable if it is tough. Bull (13) commented that many people, especially women, regard tenderness as the most important factor contributing to palatability of meats. He attributed the popularity of tenderloin steaks mainly to tenderness. The importance of tenderness was also emphasized by Hankins (36), who commented that, excepting unwholesomeness, there is no attribute of meat more of a liability than toughness.

According to the committee of the National Cooperative Meat Investigations (48), tenderness of meat is affected by the proportion of fat to lean, the age and activity of the animal from which it was obtained, the extent of action of the natural proteolytic enzymes contained in the meat during aging, the ripening period and temperature, freezing treatments and the methods and temperatures of cooking.

Ten animals were used by Griswold and Wharton (34) in the study of the effect of storage on the palatability of beef. They reported the variation between animals to be greater than that between the different grades according to mechanical tests for tenderness. However, the differences in tenderness of meat aged for 7 and 37 days were not significant either for judges' scores or for the shearing machine results. Steiner (57) also found the effect of ripening on tenderness to vary greatly from one animal to another and to vary with the sex and age of the animal.

Paul, Lowe and McClurg (52), using paired rounds from Good grade yearling steers stored at 1.7° C (35° F) for 1, 2, 4, 9 and 18 day periods, studied the changes during storage. They reported progressive increases in tenderness as indicated by panel scores and shear force tests during the storage period.

Porterhouse steaks were used by Hiner and Hankins (43) to determine the tenderizing effect of aging. They found that steaks aged 35 days at 34° F were 28 per cent more tender than those aged 5 days at 34° F. They observed that steaks aged for 5 days at 34° F and then frozen at -10° F were as tender as beef ripened 35 days at 34° F.

In another study these same investigators (43) used paired short loins of beef and observed that storage at 34° F had less tenderizing effect than freezing. They stated that beef frozen at 20° F was approximately 12 per cent more tender and beef frozen at -10 or -40° F was 18 per cent more tender than beef ripened at 34° F. They discovered no significant difference in the tenderizing effect of freezing between loins frozen at -40° F and those frozen at -10° F.

Semitendinosus muscles from the round of beef were cooked to an internal temperature of 58° C by Child and Satorious (17). They found no difference in the shear force tests among these roasts cooked by constant oven temperatures of 125°, 150°, 175° and 200° C. However, shear force results for standing rib roasts, cooked as described, were reported to be slightly higher when the roasts were cooked at the 200° C oven temperature than when they were cooked at the lower temperatures. When pork loins were cooked to an internal temperature of

84° C by constant oven temperatures of 125° C, 150° C and 175° C, Child and Satorius (17) found lowest shear force readings for the roasts cooked by the lowest temperature. They concluded that lower shear force readings were attributable to lower oven temperatures and that higher shear force readings resulted from the effect of higher oven temperatures on the muscle proteins.

Cover (23) found that the use of skewers in paired round-bone chuck roasts of beef decreased cooking time and losses but increased the toughness of the cooked cuts. Another study by the same investigator (24) was conducted to determine the effect of extremely low rates of heat penetration on the tenderness of beef. It was found that roasts were always tender when the rate of heat penetration was slow enough to require 30 hours for the interior of the meat to lose the pinkness. Roasts cooked at 80° C were mealy and dry, because of excessive evaporation, whereas roasts cooked at 125° C were juicier but less tender.

In a further study, in which the relationship of oven temperature and tenderness was investigated, Cover (25) used constant oven temperatures of 125° C and 225° C to roast meat to an internal temperature of 80° C. She reported that round-bone chuck and rump roasts of beef and half ham roasts of pork were more tender when cooked at 125° C than when cooked at 225° C. No tenderness difference was shown in medium rare rib and chuck roasts cooked at the same temperatures, and relatively small differences in total cooking time were observed. Cover explained that the tenderizing effect noted in roasts cooked at the lower temperature probably resulted not from oven temperature alone but from the combination effect of longer cooking period and lower cooking temperature.

Extensive research was carried out by Ramsbottom and co-workers (54) on the comparative tenderness of fifty individual muscles, which weighed one pound or more each, from beef carcasses. They concluded that thirty-five of the fifty muscles studied became less tender with cooking according to the judges' scores and shear force tests. They attributed this decreased tenderness to coagulation and denaturation of the muscle proteins and to the varying degrees of shrinkage and hardening of muscle fiber. They emphasized that the amounts of collagenous and elastic connective tissue in the muscle also influenced the tenderness of the cooked muscle. Tenderizing effect of the hydrolysis of the collagen was not sufficiently great to nullify this toughening effect. These investigators (54), using samples from eight muscles, found no relationship between the amount of fat within the muscle and shear force results for raw or cooked samples. Hankins and Ellis (37), using sixty-nine grain-fed cattle, substantiated these findings and concluded that variations in tenderness were caused mainly by factors other than fatness.

Animals varying in age from 2.5 months to 5.5 years were used in a study by Hiner and Hankins (43) to determine the effect of the age of the animal on the tenderness of the meat. They found a decrease in tenderness with an increase in the age of the animal. They found that tenderness was not associated with grade to any appreciable extent in the comparison of 8 Choice, 9 Good and 8 Commercial steers which ranged from 14 to 18 months in age.

Juiciness and press fluid

Alexander and Clark (4) reported findings on the effect of grade on palatability and cooking weight losses from a study of 595 rib roasts from U.S. Choice, Good, Medium and Common grade beef carcasses. They pointed out that fat content is one of the most important factors in determining grade and that usually the higher grades are associated with higher fat content of the carcass. They reported that roasts cooked with the bone in were juicier than comparable boned and rolled roasts. These findings were substantiated by Child and Esteros (15) who found that standing rib roasts were juicier than comparable boned roasts when they were tested by a pressometer or scored for juiciness.

From their study on the effect of exterior temperature on the juiciness of beef, Child and Satorius (17) concluded that external temperatures do not affect the juiciness scores or press fluid results in comparable cuts of meat cooked to the same stage of doneness.

Child and Fogarty (16), in their study of the effect of interior temperature of beef muscle upon the press fluid, reported that 11 per cent more press fluid was obtained from roasts cooked to an internal temperature of 58° C than from roasts cooked to an internal temperature of 75° C. Child and Esteros (15) reported that increases in the degree of doneness were related directly to decreases in juiciness. From the study of the effect of different internal temperatures on veal, Paul and McLean (53) found decreases in juiciness as the internal temperatures in the roasts increased. Noble, Halliday and Klass (49) found that standing rib roasts cooked to 61° C were somewhat more juicy than those cooked to 75° C internal temperature.

Cline, Loughead and Schwartz (22) found increased juiciness related to higher grades of meat in their study of steaks from U.S. Good and Medium grades of heifers, cows and steers.

Using skewers to speed the roasting of meat, Morgan and Nelson (47) found that skewered roasts were more juicy than unskewered roasts which were cooked to the same internal temperature by the same oven temperature. Roasts from the top rounds of beef were cooked to an internal temperature of 82° C by a constant temperature oven and by pressure sauce pans in the study by Clark and Van Duyne (19). They reported that roasts cooked in the oven were juicier than those cooked in the pressure sauce pans.

Griswold and Wharton (34) found that beef aged 9 days was more juicy than beef stored 37 days at 0° C. Little variation in juiciness scores of the roasts stored from 1 to 20 days was found by Harrison (40). After 30 days of aging, the juiciness scores dropped below those of the shorter aging periods. Harrison concluded that evaporation of the fluids in the roasts during storage was great enough to reflect in the juiciness scores of the cooked roasts.

Variation in juiciness from muscle to muscle was evident from the study by Harrison (40). She found the roasts from the psoas major muscle to be most juicy and those from the semitendinosus to be least juicy of the muscles studied. Juiciness scores for the longissimus dorsi were intermediary. Paul and co-workers (53) found highly significant differences in juiciness among roasts from different muscles. They also found the roasts from the psoas major muscle to be the most juicy and roasts from the semitendinosus to be the least juicy.

Paul, Lowe and McClurg (52) reported a gradual increase in juiciness scores during the 18 days of aging paired rounds from a U.S. Good yearling steer carcass. They pointed out, however, that the press fluid decreased and then increased sharply during storage, indicating changes in the waterbinding powers of the proteins and the permeability of the cell membranes. Hanson, Stewart and Lowe (38) concluded that juiciness of fowl was not affected by storage at 0-2.2° C (32-36° F) during a storage period of 118 hours.

Cooking Losses

One of the earliest investigations of meat cookery in this country was reported by Wood (61) in 1869. He wrote that it was interesting and worthwhile to remember that a hotter fire should be used to roast the smaller cuts of meat. He believed that an intensely hot fire coagulated the exterior and thereby prevented the drying of the meat juices. He stated that shrinkage in a roast of meat during cooking was chiefly the result of water loss. Grindley and Mojonnier (32), in 1904, commented that the losses in the roasting of meat were attributable chiefly to the removal of fat and water and that higher cooking temperatures generally resulted in greater losses.

Clark (18) pointed out that pork loins, when seared, shrank more and cooked faster than when they were cooked by constant oven temperature. She indicated that the increased losses were attributable mainly to the rendering of more fat from the roasts during cooking. Using three cuts of beef cooked to the well-done stage, Cover (24) found the total cooking losses were about the same when oven temperatures of 80° C and 125° C were used.

Results of extensive cooking tests on 185 legs of lamb and mutton were reported by Alexander and Clark (3).

The variables which they studied were grade, length of ripening period and cooking methods. They found that cooking losses were lowest in roasts cooked at 125° C constant oven temperature. Losses from the roasts cooked by constant temperature at 175° C were greater than from those which were seared at 260° C for 20 minutes and then were finished at 125° C. These investigators concluded that smaller losses occurred when the average oven temperature was low, regardless of the procedure used for roasting. Additional studies in 1939 by the same investigators (4), based on 595 rib roasts of beef, gave further evidence that greater shrinkage of roasts was not dependent upon searing as such but upon higher average oven temperatures.

