EFFECT OF GRADE AND INTERNAL TEMPERATURE ON PALATABILITY AND COOKING LOSSES OF TOP ROUND ROASTS COOKED IN A GAS-FIRED INSTITUTIONAL ROAST OVEN

by

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INTRODUCTION

A vast amount of research concerning the roasting of meat has been undertaken in the past fifty years. For the most part, comparatively small cuts of meat and either laboratory or household equipment was used. Few studies have been done on the roasting of meat in large quantities. Since meat is the most expensive item in the budget, the food service manager is interested in methods of roasting that will yield the largest possible number of servings, and at the same time, assure a highly acceptable product.

An observed tendency in many food services is that of overcooking meat due to inadequate methods of determining doneness. Length of cooking time, in minutes per pound, is a method often used. At best this procedure will serve only as an approximate guide for meat timetables available are based on data obtained from roasting small cuts of meat. In quantity preparation, additional factors affecting the length of cooking time that must be considered are size of the cut, oven load, and grade of meat. Although extended cooking of meat beyond the desired degree of doneness may increase tenderness, the effect of this practice on cooking losses and juiciness is important. Shrinkage during cooking affects not only the appearance and palatability, but also the cost of the meat as served. This may mean the difference between profit and loss, and emphasizes the need for roasting time schedules adapted specifically for institutional use.

In planning work schedules, information on length of cooking time is needed, also. When roast beef appears on the menu, it frequently is cooked the day before with subsequent reheating just prior to serving. With more accurate cooking timetables, work schedules could be planned to include the preparation of roasts on the day to be served. Thus, the possibility of decreased palatability and the extra time required for reheating the meat would be eliminated.

Economy-wise, the initial cost of the meat is important. Cost per pound will vary depending upon the location of the cut in the carcass. However, for a given cut, the variation in cost per pound is dependent primarily upon grade; higher grades commanding higher prices. Quality, as a basis for grading beef, is concerned with those factors that affect the palatability of the cooked meat. In general, meat from high grade carcasses is considered to be more palatable, provided the cooking process has been done properly.

This study was conducted to determine the effect of grade and internal temperature on the palatability and cooking losses of top round roasts cooked in a gas-fired institutional roast oven. Cuts of U. S. Choice and U. S. Good grades were cooked to internal temperatures of 80° C. (176° F.), 85° C. (185° F.), and 90° C. (194° F.). Eighty degrees Centigrade is a recommended internal temperature for cooking beef well-done. The temperatures 85° and 90° C., were selected as additional internal temperatures representing well-done beef.

REVIEW OF LITERATURE

Grading of Beef

Development of Grades. Federal standards for carcass grades of beef became effective in 1927 (Official United States standards for grades of carcass beef, 1956). Grades, as they were recognized at that time, included U. S. Prime, U. S. Choice, U. S. Good, U. S. Medium, U. S. Common, U. S. Cutter, and U. S. Low Cutter. The first amendment to the official standards in 1939 established a single standard for grading of steers, heifers, and cow beef, based on similar characteristics inherent in all three classes. This amendment also changed grade designations from U. S. Medium, U. S. Common, and U. S. Low Cutter to U. S. Commercial, U. S. Utility, and U. S. Canner, respectively.

A second amendment, in 1950, combined U. S. Prime and U. S. Choice grades into one grade designated as U. S. Prime. Old U. S. Good was renamed U. S. Choice. The U. S. Commercial grade was divided into two grades; the top half of the grade, including beef produced from young animals, was designated as U. S. Good and the grade term, U. S. Commercial, was retained for the remainder of beef included in the original grade. An amendment in 1956 divided U. S. Commercial into two grades. U. S. Standard was the grade name for beef produced from young animals, whereas the name, U. S. Commercial, was given to beef produced from mature animals.

Bases for Grades. Grading of beef carcasses was based primarily on the factors, conformation, finish, and quality. Maturity of the animal from which the meat was produced was an additional factor affecting grade designation. Standards for grades were intended to describe the characteristics of carcasses representative of the midpoint of each grade (Official United States standards for grades of carcass beef, 1956).

Conformation. Conformation was the term used to denote the general shape or blockiness of the carcass and was dependent on the skeleton, the depth of flesh, and the degree of finish. For good conformation, choice cuts from the loin, rib, and round were expected to have full muscles and a large proportion of meat to bone. Although the level of nutrition would affect conformation, breeding was the most important determinant.

Finish. Carcass finish was concerned specifically with the amount, quality, and distribution of fat. Good distribution required that the carcass have a smooth, even external fat covering and abundant internal marbling. Firm, flaky fat implied good quality.

Quality. This factor was limited to carcass characteristics that would affect the palatability of the cooked meat. Quality as an overall factor was based, to a certain extent, on the conformation and degree of finish of the carcass. Firm, fine-grained muscle tissue was considered to be an indication of quality. Although color of meat was not specifically an indication of quality, it was considered in grading.

Maturity. Maturity of the animal was included in the standards for some grades. Advancing maturity generally was associated with decrease in thickness of the muscle and increased irregularity in conformation and finish of the carcass. Also, in any specified grade, the degree of finish and marbling would increase progressively with age. Maximum age limitations for U. S. Prime, U. S. Choice, U. S. Good, and U. S. Standard grades were 36 months, 42 months, 48 months, and 48 months, respectively (Official United States Standards for grades of carcass beef, 1956). U. S. Commercial grade was restricted to carcasses with indications of more advanced maturity than permitted in the U. S. Good and U. S. Standard grades. No age limitations were specified for U. S. Utility, U. S. Cutter, and U. S. Canner.

Palatability Factors of Beef

Flavor and Aroma. Aroma generally is considered to be a part of flavor. Satorius and Child (1938a) indicated a high correlation coefficient, 0.7, between these two factors when they were scored separately on the grading sheet. Feeling factors in the mouth, such as greasiness, were considered by some workers to be a part of flavor, also (Crocker and Platt, 1937).

A small but statistically significant association between degree of fatness and the desirability and intensity of flavor of lean beef was noted by Barbella et al. (1939). Jacobson and Fenton (1956) found no consistent effects of increase in fat on aroma; however, flavor of meat from animals with a higher muscle fat content was preferred over unfinished beef. According to Simone et al. (1958), flavor of beef appeared to be more closely associated with intramuscular fat than with total fat.