In experiments to observe the effect of metallic skewers on cooking time, Morgan and Nelson (47) used constant oven temperatures of 150° C, 175° C and 250° C. They concluded that the loss of weight during cooking was not greatly increased by the higher external temperatures. They explained that the shorter cooking time required when higher temperature was used probably served to counterbalance the losses generally attributed to the effect of higher temperature as such.

Studies were conducted by Child and Satorius (17) to determine the effect of exterior temperature upon the press fluid, shear force and cooking losses of roasted beef and pork muscles. Results indicated that cooking losses in beef were greater when the meat was prepared by roasting at constant temperatures of 200° and 175° C or by searing at 260° C for 20 minutes and finishing at 150° C than when they were cooked at 150° C constant temperature. Weight losses of pork loins cooked to an internal temperature of 84° C by the same methods just described were not affected by the external temperatures. They suggested that cooking losses of beef were increased with higher oven temperatures because of excessive evaporation. Cline and co-workers (21), after studying different classes and grades of beef cooked by different oven temperatures, indicated that higher external temperatures increased the total cooking losses. Cline and Foster (20) found that low oven temperatures gave less loss than high oven temperatures.

Paired beef roasts were cooked by constant temperature of 125° C to the well-done stage in an experiment to show the effect of the use of metal skewers. Cover (23) reported that the roasts into which copper skewers were inserted cooked in less time and with smaller losses than roasts cooked without skewers. A similar study by Morgan and Nelson (47), indicated a marked decrease in cooking time and cooking losses with the use of skewers in roasts. Aldrich (1) found an appreciable continued weight loss in both U.S. Good and U.S. Choice pot roasts held an additional hour at 150° C, after they had reached an internal temperature of 90° C.

The stage of doneness may have greater influence on shrinkage than the specific oven temperature used, according to Alexander and Clark (3). The shrinkage of lamb legs cooked to an internal temperature of 83° C was not significantly different whether they were cooked by constant temperatures of 125° C and 175° C or were seared at 260° C for 20 minutes and finished at 125° C. These investigators (4) in a similar study found that, even with low oven temperatures, it was not possible to cook meat well-done and keep shrinkage low. As early as 1904 Grindley and Mojonnier (32) commented that, in cooking meats by roasting, the losses increased in proportion to the degree of doneness. From work done at the University of North Dakota, Latzke (44) reported that cooking losses varied with the degree of doneness. She indicated that average percentage cooking losses for beef were 16.8 for rare roasts, 18.06 for medium roasts and 22.3 for well-done roasts.

Alexander and Clark (4) found that among roasts classified according to grade, those in the higher grade usually showed smaller evaporation losses and larger dripping losses, regardless of the style of cutting or the method of cooking. Black, Warner and Wilson (7) reported that meat from supplement-fed steers showed less evaporation during cooking than did meat from thinner grass-fed cattle. There were more drippings from the fatter animals than from the thinner cattle. Helser, Nelson and Lowe (42), at Iowa State College, found that fatter roasts had a greater amount of drippings. Thille, Williamson and Morgan (59) agreed that total cooking losses of fat roasts were greater than those of lean roasts because of the large amount of fat rendered during cooking. However, volatile losses were reported by these workers to be less in the fat roasts than in the lean roasts.

Methods of Evaluating Palatability of Meats

Subjective methods

The problems involved in evaluating subjective tests for food acceptance have been pointed out by many investigators. Eating qualities of food are evaluated principally through impressions on the sensory organs.

Some of the problems of subjective testing were pointed out by Halliday (35), who stated that subjective tests do not provide reproducible results. Tanner, Clark and Hankins (58) also suggested that the influence of one palatability factor upon another presents one of the greatest obstacles to accurate grading of a single factor of palatability. The psychological and physiological factors affecting food acceptability were discussed by Bogga and Hanson (8), Lowe and Stewart (46), Dove (30) and Crocker (27). Overman and Li (51), concerned with the problem of the dependability of subjective scores, established an analysis of food tasting panels to determine the dependability of the judges' scores.

Because of the need for standardizing procedures in taste-testing work, the Bureau of Human Nutrition and Home Economics sponsored a conference for the critical appraisal of sensory methods for measuring food quality

by taste panel methods. Dawson and Harris (28) prepared the bulletin which included the proceedings of the conference and an extensive review of literature on the subject. Recommendations for subjective testing, evolved through the combined efforts of the participants, are printed in the bulletin. Important methods in planning organoleptic tests to increase the validity and accuracy of panel scores were outlined by Crist and Seaton (26), Lowe and Stewart (46) and Dove (30).

Despite the difficulties inherent in subjective testing, it is still recognized as an important means of determining food acceptability (25, 48).

Objective methods

The need for mechanical and chemical methods for measuring objectively the characteristics of quality has been emphasized by Dove (30) and Crocker (27).

The Warner - Bratzler shear machine, or some modification of it, has been found to be a satisfactory objective means of determining tenderness in meats. This shearing apparatus measures the pounds of force required to cut through a sample of meat of prescribed dimensions (11). A high degree of correlation between taste panel scores for tenderness and shear force readings has been established by many investigators.

Noble, Halliday and Klass (49), using the New York Testing Laboratory Penetrometer, found little difference in the average tenderness values from the right and left sides of wholesale rib cuts of beef when the cuts were cooked in the same manner. A limited number of other mechanical devices and chemical and histological methods have been developed to determine tenderness of foods objectively.

The objective measurement of the juiciness of meat was developed on the principle of expressing fluid from meat samples of known weight. Child and Baldelli (14) reported the development of apparatus called the Pressometer and the standardization of the method for determining the percentage of press fluid and the ratio between it and dry matter. These workers define press fluid as the fluid consisting of moisture plus soluble material and the colloidal fraction that is pressed from the muscle by the pressometer. Aldrich (1) found good correlation between the judges' scores for juiciness and the percentage of press fluid, determined by the Minnesota pressometer, in muscles from Good and Choice grade beef rounds which were cooked to 90° C internal temperature. She found no significant correlation between press fluid tests and juiciness scores for either the Choice or Good grades when the pot roasts were cooked beyond an internal temperature of 90° C.

Tanner, Clark and Hankins (58), from the results of the work in which an apparatus operated by hydraulic pressure was used, admitted that the correlations between judges' scores and the percentage of expressible juice of three groups of samples were not significantly high. However, the results were regarded as sufficiently consistent to be encouraging. Tests on beef, lamb and pork indicated that, although all samples had the same percentage of press fluid, beef was consistently scored highest and pork lowest in juiciness. The results for press fluid tests for beef cooked to an internal temperature of 58° C showed no close correlation with the judges' scores for juiciness of these samples.

Only a limited number of objective tests have been found satisfactory in determining the acceptability of meats, and much more work is needed to develop additional tests to supplement the subjective methods now used for testing.

Combination of subjective and objective methods

Dove (30) expressed the need to raise subjective measures to a quantitative level. "To judge the merit and range of use of each and every objective test, we must hunt out a scientific basis for our judgment by developing a method of measuring the subjective responses," Dove (30) reported. In the end, all measures of the palatability of a food are liable to the subjective response. Dove (30) recommended the subjective-objective approach to the study of food acceptability.

Lowe and Stewart (46) emphasized that objective tests for organoleptic qualities must measure the characteristics which can be correlated with subjective evaluations of acceptability. They pointed out the difficulties of subjective tests but emphasized that they give information concerning the acceptability of the product which cannot be obtained in any other way at present.

Because of the recognized shortcomings of both subjective and objective tests used separately, many investigators have combined the two methods of determining the acceptability of food.

Cost of Edible Portion

From the study of a precise method of roasting, Gridley and Sprague (33) pointed out that roasts cooked as quickly at 175° C (347° F) as at 195° C (382° F). They emphasized that this information was important from a practical standpoint, because the economy in fuel, a contributing factor in the cost of the edible portion of meat, was involved.

Alexander (2), from her study of the shrinkage of roast beef in relation to the fat content and cooking temperature, reported that shrinkage of meat during cooking affected the quantity as well as the quality of the cooked meat. She stated that shrinkage of meat during cooking must be considered both in estimating the number of servings and in determining the cost of servings.

In a study at the University of Illinois 12 Prime, 16 Choice, 15 Good and 8 Utility carcasses were divided into retail cuts. Each cut was divided into lean, fat and bone and the percentage of each was determined. This information was compiled in the book, Meat for the Table (13). Charts were constructed so that the comparative cost of a pound of lean from any cut of each of the grades could be easily calculated. The economy of different retail cuts from the same wholesale cut was emphasized also (13).

Aldrich (1), from her study of the effect of the extent of cooking on muscles from the round of beef, found the cost of the cooked pot roasts to be $1.4026 per pound for Good grade and $1.4731 for Choice grade when the pot roasts were cooked to an internal temperature of 90° C. The costs per pound of the same pot roasts cooked an additional hour after reaching 90° C internal temperature were $1.5081 for Good grade and $1.5460 for Choice grade. Using 2.5 ounces as a standard size serving in calculating the cost of edible portion, she pointed out the importance of these slight differences in portion cost when they were applied to the large number of portions often used in quantity food service.

From the study reported in 1943 by Dunnigan (31), the cost per pound of edible meat for Choice grade was found to be $.5342 for bone-in roasts and $.4236 for boned roasts. For Utility grade, the cost per pound of edible meat was $.5298 for bone-in roasts and $.3575 for boned roasts.