Although these studies demonstrated that flavor of beef may be attributed, in part, to degree of finish, other workers have produced contradictory results. In flavor and aroma, Nelson et al. (1930) reported unfinished roasts to be scored higher than roasts from fattened animals, whereas Masuda (1955) showed average aroma and flavor scores of roasts from U. S. Commercial grade beef to be significantly higher than scores from U. S. Good and U. S. Choice grade roasts.

Hammond (1940) suggested that flavor of meat was closely related to its color. As the color of meat darkened with age and exercise of the muscle, the flavor of the cooked meat became more pronounced. In considering the effect of age of the animal on the palatability of beef, Jacobson and Fenton (1956) found that scores for aroma and flavor tended to decrease after the animals reached 48 weeks of age. The ages for heifers included in the study were 32, 48, 64, and 80 weeks.

Tenderness. Fat, connective tissue content, texture of muscle, and age of the animal have been considered to affect tenderness of beef. Whereas each of these factors might have a definite role, it would appear that a balance of all may be essential in producing potentially tender meat.

Amount, character, and distribution of connective tissue as related to tenderness of beef muscle was studied by Hiner et al.

(1955). It was noted that both collagenous and elastic fibers were abundant in samples with a high resistance to shearing. As resistance to shearing decreased, the quantity of these fibers present decreased. The diameter and length of the elastic fibers in younger animals were noticeably smaller than fibers in older animals, whereas collagenous fibers increased somewhat with maturity. These workers maintained that this increase in size could be a factor in the increase of shearing resistance found to be associated with maturity. When marbling was evident, the collagenous fibers formed more of a loose network between muscle bundles; in muscles with less fat, the collagenous fibers appeared bunched. These workers considered that the meat from well-fattened animals usually being more tender than that from lean animals might be explained by the dispersing effect of intramuscular fat. Husaini et al. (1950) reported a similar relationship between marbling of beef and tenderness, and a very significant correlation coefficient between beef carcass grades and tenderness values.

Fat content of steaks from U. S. Choice, U. S. Good, and U. S. Commercial grade yearling steers was determined by estimation of marbling, physical separation, and ether extract by Cover et al. (1956). Since none of the correlations obtained between fat determination methods and tenderness were very high, they concluded that fatness alone was not responsible for a marked increase in tenderness. Nelson et al. (1930) found that fattened beef animals scored higher in tenderness than unfinished ones. They further maintained that tenderness was not greatly influenced by age. With increase in age of the beef animal from 32 to 80 weeks, Jacobson and Fenton (1956) reported that fat content of the meat increased; however, shear values tended to increase, also. Tenderness scores became lower after the animals reached 48 weeks of age.

Texture and diameter of muscle fibers have been found to be related to tenderness of beef muscle. Brady (1937) explained that the texture of muscle was dependent upon the number of muscle fibers per bundle; a greater number of fibers per bundle indicated finer texture and more tender meat.

Smaller fiber diameter was demonstrated by Hiner et al. (1953) to be correlated with greater tenderness. With increasing age of the animal there was a consistent increase in average muscle fiber diameter for all beef muscles studied. Satorius and Child (1938b) reported that shear force was lower, muscle-fiber diameter was smaller, and number of fibers per bundle was larger for steers than for cows. These same workers found no difference in shear force, either of cooked or raw meat, when comparing heifers of U. S. Medium and U. S. Good grades.

Juiciness. The presence of fat around and within the muscle is considered to increase the juiciness of cooked meat. Nelson et al. (1930) compared palatability factors of feeder and fattened beef animals. In judging for quality in juiciness there was very little difference between the two groups. However, for quantity of juice, a greater difference was noted; the fattened animals received higher scores than the feeders. Analysis of data by Barbella et al. (1939) revealed a statistically significant association between degree of fatness of beef animals and quality and quantity of juice obtained. Drying of the centers of beef roasts by cooking was found by Thille et al. (1932) to be less in fat-covered than in lean roasts.

Varying theories have been given in an attempt to explain the effect of fat on juiciness. Wanderstock and Miller (1948) determined the effect of grade on palatability. Averages for the five lots of animals included in the study indicated that the more finish a carcass carried, the smaller was the measured amount of expressible juice in raw meat. These workers considered that fat particles in the meat tended to inhibit the loss of press fluid. Therefore, they concluded that beef having a higher degree of finish should be juicier when cooked. This conclusion was borne out in the palatability scoring; for roasts from animals receiving the lowest grades were poorer in quality of juice and juiciness than any of the others.

Specially prepared samples of beef with known added quantities of suet were used by Siemers and Hanning (1953) to study factors influencing juiciness. With increasing percentages of suet, loss of the water phase of juice from blended samples of lean and suet were significantly decreased. Suet-covered samples gave similar results, but judges did not detect the lower juice losses in these samples. The major part of the juice retention caused by suet content was attributed to slower rate of heat transfer in the suet and connective tissue present in the samples.

Cover et al. (1956) reported that juiciness scores for steaks from U. S. Choice, U. S. Good, and U. S. Commercial grade steers were more closely correlated with ether extract than with other measures of fatness. However, since none of the coefficients were high, they considered that fatness alone was not responsible for increase in juiciness. Other factors such as ration and age were suggested to have an influence on the eating quality of meat.

Increasing the fat content of meat by feeding animals at a higher level of nutrition was found by Jacobson and Fenton (1956) to have no consistent effects on juiciness of cooked beef. Also in this study it was shown that fat content of meat increased with age and was accompanied by a small but consistent decrease in moisture. Scores for juiciness tended to decrease after 48 weeks of age.

Effect of Internal Temperature on Palatability of Beef

Flavor and Aroma. Generally, the flavor of meat is developed and enhanced by cooking. Crocker (1948) stated that the flavor formed in meat during cooking was due to chemical changes taking place in the fibers rather than in the juice, and consisted more of odor than of taste.

Howe and Barbella (1937) ascribed cooked meat flavor, in part, to heating extractive products possibly resulting from the disintegration of proteins and lipids. The quality and the quantity of these products formed were considered to be related to the extent and duration of cooking. More recent studies have further acknowledged a relationship between degree of doneness in meat and the flavor and aroma factors. Veal roasts were cooked by Paul and McLean (1946) to internal temperatures ranging from 71° C. to 88° C., and flavor scores increased at the higher end point temperatures. Willhoite (1957) reported that beef roasts cooked well-done were rated higher in aroma and flavor than those roasted to the medium-done stage. Although the flavor of beef may be improved by increasing the degree of doneness, excessive cooking may be detrimental to this quality. After beef pot roasts had reached 90° C. internal temperature, an additional hour of cooking was demonstrated by Aldrich and Lowe (1954) to result in a decline of aroma and flavor scores for the roasts.

Tenderness. During the cooking process, protoplasmic proteins of muscle fiber start to coagulate and as coagulation progresses, the fibers become hard and tough. At the same time, the collagenous connective tissue starts to soften and this process continues with further heating. According to Lowe (1955) the tenderizing of meat by cooking depends upon the balance between the extent of softening of connective tissue and the hardening of muscle fibers.

Ramsbottom et al. (1945) determined the tenderness of 25 representative beef muscles, both raw and cooked. Most of the muscles used, decreased in tenderness on cooking. This decrease in tenderness was attributed to coagulation of muscle protein together with shrinkage and hardening of the fiber. The effect of degree of coagulation on shear force values of semitendinosus muscle of beef was reported by Satorius and Child (1938c). One of four comparable cuts was analyzed raw and the remaining three were cooked to internal temperatures of 58°, 67°, and 75° C. Tenderness increased with coagulation up to 67° C. At 75° C. the muscle was found to be less tender. These workers maintained that increase in tenderness at 58° C. and 67° C. was attributable to the greater effect of collagen hydrolysis, whereas decreased tenderness at 75° C. was the result of more complete coagulation and hardening of muscle protein.

Juiciness. The internal temperature to which meat is cooked has been reported to affect not only the quantity of juice expressed, but also the quality of the juice. Noble et al. (1934) demonstrated that beef ribs cooked to 61° C. yielded more press fluid than those cooked to 75° C. The larger quantity of juice was found to be richer in solids, total nitrogen, and in one case, also richer in coagulable nitrogen.

Similar results with the semitendinosus muscle of beef were acknowledged by Child and Fogarty (1935). Moisture content of the press fluid varied directly with internal temperature; 93.57 per cent moisture at 75° C. and 91.37 per cent at 58° C. They explained that with increased internal temperature, coagulation of muscle protein removed the coagulable nitrogen fraction, thus yielding a less concentrated press fluid. A more recent study by Paul and McLean (1946) showed the effect of increasing internal temperatures on veal roasts. Palatability scores for juiciness decreased with each increment of internal temperature.

Roasts cooked to the same internal temperature might vary in juiciness. Length of cooking time as affected by style of cut and oven temperature appeared to be a determining factor. Child and Esteros (1937) reported that standing beef rib roasts had a larger quantity and richer quality of juice than rolled roasts when both styles of cut were cooked to the same internal temperature. Total cooking losses and cooking time were greater for the rolled roasts. Constant oven temperatures of 250° F. and 300° F. were used by Griswold (1955) to cook beef rounds to an internal temperature of 85° C. Roasts cooked at 300° F. were significantly juicier than those cooked at 250° F. and also required much less cooking time per pound.

Factors Affecting Cooking Losses of Roasts

During cooking of meat, the total loss that occurs includes both dripping and volatile losses. Dripping losses are composed of fat, water, salts, and both nitrogenous and non-nitrogenous extractives. Volatile loss is due mainly to the evaporation of water. It includes small amounts of aromatic substances and may include volatile decomposition products of fat and protein

(Lowe, 1955).

Grade. Fat content of meat is related to the nature of cooking losses and is less related to the extent of losses. Higher grades of beef generally indicate a thicker fat covering and a greater amount of intramuscular fat.

Grindley et al. (1901) concluded that fat loss was directly related to, and water loss was inversely related to the fat content of beef. These conclusions have been verified by other studies. Well-fattened, high-grade beef ribs were found by Alexander (1930) to shrink more by drippings and less by evaporation than lean low-grade ribs. Roasts from fattened beef animals were reported by Nelson et al. (1930) to have a higher dripping loss than lean roasts and also a greater total cooking loss. These workers believed that the heavier layer of fat over roasts from fattened animals tended to prevent volatile water losses. The rendering out of surface fat was considered by Thille et al. (1932) to be responsible for greater total cooking losses in beef roasts that had a heavier fat covering.

In comparing U. S. Medium and U. S. Good grade heifers, Satorius and Child (1938b) noted no difference in total shrinkage attributable to the grades. Griswold (1955) found that beef round of U. S. Prime grade consistently yielded a smaller percentage of total cooking loss than rounds of U. S. Commercial grade when the meat was prepared by roasting and by braising.

In a study conducted by Willhoite (1957) U. S. Choice grade beef roasts averaged less total shrinkage than cuts of U. S.

Standard grade. Analysis of results seemed to indicate that the degree of cooking affected the nature of the cooking losses. The percentage of fat in total drippings was greater for the U. S. Choice roasts cooked to 170° F. than for roasts of the same grade cooked to 150° F.; whereas, no appreciable difference was noted in the percentage of fat loss for U. S. Standard grade roasts cooked to the same internal temperatures. U. S. Standard grade roasts, however, had greater volatile losses at the higher internal temperature whereas evaporation losses did not increase for U. S. Choice roasts cooked to the two stages of doneness.

Aging. The influence of aging on shrinkage of legs of lamb during cooking was demonstrated by Alexander and Clark (1934). Paired roasts, ripened for varying lengths of time, were cooked by the same method to the same internal temperature. Increasing the length of aging time was found to decrease the cooking losses and shorten the time required for roasting. Wierbicki et al. (1956) suggested that decrease of shrinkage of beef during cooking might be related primarily to the degree of hydration of meat proteins during aging.

During the ripening period beef ordinarily is held in cold storage at a temperature just above freezing. A recent study determined the effect of higher storage temperatures on the quality and cooking losses of beef (Sleeth et al., 1957). The results indicated that aging at a higher temperature (68° F.) for shorter periods of time greatly aided in reducing weight losses during cooking.