Brown (12) studied waste attributable to boning and trimming of square-cut chuck and round of beef in dividing the wholesale cuts into inside and outside retail roasts. In addition, losses from oven roasting and slicing were considered in the problem. She reported the cost of edible round to be $.12 per pound more than that of chuck. There was no preference for inside roasts over outside roasts from either of the wholesale cuts indicated by Brown (12).

METHOD OF PROCEDURE

Preparation of Longissimus Dorsi

Dissection from carcass

For this study, one longissimus dorsi muscle was dissected from three sides of beef carcass of each grade, U.S. Good, U.S. Commercial and U.S. Utility.

The sides of beef, divided by the wholesaler according to standard cutting procedure between the twelfth and thirteenth ribs, were purchased from the Armour Packing Company of Chicago and the Plankinton Packing Company of Minneapolis. The sides of beef were aged 14 days following slaughter at approximately 1.7^{o} C (35^{o} F) before the muscles were dissected.

Division into four cuts

Four cuts were prepared from the longissimus dorsi muscle dissected from each side of beef. The division of the muscle into four cuts was partially determined by the separation of the sides into fore and hind quarters by the packers. The part of the longissimus dorsi from the hind quarter was divided into two roasts of approximately equal size, and the part of the muscle from the fore quarter was divided so that the posterior cut was comparable in size to the two roasts taken from the hind quarter. The cut from the anterior or tip end of the muscle was the smallest of the four cuts.

Freezing and storage of cuts

After the external sheath of connective tissue and the fat covering were trimmed, the cuts were labeled, individually wrapped in polyethylene bags and frozen at approximately -12.2° C (+10° F). The cuts were stored at -12.2° C (+10° F) until defrosting just prior to cooking. Storage periods for the frozen cuts used in the experiment ranged from 5 days to 63 days.

Cooking of Cuts

Defrosting of cuts

The cuts were unwrapped and defrosted in a refrigerator at 5° C (41° F) for 12 to 15 hours to an internal temperature of approximately 0° C (32° F).

The cuts were weighed on a torsion balance and measured for length, width and depth. A thermometer was inserted so that the bulb was at the center of each cut. Each cut was placed on a trivet in a 12 by 18 inch pan of 18 gauge stainless steel.

Roasting process

The meat was cooked in a thermostatically controlled Hot Point electric oven, built with open fire brick bottom. Taylor oven thermometers were used to check the oven temperature. The cuts were cooked, uncovered, at constant oven temperature of 149° C (300° F) to an internal temperature of 80° C (176° F).

One cut from the same muscle location from each of the three grades, U.S. Good, Commercial and Utility, was roasted simultaneously in the same oven at each of the twelve cooking periods.

Temperatures of both oven and meat thermometers were recorded at 20 minute intervals until the internal temperature of the meat had reached 75° C (167° F). Temperature readings were then taken at more frequent intervals. It was necessary to open the oven door to make the temperature observations because the oven doors did not have glass windows.

The cooked roasts were weighed, and measurements of their length, width and depth were taken. Drippings from each roast were weighed. Volatile losses were calculated by subtracting the sum of the dripping weight and the cooked weight of each roast from the raw weight of each roast.

Preparation of Samples

The roasted cuts were allowed to cool at room temperature for approximately 30 minutes before samples were removed for the taste panel judges or the objective tests. Approximately 0.5 inch was then removed from the posterior end of each roast by cutting across the grain with a sharp knife to produce a straight edge for machine slicing. Another cut, parallel to the first was made 2.5 inches from the trimmed edge. Samples from this 2.5 inch section of roast were used for all tests.

Samples for shear force testing

A sample for testing tenderness on the Warner-Bratzler Shear Machine was obtained from the center of the 2.5 inch section of roast. This sample was cut with a 1-inch metal core with a sharp edge by using a rotating motion along the grain of the meat. Care was taken to avoid connective tissue in selecting the location for cutting the cylinder of meat. The samples were kept in air tight jars approximately 3 or 4 hours before the shear force tests were made.

Samples for press fluid determinations

Samples to be tested for press fluid with the Carver Press were taken from the portion of the 2.5 inch section of roast which remained after slices had been removed for palatability tests. This sample was placed in an air-tight half-pint jar and was held at approximately 1.7° C (35° F) for 18 hours. The sample was removed from refrigeration 1 hour before testing. The browned surfaces and visible connective tissue were removed from the portion, and the remaining muscle fiber was then ground twice in a Number 2 Universal food chopper through a plate perforated with 1/8" openings. The ground meat was placed in a glass jar and mixed thoroughly by vigorous shaking. A 25 gram sample of the mixture was used for each test on the Carver Press.

Samples for palatability scoring

Slices, approximately 0.25 inch thick, were cut from the posterior end of the 2.5 inch section of roast with a General Slicing Machine, Model 225. Each judge received a slice of meat from the same relative position in each roast. Samples for palatability tests were labeled and kept in small, individual polyethylene bags from the time of cutting until scoring.

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 1-inch in diameter. Five tests were made on a cylinder from each roast.

Press fluid tests

Juiciness was objectively evaluated by determining the amount of fluid which could be expressed with a Carver Press from 25 grams of the sample prepared for testing as previously described. A double thickness of cheesecloth, cut about 5 inches in diameter, was arranged to form a pouch in the bottom of the cylinder, 5.5 centimeters in diameter. Two No. 2 filter papers, 5.5 centimeters in diameter, were placed in the bottom of this cheesecloth pouch. Four layers of ground meat, weighing approximately 6.25 grams each, were placed in the pouch and the layers were separated by 5.5 centimeter filter paper. The top layer was covered with two 7 centimeter filter papers which had been pressed to form an inverted cap to fit in the top of the cylinder. The edges of the cheesecloth pouch were gathered and folded over the sample. The plunger was placed in position on the sample, and the cylinder was placed in the center of the platform of the Carver Press. The pressure exerted per square 1.25 centimeters was increased at intervals (as read from the inside rim of the scale) according to the following schedule:

1 minute at 5,000 pounds

1 minute at 7,500 pounds

4.5 minutes at 10,000 pounds

2.5 minutes at 12,000 pounds

1 minute at 15,000 pounds

4 minutes at 16,000 pounds

Subjective tests

Each of six judges scored a sample from each roast. The scoring was based on a scale ranging from 0 to 10 for aroma, appearance, flavor, texture, tenderness and juiciness. Descriptive terms for each palatability factor were also listed for checking by the judges.

Cost for edible portion

Because the longissimus dorsi muscle of beef is not sold as a separate wholesale cut, the cost of the individual muscles used in this study was based on the market price of stripped loin and the estimated percentage of the strip loin which the longissimus dorsi represented. In this study percentages allowed for trim from the full wholesale cuts of strip loin were 40 for Good, 35 for

Commercial and 30 for Utility. On this basis the trimmed longissimus dorsi constituted the following percentages of the wholesale cut: 60 for Good grade, 65 for Commercial grade and 70 for Utility grade.

Price quotations for June, 1952, were obtained from Swift and Company, Armour and Company and Phaelzer Brothers Company for stripped loin. The average of these three quotations was used in calculating cost of the meat used. The average market cost for the untrimmed strip loin and the percentage of usable muscle were used to determine the cost per pound of the uncooked longissimus dorsi muscles for each grade. The cost per pound of the cooked meat was calculated by dividing the total raw weight cost by the total weight of the cooked roasts for each grade.

RESULTS AND DISCUSSION

Palatability Factors

Aroma and flavor

Aroma and flavor are considered important factors in the acceptability of meat. The aroma is produced principally by the action of heat upon the meat fibers and fat, and the flavor resides mainly in the juices. Aroma makes its impression on the taster first, and some feel that it is even more important than flavor although they are very closely associated.

Averages of aroma scores for all cuts for the three animals of each grade are shown in Table 1 and Figure 1. A comparison of the average scores for grade shows 8.2 for Good, 7.5 for Commercial and 7.1 for Utility. The range of scores within grade was 7.7 to 8.5 for Good, 6.7 to 8.0 for Commercial and 5.7 to 8.5 for Utility.

Analysis of variance of aroma scores indicated that variation in aroma, attributable to grade, was significant at the 1 per cent level of probability.

It is obvious from the average scores for aroma that animal VIII was less desirable than any other animal studied. The odor of animal VIII was described

TABLE 1

Average Aroma Scores of Cuts in Sequence from the Anterior to the Posterior End of the Longissimus Dorsi of Beef

	Cut				
Animal	1	2	3	4	Average
			U.S. Good		
I	8.5	7.8	7.7	8.3	8.1
II	8.5	8.5	8.3	8.0	8.3
III	8.0	8.2	8.2	8.5	8.2
Average	8.3	8.2	8.1	8.3	8.2
			U.S. Commercial		
IV	8.0	7.0	7.8	7.8	7.6
V	7.0	7.7	7.5	6.7	7.2
VI	7.5	7.8	7.8	7.7	7.7
Average	7.5	7.5	7.7	7.4	7.5
			U.S. Utility		
VII	8.5	6.3	7.5	6.5	7.2
VIII	5.7	7.2	6.5	6.3	6.4
IX	7.7	7.8	7.3	7.7	7.6
Average	7.3	7.1	7.1	6.8	7.1