Style of Cut. The surface area of a piece of meat of a given weight depends on the style or shape of the cut. Compact pieces with small surface area have smaller cooking losses than irregularly-shaped pieces with greater surface area (Lowe, 1955). However, several studies have shown length of cooking time to be related to cooking losses when different styles of cuts were compared.

Alexander (1931) demonstrated that short-rib, standing beef roasts and boned and rolled beef rib roasts required more minutes per pound to cook than long-rib standing roasts. In addition to longer cooking time, greater total cooking losses were noted for the boned and rolled roasts. A comparison of shrinkage and cooking time of standing and rolled beef rib roasts showed that standing roasts shrank less and cooked more rapidly than rolled roasts (Child and Esteros, 1937). Alexander and Clark (1939) reported similar results with beef rib roasts. However, when shrinkage of the rolled roasts was expressed as percentage of the weight of the cuts before boning and rolling, it was somewhat less than that of the standing roasts. When cooking loss was determined in this manner, these workers believed that the greater relative shrinkage of standing roasts came from bone and connective tissue rather than from edible portion. Paul et al. (1950) reported similar cooking losses for bone-in and boneless beef cuts, thus indicating that bone did not contribute noticeably, if at all, to total shrinkage.

Weight of Cut. Length of cooking time, in minutes per pound, has been found to vary inversely with the weight of the cut. Total surface area of a roast does not increase proportionately with increase in weight. Therefore, with shorter cooking time and less surface area per unit weight, it might be expected that the percentage of total cooking losses would be less in large roasts. However, contradictory results have been reported in the literature.

With increase in weight of beef roasts, Child and Esteros (1937) found that total cooking time was longer, but cooking time per pound became shorter. The percentage of total cooking losses was less for large roasts than for the small roasts. In the preparation of veal roasts obtained from small, medium, and large calves it was observed that, while cooking time in minutes per pound decreased, cooking losses increased slightly with size of animal (Paul and McLean, 1946). Sandson (1955) determined the effect of size of beef roasts on total cooking losses and time of cooking. One roast of each pair was cooked whole and the other was cut into two roasts, one being one-third and the other two-thirds of the size of the whole roast. The small roasts had the least amount of shrinkage and the medium-sized roasts the most. More cut surface and less fat covering were factors considered to be responsible for the greater total cooking losses in the medium-sized roasts.

Oven Temperature. Although lower oven temperatures require longer cooking times, total cooking losses generally are greater at higher oven temperatures. Increase of oven temperature increases both the rate and extent of cooking loss (Lowe, 1955).

Two constant oven temperatures, 257° F. and 311° F., were employed by Cline et al. (1932) in roasting beef. The higher temperature increased total cooking losses and shortened the time per pound required for cooking. These results with beef roasts were further substantiated in a study by Cline and Foster (1933).

In early work, searing of meat at the beginning of the roasting period was thought to reduce the total cooking losses. This reduction in loss was attributed to retention of the meat juices by the crust formed during searing. This theory, however, was disproved in later studies. Cline and Swenson (1934) studied searing and constant temperature methods in roasting of beef, lamb, and pork. Roasts were seared at 260° C. and finished at 125° C. These workers found that leg of lamb and pork loin roasts prepared by the searing method had similar or greater cooking losses than those cooked at constant oven temperatures of 302°, 329°, and 347° F. For all cuts studied, increase in oven temperature resulted in greater cooking losses. The use of paired cuts in comparing constant temperature roasting with methods that included an initial sear led Alexander and Clark (1939) to confirm that searing in itself did not reduce shrinkage. They maintained that, whether beef was roasted by searing or constant temperature, the most important factors affecting losses were the average oven temperature and the cut used.

Internal Temperature. If all other conditions of cooking are standardized, the more well-done beef is cooked, the greater will be the cooking losses. Lowe (1955) illustrated this by roasting 12 pairs of two-rib beef roasts. The internal temperatures of the rare and well-done roasts when removed from the oven were 55° and 75° C., respectively. The 55° C. roasts had an average total cooking time of 102 minutes and a mean cooking loss of 7.7 per cent; whereas, roasts cooked to 75° C. required an average of 167 minutes and the mean cooking loss was 16.6 per cent. Similar cooking loss percentages were reported by Bunyan (1958) when beef roasts from the psoas major muscle were cooked to internal temperatures of 55° and 70° C. Paul and McLean (1946) cooked veal roasts to internal temperatures ranging from 71° C. to 88° C. They noted a steady increase in total cooking losses, loss by evaporation, and cooking time in minutes per pound with each rise in internal temperature.

While slower rates of cooking generally resulted in smaller cooking losses, Alexander and Clark (1939) indicated that shrinkage was less definitely related to oven temperature when meat was cooked well-done than when cooked to the rare, medium, and medium well-done stages. Roasts cooked in 257° F. and 347° F. ovens yielded total cooking losses of 27.0 per cent and 28.3 per cent, respectively. At the lower temperature, cooking time was almost twice as long. Griswold (1955) used constant temperatures of 250° F. and 300° F. when roasting beef round to an internal temperature of 85° C. Roasts cooked at the lower oven temperature yielded greater cooking losses, and cooking time in minutes per pound was approximately four and one-half times as long as the cooking time for roasts cooked at 300° F.

Initial internal temperature of meat may be an additional factor affecting total shrinkage. Total cooking losses and cooking time in minutes per pound were compared for beef roasts having an initial temperature of 1° C. and those having an initial temperature of 8° to 12° C. (Cline et al., 1930). Longer cooking time and greater shrinkage was recorded for the roasts having the lower initial internal temperature. Paul and Bratzler (1955) observed that frozen beef steaks cooked without thawing required a longer cooking time and had higher cooking losses than either unfrozen steaks or steaks that were thawed prior to cooking.

Skewers. Length of cooking time and shrinkage are less when metal skewers are used in roasting meat. Morgan and Nelson (1926) cooked skewered and unskewered two-rib beef roasts to a given internal temperature. Roasting speed increased from 30 to 45 per cent and smaller total weight loss occurred in the skewered roasts than in the unskewered roasts. Similar results were recorded by Cover (1941) when paired round, arm-bone chuck, and standing rib roasts of beef were cooked well-done at an oven temperature of 257° F.

Press Fluid as Related to Juiciness

Subjective evaluation is used commonly in determining juiciness in meat. Variations in individual judgment and the complexity of factors affecting juiciness have been considered by many workers to affect the accuracy of this method. For these reasons, there has been an increasing realization of the need for an objective determination of juiciness to supplement tests based on the opinions of judges.

Two early methods developed to express juice from meat by pressure were restricted to raw samples. Grindley and Emmett (1905) used a compound screw press, whereas Bigelow and Cook (1908) employed a glycerine cylinder press in their work.

A mechanical method developed for the study of juiciness in cooked meat was reported by Child and Baldelli (1934). Small, weighed samples of meat wrapped in unsized filter cloth were subjected to 250 pounds of pressure for ten minutes in an apparatus called a pressometer. Amount of press fluid was determined by the difference in weight of the sample before and after pressing.

In addition to the pressometer, various modifications of a method using the Carver Press, a hydraulic laboratory press, have been widely employed in meat research. Realizing the need for standardization of procedure in the use of this instrument, Tannor et al. (1943) proposed a method for obtaining press fluid. Pressure on the sample in the test cylinder of the press, maintained at 50^{o} C., was increased gradually to 9,800 pounds and held at that point for five minutes. The quantity of expressible juice was represented by the difference in weights of the sample before and after pressing. Subsequent analysis of the fat content was facilitated by collection of the fluid.

Hanning et al. (1957) compared press fluid measures from warm and cold cubes of lean meat and from ground cold meat with subjective measures of juiciness. There was little difference in the objective methods except for a greater amount of expressible liquid from the warm samples.

Studies comparing amount of press fluid and palatability scores have revealed that the objective method does not always give an accurate indication of juiciness in meat. Satorius and Child (1938a) found no correlation between palatability juiciness and press fluid. They explained that juiciness as judged might involve other palatability factors such as flavor and aroma which would stimulate the flow of saliva; whereas press fluid could mean only the amount of juice expressed under given conditions. Although a significant relationship was obtained between press fluid and judges' scores, Hardy and Noble (1945) considered their correlation coefficients to be too low to accurately predict juiciness scores on the basis of press fluid determinations.

Data presented by Gaddis et al. (1950) indicated that percentage of press fluid was not significantly related to scores for quantity of juice. However, it was found that both the scores for quality and quantity of juice were influenced by the fat content of the press fluid. An increase in the amount of fat in the press fluid as a result of more intramuscular fat was accompanied by an increase in juiciness scores and a decrease in press fluid.

Vail and O'Neill (1937) reported that the amount of press fluid obtained was almost inversely proportional to the apparent juiciness of the meat when eaten. A comparison of similar cuts of U. S. Good and U. S. Choice grades showed U. S. Choice grade to yield appreciably less press fluid than U. S. Good. Also, rounds that were comparatively free of fat gave more press fluid than ribs or top clod.

Factors Affecting Cost of Meat

In an institution food service the portion of the total food budget allotted to meat ordinarily will exceed 30 per cent and may reach as high as 40 or 50 per cent (West and Wood, 1955). From this standpoint, meat is an important item in the food service. Factors in the selection and preparation of meat will influence the ultimate cost per serving.

Oven Temperature. Cline and Swenson (1935) compared a searing method of roasting with a constant oven temperature of 302° F. for beef rib roasts. The higher temperature of the searing method increased the total cooking losses and the cost per serving of the meat. Thirty to 40 per cent less fuel was required with the constant temperature. Another study by these same workers (Cline and Swenson, 1934) yielded similar results in total cooking losses with beef cooked by searing and low constant oven temperatures. However, higher constant temperatures of 437° and 482° F. were found to compare with the searing method in respect to cooking losses, cost per serving, and fuel consumption.

Internal Temperature. Degree of doneness has a definite effect on the cost of cooked meat. To determine the effect of extended cooking on cost, Aldrich and Lowe (1954) cooked paired pot roasts of U. S. Choice and U. S. Good grade beef round to 90° C. One roast of each pair then was cooked for an hour longer. Calculation of edible portion cost showed an increase in cost for both grades during the additional hour of cooking.

Using internal temperatures ranging from 50° to 90° C., Masuda (1955) prepared six tender cuts of three grades of beef. With each rise in internal temperature, the cost per pound of all cuts increased proportionately.

Cut. Different cuts of meat might vary considerably in yield of servings per pound and in initial cost. Vail and O'Neill (1937) found that the cost of an average serving of rib roast was about 180 per cent greater than a similar serving from either top round or clod regardless of whether U. S. Good or U. S. Choice grade beef was used. All roasts included in the study were cooked by the same method.

Inside and outside chuck cuts were compared with inside and outside round roasts from beef animals of the same grade (Brown, 1948). Throughout the experiment the price paid for rounds averaged $0.12 more per pound than for chucks. Rounds gave a 7 per cent increase in yield per pound over the chuck roasts; however, there was a 15 per cent increase in price of rounds over chucks. Therefore, under the conditions of the study, chuck roasts appeared to be more economical than round roasts.

Grade. For a given cut of meat, grade is usually the most important determinant of initial cost. As an indication of quality, higher grades command higher prices. Ohata (1956) determined the yield and cost per serving of U. S. Choice and U. S. Good top round roasts cooked to three different internal temperatures. During the time the study was conducted, the purchase price was $0.10 more per pound for U. S. Choice rounds than for rounds of U. S. Good grade. The U. S. Choice roasts yielded fewer total servings, a higher percentage of slicing losses, and a greater average cost per serving than the U. S. Good cuts. Beef cuts of U. S. Commercial, U. S. Good, and U. S. Choice grades were compared by Masuda (1955). Since no significant difference in cooking losses attributable to grade were noted, it appeared that tender cuts of U. S. Commercial grade might be more economical to purchase than similar cuts from U. S. Good or U. S. Choice grade.