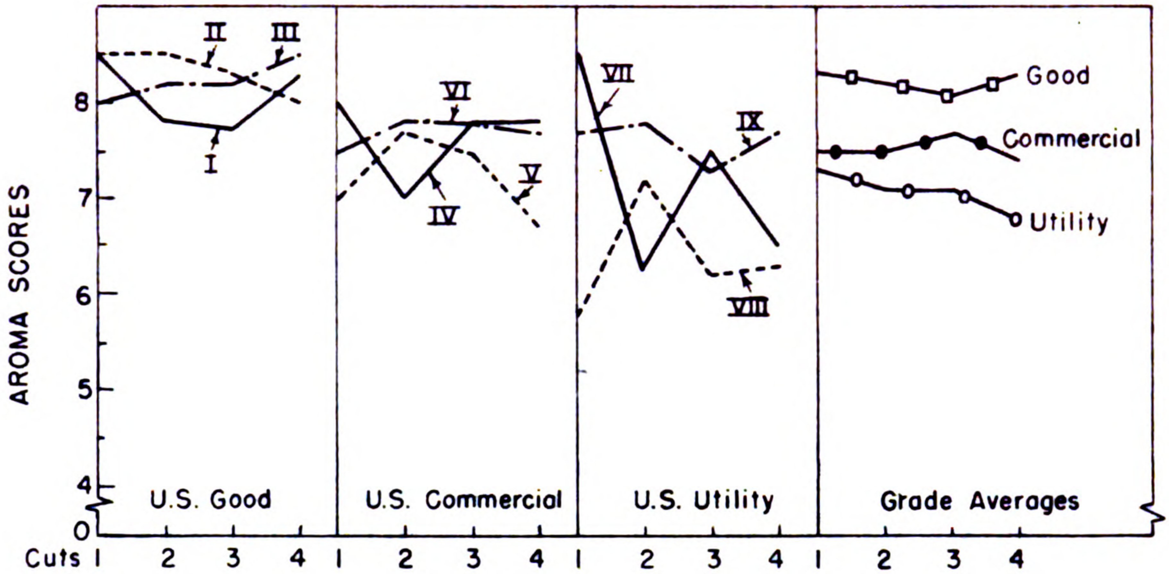

Figure 1. Aroma Scores for Cuts in Sequence from Anterior to Posterior End of the Longissimus Dorsi of Beef. Grade Averages Include the Scores for Cuts from Three Animals Within Each Grade. Roman Numerals Indicate Animal Numbers.

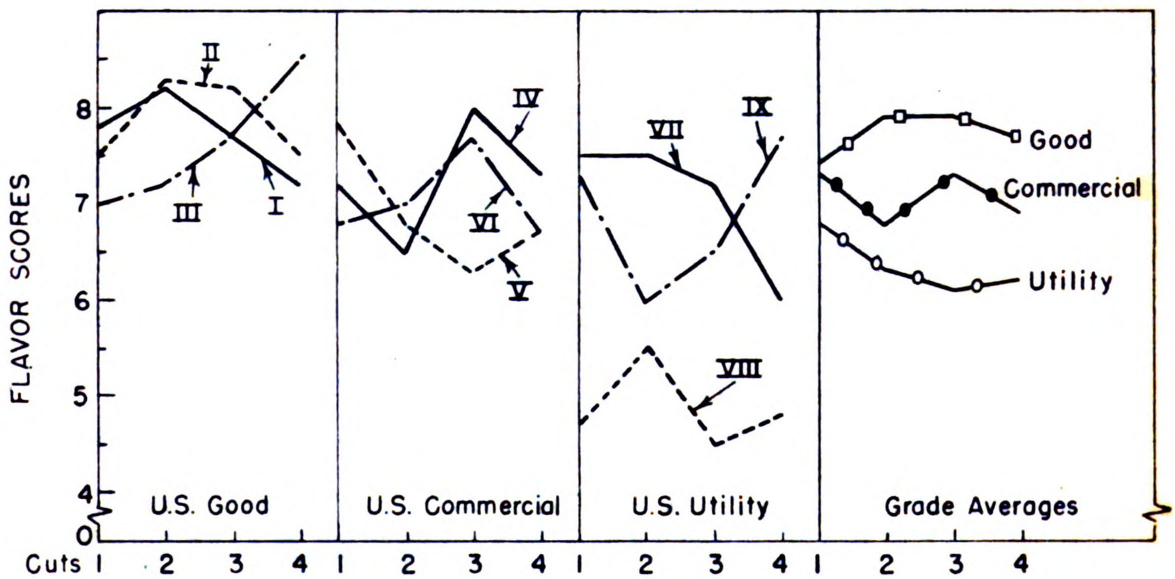

Figure 2. Flavor Scores for Cuts in Sequence from Anterior to Posterior End of the Longissimus Dorsi of Beef. Grade Averages Include the Scores for Cuts from Three Animals Within Each Grade. Roman Numerals Indicate Animal Numbers.

by the judges as "fishy", "old stew meat", "strong" and "foreign". Excluding scores for animal VIII, the average aroma scores for the Utility grade was 7.4, which is not appreciably lower than the average aroma score of 7.5 for the Commercial grade.

The average flavor score for Utility grade, excluding animal VIII, was 7.0 which was the same as the average flavor score for Commercial grade. (See Table 2). The descriptive terms used for flavor of animal VIII included "bitter", "old", and terms previously mentioned in describing aroma. One judge felt that the flavor was "rare and metallic". Flavor scores in Table 2 and Figure 2 point out differences among animals as well as variations from one grade to another. The differences in the average flavor scores were significant for animals and for grades at the 1 per cent level of probability. The average flavor scores according to grade were 7.7 for Good, 7.0 for Commercial and 6.3 for Utility.

Appearance and texture

Inasmuch as most of the fat covering had been removed from the cuts prior to cooking, the general external appearance of all cooked roasts was similar. The surfaces were dry and shiny, and distinct waviness of the muscle fibers was visible.

TABLE 2

Average Flavor Scores of Cuts in Sequence from the Anterior to the Posterior End of the Longissimus Dorsi of Beef

	Cut				
Animal	1	2	3	4	Average
			U.S. Good		
I	7.8	8.2	7.7	7.2	7.7
II	7.5	8.3	8.2	7.5	7.9
III	7.0	7.2	7.7	8.5	7.6
Average	7.4	7.9	7.9	7.7	7.7
			U.S. Commercial		
IV	7.2	6.5	8.0	7.3	7.2
V	7.8	6.8	6.3	6.7	6.9
VI	6.8	7.0	7.7	6.7	7.0
Average	7.3	6.8	7.3	6.9	7.0
			U.S. Utility		
VII	7.5	7.5	7.2	6.0	7.0
VIII	4.7	5.5	4.5	4.8	4.9
IX	7.3	6.0	6.5	7.7	6.9
Average	6.8	6.3	6.1	6.2	6.3

Light brown and grey brown were the terms most frequently checked by the judges to describe the internal appearance of roasts. There seemed to be no consistent difference in appearance among animals, grades or cuts with the exception of animal VIII which appeared to retain an iridescent pinkness not found in the other animals. There was no visible marbling in the roasts from this animal. The meat of animal VIII, in both the raw and cooked state, appeared very wet, slippery and soft in comparison with meat from other animals used in this study.

Scores for appearance and texture are found in Tables 3 and 4 and Figures 3 and 4. Analysis of variance for scores for texture and appearance showed no significant differences attributable to animals, grades or cuts.

Tenderness and shear force

Comparison of the average tenderness scores and shear force readings showed difference in tenderness among grades. Average tenderness scores and shear force readings are shown in Tables 5 and 6 and Figures 5 and 6.

Analysis of variance indicated that differences in tenderness, measured both subjectively and objectively, were attributable to grade and were significant at the 1 per cent level of probability. Variations in tenderness

TABLE 3

Average Appearance Scores of Cuts in Sequence from the Anterior to the Posterior End of the Longissimus Dorsi of Beef

	Cut				
Animal	1	2	3	4	Average
			U.S. Good		
I	7.5	7.8	7.0	7.7	7.5
II	5.8	7.2	6.8	8.0	6.9
III	6.8	6.7	7.8	7.5	7.2
Average	6.7	7.2	7.2	7.7	7.2
			U.S. Commercial		
IV	6.8	7.0	7.7	6.8	7.1
V	7.0	7.5	7.0	7.3	7.2
VI	7.0	8.0	7.0	7.2	7.3
Average	6.9	7.5	7.2	7.1	7.2
			U.S. Utility		
VII	8.5	8.0	7.7	6.2	7.6
VIII	5.5	7.0	6.5	7.3	6.6
IX	7.3	6.8	7.7	7.8	7.4
Average	7.1	7.3	7.3	7.1	7.2

TABLE 4

Average Texture Scores of Cuts in Sequence from the Anterior to the Posterior End of the Longissimus Dorsi of Beef

Animal	Cut 1	2	3	4	Average
			U.S. Good		
I	7.2	7.3	7.0	7.0	7.1
II	6.0	6.8	7.5	7.8	7.0
III	6.7	6.7	6.8	7.7	7.0
Average	6.6	6.9	7.1	7.5	7.0
			U.S. Commercial		
IV	6.7	6.8	7.7	7.3	7.1
V	7.3	7.5	7.2	7.2	7.3
VI	6.3	7.7	8.2	7.7	7.5
Average	6.8	7.3	7.7	7.4	7.3
			U.S. Utility		
VII	7.3	7.8	7.8	6.8	7.4
VIII	6.2	7.0	7.2	7.7	7.0
IX	7.7	6.8	7.3	7.8	7.4
Average	7.1	7.2	7.4	7.4	7.4