EXPERIMENTAL PROCEDURE

Design of Experiment

Trimmed, chilled top round roasts graded U. S. Choice and U. S. Good were obtained as needed from a local wholesale meat company. Specifications in ordering were given for the style, U. S. grade, and approximate weight (12 lbs.) of each cut. The roasts ranged from 10 pounds to 16 pounds 15 ounces and 7 pounds 4 ounces to 14 pounds 7 ounces for the U. S. Choice and U. S. Good grades, respectively. The average weight of the U. S. Choice cuts was 14 pounds 4 ounces and the average weight of the U. S. Good cuts was 11 pounds 8 ounces. The past history of the animal from which each cut came was unknown. The roasts were obtained in this manner to approximate purchasing procedures available to food services in this area.

Ten roasts of each grade were cooked to each of the following internal temperatures: 80° C. (176° F.), 85° C. (185° F.), and 90° C. (194° F.). The temperature 80° C., is a recommended internal temperature for cooking beef well-done. The temperatures 85° C. and 90° C. were selected as additional internal temperatures yielding well-done beef.

Three roasts were cooked at each roasting period and roasting was completed in 20 periods (Table 1). The data were analyzed in a randomized complete block design.

Roasting Procedure

The roasts were received on the day prior to the scheduled roasting period. Immediately after delivery each cut was marked with an identification number (I, II, or III) to indicate treatment and oven position. The roasts were then unwrapped and the delivery weights were recorded. After being rewrapped, the cuts

Table 1. Schedule of roasting periods.

Roasting period	U. S. grades and temperatures, ° Centigrade					
	I*		II*		III*	
1	Choice	85	Good	90	Choice	80
2	Good	80	Choice	80	Choice	80
3	Good	80	Choice	90	Choice	80
4	Good	85	Good	90	Good	90
5	Good	85	Choice	80	Choice	90
6	Good	85	Good	80	Good	85
7	Good	85	Good	90	Choice	85
8	Good	90	Choice	90	Choice	90
9	Good	90	Good	80	Choice	90
10	Choice	80	Good	80	Good	80
11	Good	80	Good	85	Choice	90
12	Choice	85	Choice	90	Good	90
13	Good	85	Choice	85	Choice	85
14	Choice	80	Good	90	Choice	85
15	Good	90	Good	85	Choice	80
16	Choice	90	Choice	85	Good	85
17	Choice	85	Choice	80	Choice	85
18	Choice	90	Choice	80	Choice	85
19	Good	80	Choice	90	Good	90
20	Good	85	Good	80	Good	80

* Identification numbers assigned to roasts at each roasting period.

were refrigerated at 2° to 3° C. for approximately 18 hours.

Following this period of storage the roasts were placed fat side up on racks in individual aluminum roasting pans. These pans were marked with the corresponding identification numbers given to the roasts at delivery. A right-angle Centigrade thermometer was inserted into the center of the thickest portion of each cut. The panned roasts were placed in a gas-fired institutional roast oven preheated to 300° F. and the time and internal temperature of each roast were recorded. Initial internal temperatures ranged from -2.0° to 3.5° C. The roasts were cooked to the predetermined internal temperatures with the oven temperature at each roast position and the internal temperature of each roast being recorded at 15-minute intervals. The predetermined oven positions employed in the study were selected during preliminary work to provide adequate space in one oven for the three roasts cooked at each period. Also, these oven positions facilitated the reading of oven and internal temperature thermometers. The oven thermometers were placed in front of each roasting pan.

After removal from the oven, the roasts stood at room temperature for one hour and were checked at 10-minute intervals in order to note any further rise in internal temperature. Throughout the procedure appropriate weights of the roasts and equipment were taken in order that storage losses and volatile, dripping, and total cooking losses could be determined. When all necessary weights had been recorded, samples from each roast were prepared for palatability and objective testing.

Testing Procedure

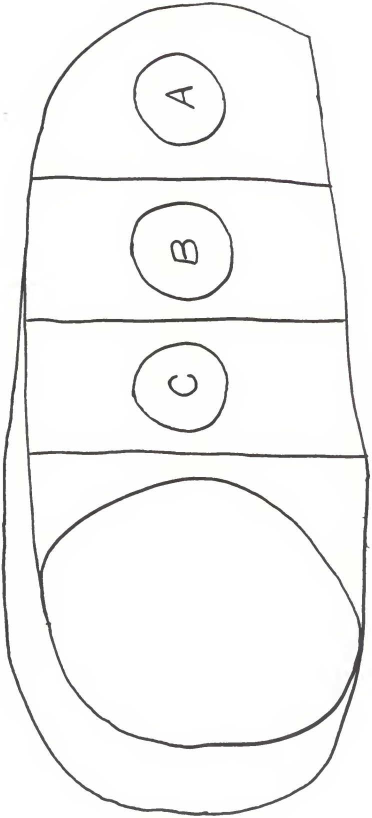
Palatability. One three-inch thick section was removed from the proximal end of each roast to give a straight edge for slicing. Three slices from each roast were cut 3/16 inch thick on a Hobart food slicer, model 1512, with the slicer blade dial set at position 16. These slices were trimmed to yield only the semimembranosus muscle and this muscle was divided into three parts for palatability scoring (Plate I). Samples from the same

EXPLANATION OF PLATE I

Semimembranosus Muscle

A, B, and C represent location of samples for taste panel and for shear force readings.

PLATE I



position within each roast were given to the same committee members at each scoring period. Seven judges scored the samples for aroma, flavor, tenderness, and juiciness. When scoring for tenderness each judge was asked to set up his own scale for the number of chews that would correspond to each numerical score. A ten-point scoring scale was used with ten indicating extremely good and one, extremely poor (Form 1, Appendix).

<u>Shear Force Values</u>. After samples were removed for palatability scoring, a three-inch thick section was cut at right angles to the muscle fibers from the center of each roast. From this piece, three one-inch cores were taken parallel to the muscle fibers and from approximately the same positions in the semimembranosus muscle as the palatability samples (Plates I and II). The cores were wrapped separately in aluminum foil, marked with the same identification number as the roast, and refrigerated at 2° to 3° C. overnight. The samples were allowed to come to room temperature before shear values were determined on a Warner-Bratzler shearing apparatus. The shearing apparatus indicated the number of pounds required for a dull blade to cut through the core of meat. Plate III shows a one-inch core of meat in position on the shearing apparatus for determining the shear value. Five shear values were obtained for each one-inch core, and the average of the mean values for the three cores was calculated for the final shear force value of each roast.

<u>Press Fluid Values</u>. The samples for press fluid determinations were taken from the semimembranosus muscle surrounding

PLATE II

The center slice of the roast and the location of the three cores in semimembranosus muscle used for mechanical determination of tenderness.

PLATE II

EXPLANATION OF PLATE III

One-inch core of semimembranosus muscle in position to determine shear value on a Warner-Bratzler shearing apparatus.

PLATE III

each of the shear cores within each roast (Plate II). The sample for each roast was wrapped in aluminum foil and refrigerated overnight. The following day each sample was allowed to come to room temperature, ground in a household manual meat grinder, and mixed thoroughly. Press fluid determinations for each roast were done in duplicate on a Carver Laboratory Press.

For press fluid measurements, 25 grams of the ground meat were packed in three layers in a metal cylinder lined with a square of cheesecloth two layers thick. The metal cylinder was placed in a stainless steel pan. Filter papers were placed between the layers and over the ground meat. The edges of the cheesecloth were folded over the top of the sample and a metal plunger was inserted in the cylinder. The assembled unit was placed on the press (Plate IV). Pressure was applied according to the following schedule:

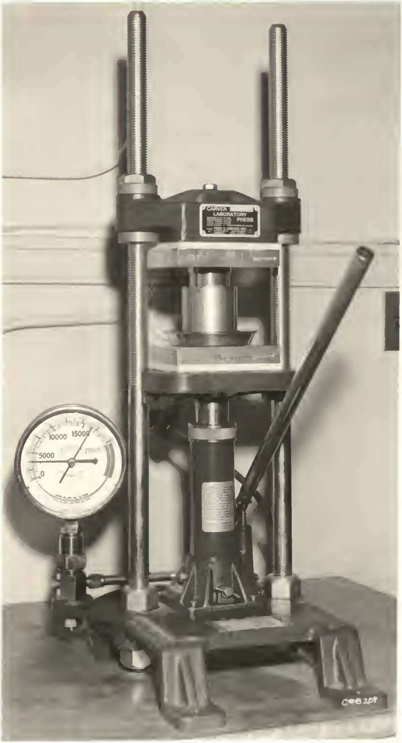
Time in minutes	Pressure in pounds*
1.0	5,000
2.0	7,500
3.0	10,000
5.0	10,000
7.5	12,500
10.0	15,000
11.0	16,000
15.0	16,000

* The pressure on the schedule refers to the load on the 1.25-inch ram of the test cylinder. The maximum load on the meat was 4,000 pounds per square inch.

EXPLANATION OF PLATE IV

Assembled unit placed in position to determine press fluid yield on a Carver Laboratory Press.

PLATE IV



Immediately after the pressure was released, the extracted fluid was poured into 15 ml. graduated centrifuge tubes. All excess juice was scraped from the cylinder and pan into the tubes. The tubes were sealed with rubber stoppers and were refrigerated overnight. Total volume of press fluid, volume of fat, and volume of serum were recorded for each sample on the following day.

Statistical Analysis

The data collected in this study were subjected to analyses of variance to determine the effect of grade and internal temperature of the meat on volatile, dripping, and total cooking losses; cooking time in minutes per pound; shear values; per cent fat and total press fluid; and the palatability factors, aroma, flavor, tenderness, and juiciness. Where appropriate, least significant differences were run on the data.

Correlation coefficients were determined for shear force values and tenderness scores; total press fluid and juiciness scores; volatile, dripping and total cooking losses and juiciness scores; volatile, dripping and total cooking losses and total press fluid; volume of fat in press fluid and dripping losses; volume of fat in press fluid and juiciness scores; and cooking time in minutes per pound and volatile, dripping, and total cooking losses.

RESULTS AND DISCUSSION

Storage Losses

In this study, roasts were received on the day prior to the scheduled roasting period and were refrigerated for approximately 18 hours before cooking. The average storage losses for 30 U. S. Good and 30 U. S. Choice top round roasts were 24 and 26 grams, respectively. The percentage storage loss, 0.47 per cent, was identical for both grades (Table 9, Appendix).

Rate of Heat Penetration

The average internal temperatures of the roasts at 15-minute intervals during cooking are given in Table 2. During the first hour of cooking, the internal temperature rose slowly for both U. S. Good and U. S. Choice grade roasts cooked to each internal temperature. From this point, the average temperature of all roasts tended to rise rapidly until the internal temperature reached approximately 70° C. Thereafter, the rate of rise in internal temperature was slower until the internal temperatures of 80° and 85° C. were obtained. For U. S. Choice and U. S. Good roasts cooked to 90° C., the rate of temperature rise became even more gradual as the internal temperature was increased from 85° to 90° C.

At each internal temperature, the average rate of heat penetration was similar for U. S. Good and U. S. Choice roasts. The U. S. Good and U. S. Choice cuts roasted to 80° and 85° C. had

Table 2. Average internal temperatures (° C.) at 15-minute intervals for two U. S. grades of top round roasts cooked to three internal temperatures.

Minutes	U. S. Good 80°	U. S. Good 85°	U. S. Good 90°	U. S. Choice 80°	U. S. Choice 85°	U. S. Choice 90°
0	3.0	2.5	2.0	2.5	2.5	3.0
15	5.0	4.0	3.0	4.0	4.0	4.5
30	7.0	5.0	4.0	5.0	5.0	5.5
45	9.0	7.5	6.0	7.0	7.0	8.0
60	14.0	10.5	9.0	10.0	10.0	11.0
75	19.0	14.5	12.0	14.0	13.5	15.0
90	24.0	19.0	16.5	18.0	18.0	19.5
105	29.0	24.0	22.0	23.5	23.0	24.5
120	34.0	30.0	28.5	28.5	28.5	29.5
135	41.5	35.5	34.0	34.0	34.0	35.0
150	44.5	41.0	39.5	39.0	39.0	39.5
165	49.0	45.0	45.0	43.5	44.0	44.5
180	53.0	51.0	50.0	48.0	49.0	49.0
195	58.0	55.0	54.0	52.5	53.5	53.0
210	61.5	59.0	58.0	56.5	57.5	57.0
225	65.0	63.0	62.0	60.0	61.0	60.0
240	68.0	66.0	65.0	63.5	64.5	63.5
255	70.5	69.0	68.0	66.5	67.5	66.5
270	72.0	72.0	71.0	69.0	70.5	69.5
285	72.0	74.5	73.5	71.5	73.0	72.0
300	74.5	77.0	75.5	73.0	75.5	75.0
315	75.0	81.0	78.0	75.0	77.5	76.0
330	77.5	82.5	80.0	77.0	79.5	78.5
345	78.5	84.0	81.5	78.5	81.0	80.5
360	79.5	84.0	83.0	79.0	82.5	82.0
375	80.0	85.0	83.0	80.0	84.0	83.5
390			83.5		85.0	85.0
405			85.0			86.5
420			86.0			87.0
435			87.0			87.0
450			87.0			88.5
465			88.0			89.0
480			88.5			89.5
495			89.0			90.0
510			90.0			