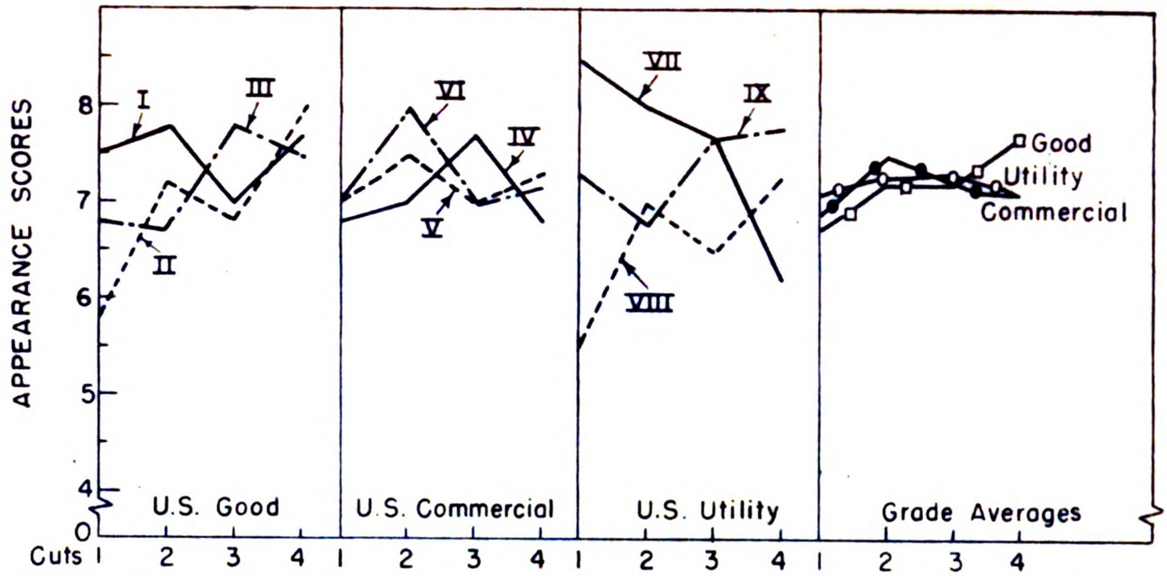

Figure 3. Appearance Scores for Cuts in Sequence from Anterior to Posterior End of the Longissimus Dorsi of Beef. Grade Averages Include the Scores for Cuts from Three Animals Within Each Grade. Roman Numerals Indicate Animal Numbers.

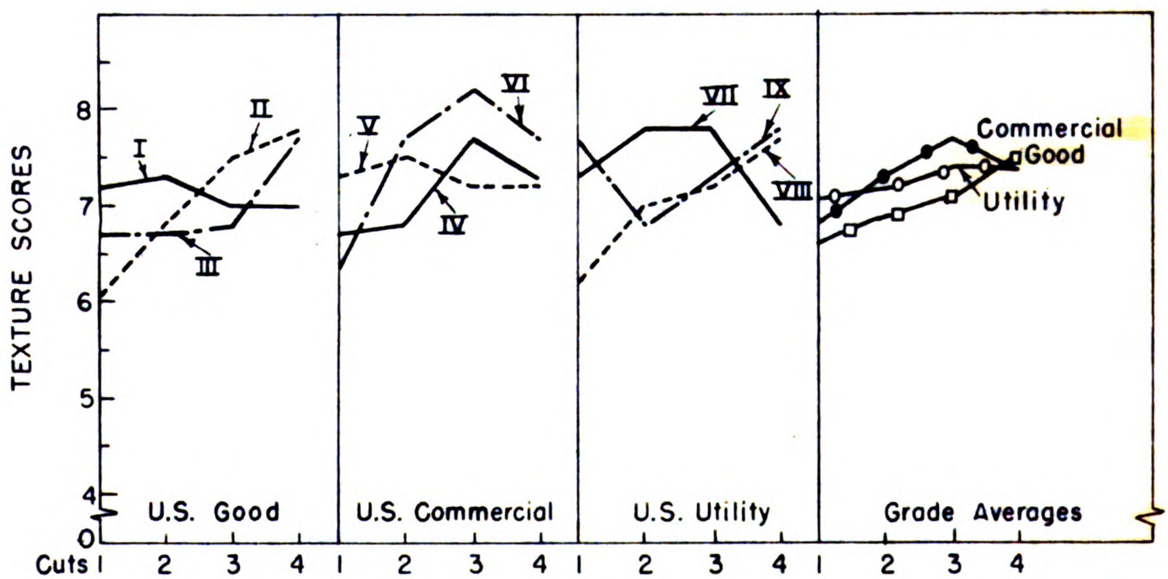

Figure 4. Texture Scores for Cuts in Sequence from Anterior to Posterior End of the Longissimus Dorsi of Beef. Grade Averages Include the Scores for Cuts from Three Animals Within Each Grade. Roman Numerals Indicate Animal Numbers.

TABLE 5

Average Tenderness Scores of Cuts in Sequence from the Anterior to the Posterior End of the Longissimus Dorsi of Beef

	Cut				
Animal	1	2	3	4	Average
			U.S. Good		
I	7.5	8.0	7.3	7.7	7.6
II	7.5	8.2	8.2	7.3	7.8
III	6.7	7.8	8.2	8.5	7.8
Average	7.2	8.0	7.9	7.8	7.7
			U.S. Commercial		
IV	7.0	7.8	7.8	6.7	7.3
V	7.3	7.3	7.2	7.5	7.3
VI	6.2	7.3	6.7	6.8	6.8
Average	6.8	7.5	7.2	7.0	7.1
			U.S. Utility		
VII	6.3	7.8	7.3	6.7	7.0
VIII	5.2	6.7	6.5	5.2	5.9
IX	7.2	7.0	6.3	7.5	7.0
Average	6.2	7.2	6.7	6.5	6.6

TABLE 6

Average Shear Force Pounds of Cuts in Sequence from the Anterior to the Posterior End of the Longissimus Dorsi of Beef

	Cut				
Animal	1	2	3	4	Average
		U.S. Good			
I	15.4	9.8	13.3	9.9	12.1
II	15.0	13.3	11.0	10.8	12.5
III	17.0	14.9	11.0	11.6	13.6
Average	15.8	12.7	11.8	10.8	12.8
		U.S. Commercial			
IV	17.0	15.4	14.8	15.2	15.6
V	18.0	15.6	13.8	10.5	14.5
VI	15.3	13.8	17.2	14.2	15.1
Average	16.8	14.9	15.3	13.3	15.1
		U.S. Utility			
VII	18.2	15.4	13.2	18.0	16.2
VIII	17.6	15.1	17.3	21.2	17.8
IX	16.8	17.0	15.0	17.4	16.5
Average	17.5	15.8	15.2	18.8	16.8

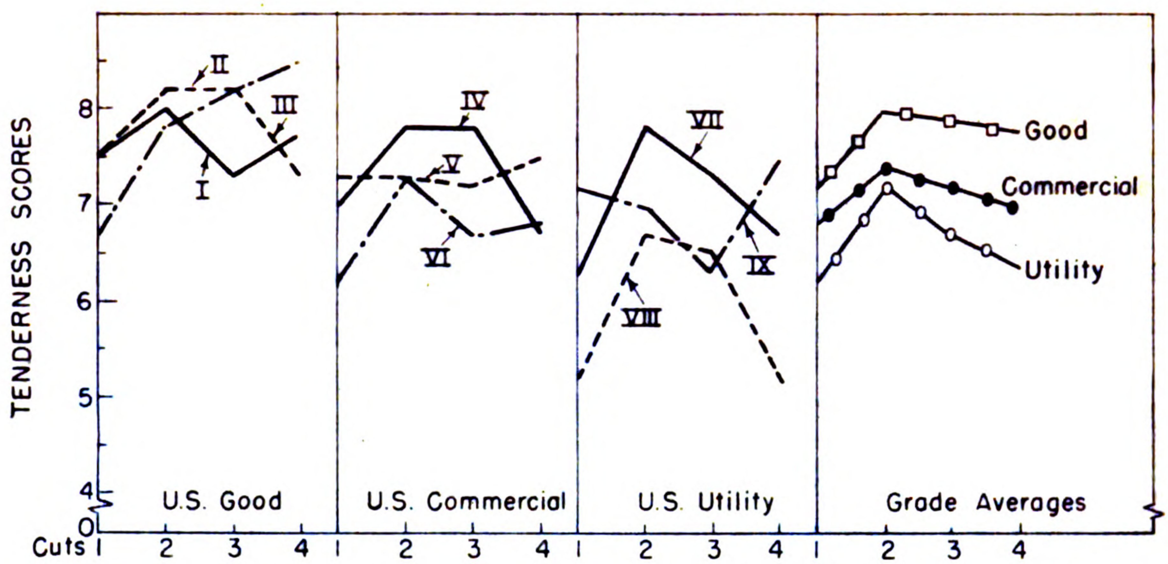

Figure 5. Tenderness Scores for Cuts in Sequence from Anterior to Posterior End of the Longissimus Dorsi of Beef. Grade Averages Include the Scores for Cuts from the Three Animals Within Each Grade. Roman Numerals Indicate Animal Numbers.

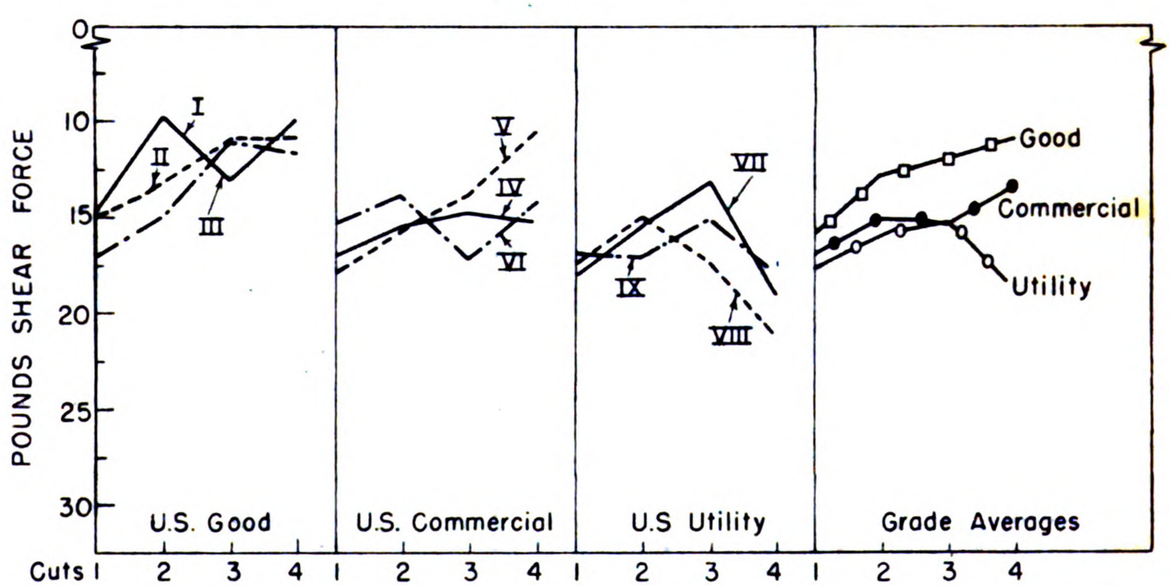

Figure 6. Pounds Shear Force for Cuts in Sequence from Anterior to Posterior End of the Longissimus Dorsi of Beef. Grade Averages Include the Readings for Cuts from Three Animals Within Each Grade. Roman Numerals Indicate Animal Numbers.

attributable to cut were significant at the 5 per cent level of probability. Interaction between grades and cuts was found to constitute a source of difference according to the averages of the shear force readings. The F value for this interaction between grades and cuts was significant at the 5 per cent level of probability.

The correlation between tenderness scores and shear force readings was -.65, which was significant at the 1 per cent level of probability. From this correlation it may be assumed that the objective test measured the same characteristic that the judges scored for tenderness.

Tables 5 and 6 show lower average tenderness scores for the four cuts and higher average shear force readings for the four cuts from animal VIII than for any of the other animals. The average scores for tenderness of Commercial and Utility grades are about the same when animal VIII is removed from the average of the Utility grade.

The average tenderness scores for grades are 7.7 for Good, 7.1 for Commercial and 6.6 for Utility. Average shear force readings for grades are 12.8 for Good, 15.1 for Commercial and 16.8 for Utility.

The tendency for the average scores of the anterior or Number 1 cut of each grade to be somewhat less tender than other cuts is apparent in Table 5 and in the grade averages of Figure 5. Average shear force readings for relative tenderness of cuts showed the same trend with the exception of the average of cut Number 4 of Utility grade, which was somewhat less tender than cut Number 1.

According to the average tenderness scores of cuts for the 3 animals within each grade, cut Number 2 generally appears to be slightly more tender than the other three cuts for each grade. Average shear force readings did not consistently follow the same pattern.

Juiciness and press fluid

Scores for juiciness and results of press fluid tests are shown in Tables 7 and 8 and Figures 7 and 8. Average juiciness scores and average press fluid percentages were similar for the three grades. The average juiciness scores for the three grades were 6.8 for Good, 6.7 for Commercial and 6.4 for Utility. The differences in juiciness scores and press fluid percentages showed no consistent pattern among animals or cuts.

Analysis of variance of average juiciness scores showed non-significant F values for animals, grades and cuts. According to analysis of variance for press fluid percentages, variation attributable to cuts was significant at the 1 per cent level.

TABLE 7

Average Juiciness Scores of Cuts in Sequence from the Anterior to the Posterior End of the Longissimus Dorsi of Beef

Animal	Cut 1	2	3	4	Average
		U.S. Good			
I	8.3	6.0	6.3	5.7	6.6
II	7.2	8.0	7.0	6.8	7.2
III	6.2	6.5	7.5	6.5	6.7
Average	7.2	6.8	6.9	6.3	6.8
		U.S. Commercial			
IV	7.3	5.7	7.5	5.0	6.4
V	8.3	8.2	7.7	6.3	7.6
VI	6.3	7.0	6.8	4.8	6.2
Average	6.3	7.0	7.3	5.4	6.7
		U.S. Utility			
VII	8.2	4.8	6.7	6.5	6.6
VIII	4.3	4.8	7.5	7.8	6.1
IX	7.5	5.7	6.3	6.0	6.4
Average	6.7	5.1	6.8	6.8	6.4

TABLE 8

Average Percentage Press Fluid of Cuts in Sequence from the Anterior to the Posterior End of the Longissimus Dorsi of Beef

	Cut				
Animal	1	2	3	4	Average
			U.S. Good		
I	36.0	31.6	30.8	26.4	30.0
II	24.0	35.2	25.6	24.8	27.2
III	29.6	35.6	31.2	29.6	31.6
Average	30.0	34.0	29.2	26.8	30.0
			U.S. Commercial		
IV	26.4	33.6	36.0	24.8	30.4
V	31.2	38.4	30.4	28.8	32.0
VI	23.2	36.0	34.4	28.0	30.0
Average	26.8	36.0	33.6	27.2	30.8
			U.S. Utility		
VII	26.0	27.2	32.0	32.8	29.6
VIII	26.0	32.0	40.0	36.8	33.6
IX	29.6	31.6	35.2	30.4	31.6
Average	27.2	30.4	35.6	33.2	30.8

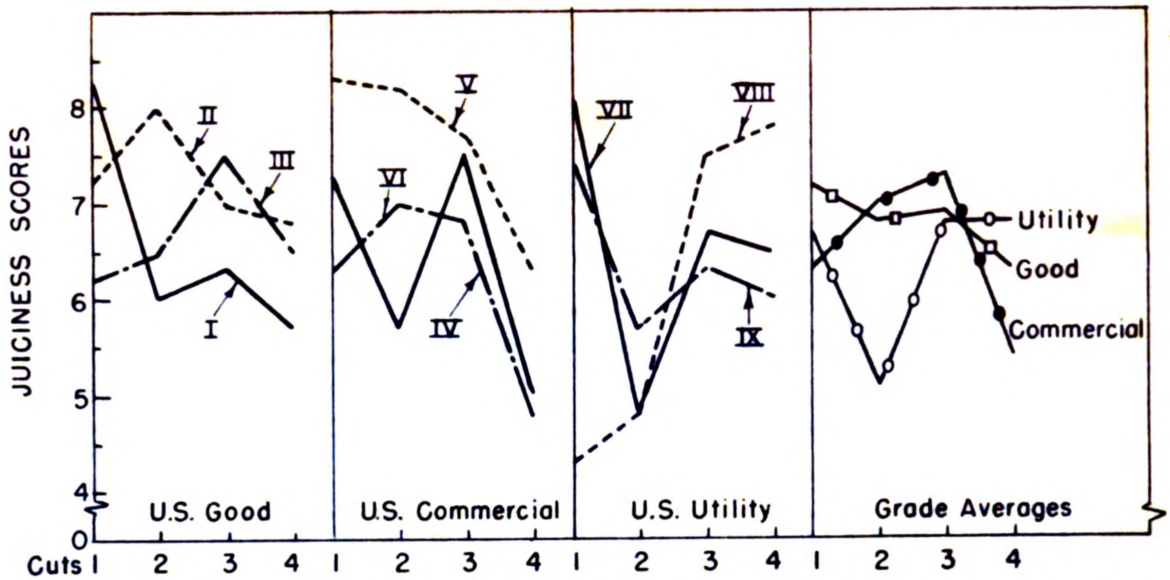

Figure 7. Juiciness Scores for Cuts in Sequence from Anterior to Posterior End of the Longissimus Dorsi of Beef. Grade Averages Include the Scores for Cuts from Three Animals Within Each Grade. Roman Numerals Indicate Animal Numbers.

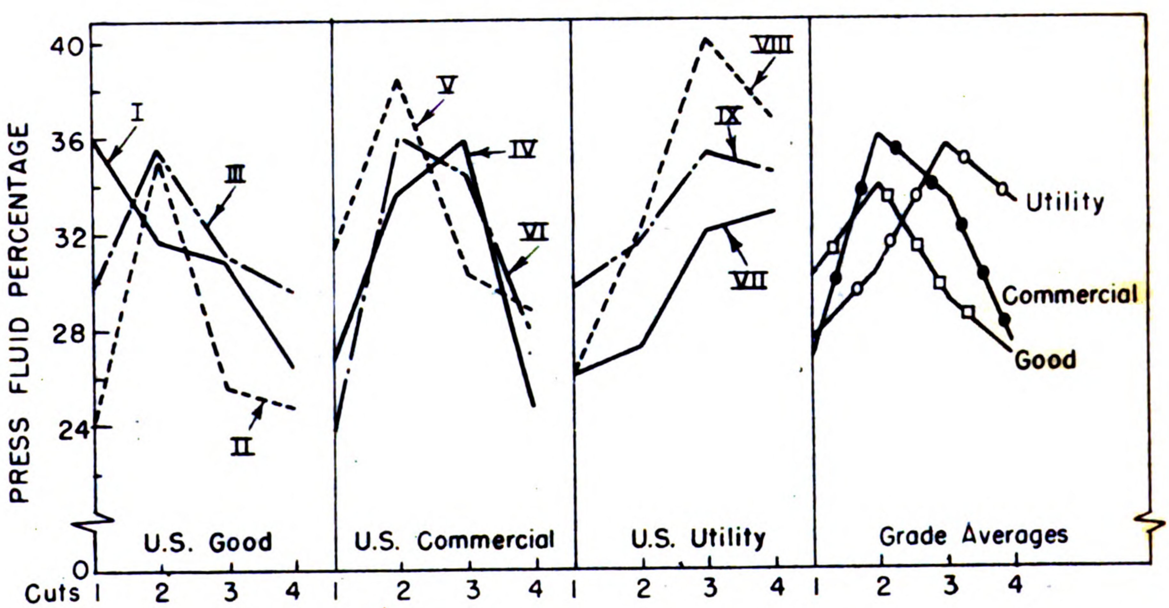

Figure 8. Press Fluid Percentages for Cuts in Sequence from Anterior to Posterior End of the Longissimus Dorsi of Beef. Grade Averages Include the Scores for Cuts from Three Animals Within Each Grade. Roman Numerals Indicate Animal Numbers.

Positive correlation between judges' scores and press fluid percentages was significant at the 5 per cent level of probability.

Cooking Weight Losses

Total cooking weight losses

The averages of the total cooking weight loss percentages of the cuts from the longissimus dorsi were very similar for the three grades studied. The variation in total cooking weight losses of the individual cuts for each animal of the three grades is shown in Table 9 and Figure 9. There was a tendency for the anterior, or Number 1 cut, and the posterior, or Number 4 cut, to have higher cooking weight losses than did the cuts from the two center positions. In Good and Commercial grades, the percentage losses were greater for cuts Number 1 and Number 4 than for cuts Number 2 and Number 3. However, this pattern of cooking losses was not evident in cuts from Utility grade animals.

Analysis of variance showed the differences in total cooking weight loss percentages attributable to cuts to be significant at the 1 per cent level of probability.

The lowest average cooking weight loss percentage was that of animal VIII, which was also noticeably different from the other animals in most palatability characteristics.

TABLE 9

Percentage Total Cooking Weight Losses of Cuts
from the Anterior to the Posterior End
of the Longissimus Dorsi of Beef

Animal	Cut 1	2	3	4	Average
			U.S. Good		
I	36.3	34.6	33.5	40.2	36.2
II	36.9	32.4	36.6	39.0	36.2
III	40.3	34.4	35.1	39.0	37.2
Average	37.8	33.8	35.1	39.4	36.5
			U.S. Commercial		
IV	39.7	33.0	30.7	42.7	36.5
V	40.1	30.7	33.8	31.9	34.1
VI	42.0	35.9	33.6	42.3	38.5
Average	40.6	33.2	32.7	39.0	36.4
			U.S. Utility		
VII	40.1	39.7	38.3	36.7	38.7
VIII	39.7	35.4	26.6	29.7	32.9
IX	36.5	38.7	36.8	42.6	38.7
Average	38.8	37.9	33.9	36.3	36.8

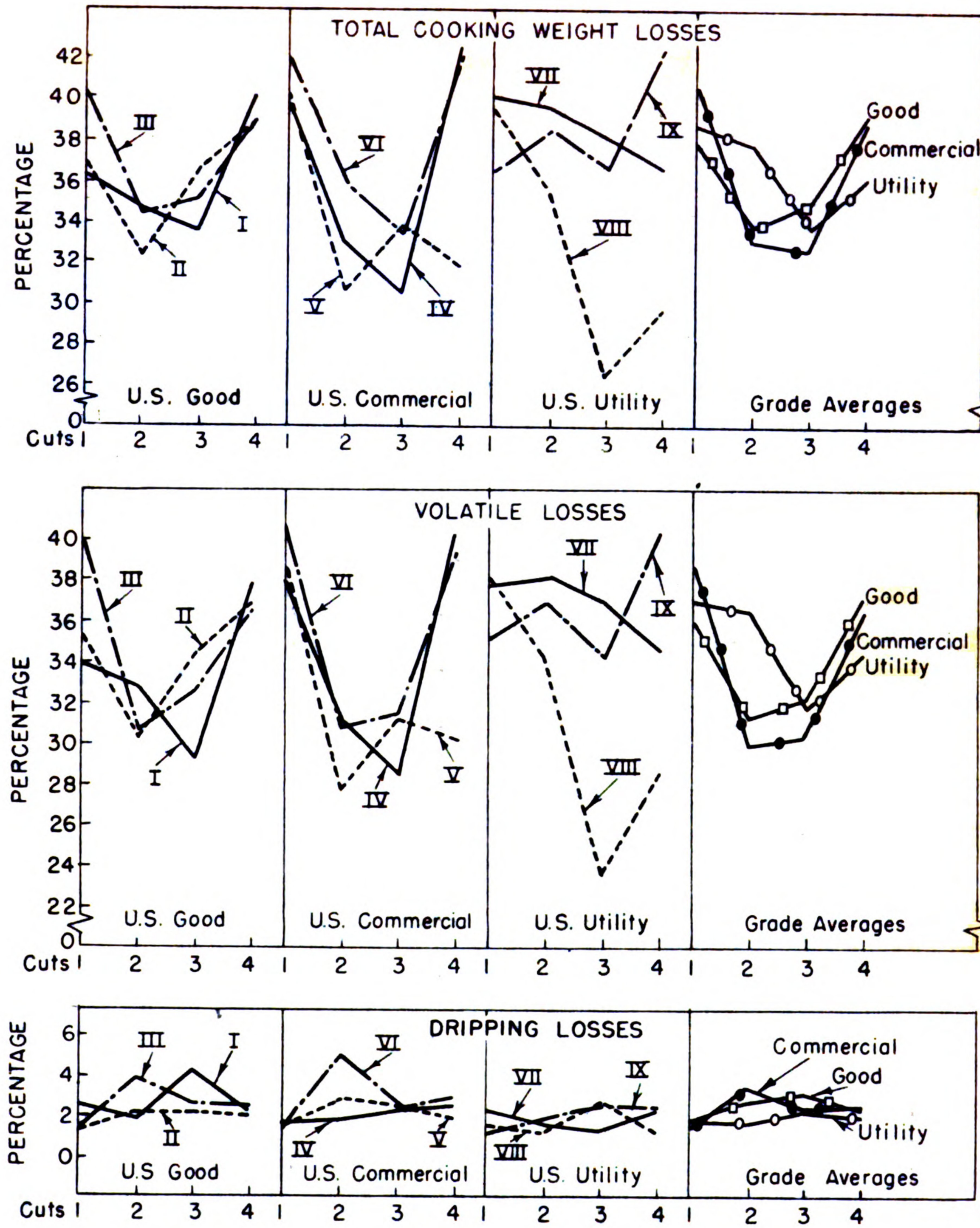

Figure 9. Percentages of Cooking Weight Loss for Cuts in Sequence from Anterior to Posterior End of the Longissimus Dorsi of Beef. Grade Averages Include the Percentage Loss for Cuts from Three Animals Within Each Grade. Roman Numerals Indicate Animal Numbers.

Dripping losses

Dripping losses, as indicated by Table 10 and Figure 9, did not vary significantly for animals, grades, cuts or interaction of grades and cuts.

The quantity of drippings was very small from many of the roasts, and frequently the drippings were dried on the roasting pans and could not be measured volumetrically. The drippings from the roasts of animal VIII were golden in color, and had a peculiar, viscous consistency. The odor was fishy and pungent, suggestive of ammonia and sulphur.

Volatile losses

The general pattern of volatile loss percentages was found to be similar to the total cooking weight loss percentages. Average percentages for volatile losses were comparable for the three grades studied as shown by Table 11 and Figure 9. The analysis of variance indicated the variation in volatile loss percentages, attributable to cut, were significant at the 1 per cent level of probability.

TABLE 10

Percentage Dripping Losses of Cuts in Sequence from the Anterior to the Posterior End of the Longissimus Dorsi of Beef

	Cut				
Animal	1	2	3	4	Average
			U.S. Good		
I	2.5	1.9	4.3	2.3	2.8
II	1.3	2.2	2.2	2.0	1.9
III	1.4	3.9	2.6	2.5	2.6
Average	1.7	2.7	3.0	2.3	2.4
			U.S. Commercial		
IV	1.6	1.9	2.3	2.5	2.1
V	1.5	2.9	2.6	1.9	2.2
VI	1.3	5.0	2.4	2.9	2.9
Average	1.5	3.3	2.4	2.4	2.4
			U.S. Utility		
VII	2.3	1.6	1.3	2.3	1.9
VIII	1.5	1.3	3.1	1.3	1.8
IX	1.4	1.8	2.5	2.4	2.0
Average	1.7	1.6	2.3	2.0	1.9

TABLE 11

Percentage Volatile Losses of Cuts in Sequence from the Anterior to the Posterior End of the Longissimus Dorsi of Beef

Animal	Cut 1	2	3	4	Average
			U.S. Good		
I	33.9	32.7	29.2	37.9	33.4
II	35.5	30.2	34.4	36.9	34.3
III	38.9	30.6	32.6	36.5	34.7
Average	31.6	31.2	32.1	37.1	34.1
			U.S. Commercial		
IV	38.1	31.1	28.4	40.2	34.5
V	38.6	27.8	31.2	30.1	31.9
VI	40.8	30.8	31.4	39.3	35.6
Average	39.2	29.9	30.3	36.5	34.0
			U.S. Utility		
VII	37.8	38.1	36.9	34.5	36.8
VIII	38.2	34.1	23.5	28.4	31.1
IX	35.1	36.9	34.3	40.2	36.6
Average	37.0	36.4	31.6	34.4	34.8

Edible Portion Cost

The edible portion cost of cooked meat is of great importance to the institution food service operator. In this study the factors which were considered in calculating the cost of cooked meat included trim and cooking losses. The labor and fuel used in the preparation of the meat were not included as part of the edible portion cost.

In determining the cost per pound of the uncooked muscles for each grade, the averages of the price quotations for stripped loin and the percentage of the stripped loin represented by the longissimus dorsi muscle were used as a basis. The cost per pound of the uncooked muscle was found to be $2.3028 for Good, $1.8046 for Commercial and $1.3071 for Utility. The total cost of the uncooked muscles for each grade was divided by the total cooked weight of the roasts in each grade to determine the cost per pound of the cooked meat. The cost per pound of cooked meat, calculated by this method, was $3.6118 for Good, $2.8640 for Commercial and $2.0655 for Utility. The comparative costs of the raw and cooked meat are shown in Table 12.

TABLE 12

Cost of Wholesale Cuts and Longissimus Dorsi
(per pound)

Grade	Stripped loin, Untrimmed	Longissimus Dorsi Uncooked	Longissimus Dorsi Cooked	Edible Portion, 2.5 ounces
Good	$1.3817	$2.3028	$3.6118	$.5644
Commercial	1.1730	1.8046	2.8640	.4475
Utility	.9150	1.3071	2.0655	.3228

The cost for a 2.5 ounce cooked portion, based on the calculations shown in Table 12, was $.5644 for Good, $.4475 for Commercial and $.3228 for Utility. The cost per pound of meat for this study, appears to be higher than that reported by other workers. In determining the cost per pound for both raw and cooked meat in this study, no value was assigned to the edible trim which remained after the removal of the longissimus dorsi from the wholesale cut. For practical use it is likely that the strip loin would be roasted in its entirety. Therefore, the cost per pound under these conditions would be somewhat less than that reported here.

After edible portion cost is considered, it is doubtful that the variations in palatability attributable to grade would justify the use of the longissimus dorsi muscle of a grade higher than Utility in commercial food establishments. However, the extremely erratic results from animal VIII of Utility grade would seem to indicate the need for further study of the palatability factors of samples from this grade. When data from animal VIII were omitted from the palatability evaluations, there appeared to be only very small differences in acceptability between Commercial and Utility grades. These differences in palatability were not great enough to justify the additional expenditure represented by the difference in edible portion cost between the two grades. Results of this study indicate the desirability of further investigation of the palatability characteristics of cuts from Utility grade. Data from this study do not give a sufficient basis for recommending the purchase of Utility grade strip loins for use in large quantity food service.

SUMMARY AND CONCLUSIONS

The objective of this study was to compare palatability, cooking weight losses and edible portion cost of cuts from the longissimus dorsi of U.S. Good, Commercial and Utility grades of beef.

The cuts from this muscle were roasted by constant oven temperature at 149° C (300° F) to an internal temperature of 80° C (176° F). Samples of the roasted meat were scored by six judges for aroma, appearance, flavor, texture, tenderness and juiciness. The score card scale was 0 to 10, with 10 high. Objective tests were also used for determining tenderness and juiciness.

The summary of results of the comparison of the three grades follows:

1. According to the averages of the judges' scores variations in aroma, flavor and tenderness appeared to be attributable to grade. Analysis of variance based on the averages of the shear force readings for tenderness indicated that differences in tenderness, attributable to grade, were significant at the 1 per cent probability level.

2. From the analysis of judges' scores, it appeared that there was little difference between grades in appearance, texture and juiciness. Results of press fluid tests did not show a significant difference in juiciness attributable to grade.

3. A highly significant negative correlation was found between shear force tests and tenderness scores.

4. A positive correlation, significant at the 5 per cent probability level, was found between press fluid tests and juiciness scores.

5. There was no significant difference attributable to grade in the average total cooking weight losses, volatile losses or drip losses.

6. The cost of a 2.5 ounce cooked portion of the longissimus dorsi muscle was $0.5644 for Good, $0.4475 for Commercial and $0.3228 for Utility grade.

7. From the results of this study it was apparent that the edible portion cost of roasted strip loin from U.S. Good beef carcass would be too expensive for use in most commercial food establishments.

8. When the data from animal VIII of Utility grade were omitted from palatability evaluations, Commercial and Utility grade samples were found to be quite similar.

The difference in edible portion cost of these two grades is great enough to warrant careful consideration. However, further studies of the acceptability of roasts from animals of the Utility grade would need to be made before sound recommendations would be feasible concerning the purchase of cuts from this grade for roasting.

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APPENDICES

APPENDIX A. STATISTICAL ANALYSES

1. Analysis of Variance Based on Aroma Scores.

Variance	Degrees of freedom	Mean squares
Total	35	
Animals	6	.59
Grade	2	3.86**
Cuts	3	.07
Grades and Cuts	6	.06
Error	18	.33

2. Analysis of Variance Based on Flavor Scores.

Variance	Degrees of freedom	Mean squares
Total	35	
Animals	6	2.02**
Grades	2	6.47**
Cuts	3	.04
Grades and Cuts	6	.22
Error	18	.43

**Significance exceeds the 1 per cent probability level.

3. Analysis of Variance Based on Appearance Scores.

Variance	Degrees of freedom	Mean squares
Total	35	
Animals	6	.51
Grades	2	.00
Cuts	3	.35
Grades and Cuts	6	.20
Error	18	.46

4. Analysis of Variance Based on Texture Scores.

Variance	Degrees of freedom	Mean squares
Total	35	
Animals	6	.12
Grades	2	.25
Cuts	3	.75
Grades and Cuts	6	.10
Error	18	.28

5. Analysis of Variance Based on Tenderness Scores.

Variance	Degrees of freedom	Mean squares
Total	35	
Animals	6	.69
Grades	2	3.65**
Cuts	3	.96*
Grades and Cuts	6	.05
Error	18	.30

6. Analysis of Variance Based on Pounds Shear Force.

Variance	Degrees of freedom	Mean squares
Total	35	
Animals	6	2.20
Grades	2	50.72**
Cuts	3	13.38*
Grades and Cuts	6	7.65*
Error	18	2.86

**Significance exceeds the 1 per cent probability level.

*Significance exceeds the 5 per cent probability level.

7. Analysis of Variance Based on Juiciness Scores.

Variance	Degrees of freedom	Mean squares
Total	35	
Animals	6	1.04
Grades	2	.82
Cuts	3	2.06
Grades and Cuts	6	1.52
Error	18	1.01

8. Analysis of Variance Based on Percentage Press Fluid.

Variance	Degrees of freedom	Mean squares
Total	35	
Animals	6	.90
Grades	2	.43
Cuts	3	4.05**
Grades and Cuts	6	2.07*
Error	18	.60

**Significance exceeds the 1 per cent probability level.

*Significance exceeds the 5 per cent probability level.

9. Analysis of Variance Based on Percentage Total Cooking Losses.

Variance	Degrees of freedom	Mean squares
Total	35	
Animals	6	22.33
Grades	2	3.35
Cuts	3	69.36**
Grades and Cuts	6	19.29
Error	18	12.15

10. Analysis of Variance Based on Percentage Volatile Losses.

Variance	Degrees of freedom	Mean squares
Total	35	
Animals	6	19.51
Grades	2	2.53
Cuts	3	74.69**
Grades and Cuts	6	16.25
Error	18	9.90

**Significance exceeds the 1 per cent probability level.

11. Analysis of Variance Based on Percentage Drip Losses.

Variance	Degrees of freedom	Mean squares
Total	35	
Animals	6	.53
Grades	2	1.06
Cuts	3	1.63
Grades and Cuts	6	.62
Error	18	.63

APPENDIX B. SCORE SHEET

SCORE CARD FOR MEAT

ample No. ________ Scorer ________
nimal 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	
ma												___ mild ___ sharp ___ strong ___ faint ___ foreign
earance												___ light brown ___ dark brown ___ grey brown ___ light grey ___ dark grey ___ irridescent
vor												___ mild ___ mellowed ___ rich ___ strong ___ old ___ bitter ___ acid ___ salty ___ sweet
ture	Extremely fine, no stringy-ness	Very Fine	Fine	Medium Fineness Plus		Minus	Fair	Coarse & stringy	Very coarse stringy	Extremely coarse stringy		___ powdery ___ gelatinous ___ separation of fiber
derness	Extremely tender	Very tender	tender	Medium Tenderness Plus		Minus	Fair	Tough	Very Tough	Extremely tough		[ ] No. of chews
ciness	Extremely juicy	Very juicy	Juicy	Medium Juiciness Plus		Minus	Fair	Dry	Very Dry	Extremely Dry		

APPENDIX C. COST DATA

Price Quotations of Three Grades of Stripped Loin
June 1, 1952

Packing Company	Cost Per Pound		
	U.S. Good	U.S. Commercial	U.S. Utility
Swift	$1.370	$1.160	$ .930
Armour	1.369	1.154	.904
Phaelzer Bros.	1.406	1.205	.911
Average	1.382	1.173	.915

Costs of Cooked Portions

U.S. Grades	Cost of Cooked Portions		
	2 ounce	2.5 ounce	3 ounce
Good	$.4515	$ .5644	$ .6771
Commercial	.3580	.4475	.5370
Utility	.2582	.3228	.3873

APPENDIX D. STORAGE DATA

Storage Data for Sides of Steer Beef From Which Longissimus Dorsi Muscles were Dissected for this Study

Animal Number	Grade	Side	Packing Company Source	Date Killed	Purchase Weight of Side	Shrink.[1]
I	Good	Right	Plankinton	5-21-52	332#	7#
II	Good	Right	Armour	5-21-52	298#	5#
III	Good	Left	Armour	5-21-52	313#	5½#
IV	Commercial	Left	Armour	6-11-52	306#	9#
V	Commercial	Left	Armour	6-11-52	298#	7-3/4#
VI	Commercial	Left	Armour	6-11-52	300#	9#
VII	Utility	Right	Armour	6- 4-52	280#	7#
VIII	Utility	Left	Armour	7- 2-52	230#	11#
IX	Utility	Right	Armour	6- 4-52	271#	7#

[1] Shrinkage includes evaporation and dripping losses from sides of beef ripened 13 days at approximately 2° C (35° F).