approximately the same total cooking times. The 90° C. roasts of U. S. Good and U. S. Choice grades had the longest total cooking times and these total times were similar for both grades.

Internal Temperature Rise of Roasts After Removal from Oven

Each roast was checked at 10-minute intervals for one hour after removal from the oven to observe the extent and duration of the internal temperature rise. According to Lowe (1955), when cooking is halted at lower internal temperatures, there will be a greater tendency for the inner temperature to continue to rise. Beyond 75° C. there is usually little or no elevation of internal temperature. These statements appeared to hold true for the data presented in Table 3. A slight average internal temperature rise was noted for roasts of either U. S. Good or U. S. Choice grade cooked to 80° C. These averages tended to decrease within both grades as the internal temperature increased.

Table 3. Average maximum internal temperature rise (° C.) of two U. S. grades of top round roasts after removal from the oven.

U. S. grade	Internal temperature 80° C.	85° C.	90° C.
Good	0.30	0.10	0.10
Choice	0.60	0.10	0.00

Although the data from all roasts were used in calculating the average internal temperature rise, only 15 of the 60 roasts prepared registered an increase. The greatest internal temperature rise observed was 1.5° C. and this occurred in one U. S. Choice roast cooked to 80° C. For those roasts that showed an increase in inner temperature, the maximum temperature was reached approximately one-half hour after removal of the roasts from the oven.

Flavor and Aroma

Flavor and aroma are palatability factors that are closely related. In this study, no significant differences attributable to grade or internal temperature were found for either flavor or aroma mean scores (Table 4).

Tenderness and Shear Force Values

Tenderness scores and shear force values were used in this study to evaluate tenderness of the roasts. No significant differences in average tenderness scores or average shear force values attributable to grade or internal temperature were observed (Table 4).

Negative correlation coefficients between shear force values and tenderness scores were obtained at each internal temperature for both U. S. Good and U. S. Choice roasts (Table 5). The correlation coefficient for these two factors for U. S. Good roasts cooked to 85° C. was highly significant. The correlation coefficients for shear force values and tenderness scores of U. S. Choice roasts were very highly significant for roasts cooked to 80° C., highly significant for 85° C. roasts, and significant for roasts cooked to 90° C.

Table 4. Average of mean values for factors related to aroma, flavor, and tenderness for roasts from two U. S. grades cooked to three internal temperatures.

U. S. grade	Internal temperature ° C.	Aroma[1]	Flavor[1]	Tenderness[1]	Shear force values
	80	8.1	7.7	7.6	21.38
Good	85	8.3	7.7	7.7	17.07
	90	7.8	7.3	7.6	16.91
	80	8.0	7.7	7.1	21.24
Choice	85	8.4	7.9	7.6	18.36
	90	8.1	7.7	7.7	19.55
Sig. of F values		ns	ns	ns	ns

1 - Maximum score possible, 10.

Table 5. Correlation coefficients for shear values and tenderness scores; juiciness scores and press fluid (total and per cent fat); and cooking time, in minutes per pound, and cooking losses (total, volatile, and dripping).

Factors	80° C.	85° C.	90° C.
Shear values and tenderness scores			
Good	-.04	-.82**	-.43
Choice	-.94***	-.78**	-.64*
Juiciness scores and press fluid			
Good	-.71*	-.52	.15
Choice	.46	-.08	.61 near*
Juiciness scores and per cent fat in press fluid			
Good	-.60 near*	.89***	.20
Choice	-.02	-.46	.50
Cooking time and total cooking losses			
Good	-.61 near*	.55 near*	.57 near*
Choice	-.44	.34	.48
Cooking time and volatile losses			
Good	-.42	.57 near*	.75**
Choice	-.21	.46	.53
Cooking time and dripping losses			
Good	-.39	-.57 near*	-.33
Choice	-.33	-.31	-.02

* Significant at the five per cent level (8 D/F, r=.632).
** Significant at the one per cent level (8 D/F, r=.765).
*** Significant at the one-tenth per cent level (8 D/F, r=.872).

Juiciness and Related Factors

Juiciness, total press fluid, volume of fat in press fluid, cooking time and volatile, dripping and total cooking losses are considered to be related factors. In this study, the foregoing factors were analyzed with respect to their relationships.

In both U. S. Good and U. S. Choice roasts, juiciness decreased significantly as the end point temperatures were raised from 80° to 90° C. (Table 6). Significantly lower juiciness scores were noted for the U. S. Choice roasts cooked to 90° C. than for roasts of that grade cooked to 85° C. Juiciness scores were significantly higher for U. S. Choice roasts cooked to 90° C. than for U. S. Good roasts cooked to the same end point temperature.

Press fluid yields are employed widely as an objective method for evaluating juiciness in meat; however, there has been disagreement in the literature regarding the reliability of the comparison. The average press fluid yields within each grade generally decreased with increase in end point temperature (Table 6). As the internal temperature increased from 80° to 85° C. the average press fluid yields decreased significantly for U. S. Good and U. S. Choice roasts. Similarly, significant decreases in average press fluid yields were observed within both grades between roasts cooked to 80° C. and those cooked to 90° C. Although U. S. Choice roasts gave higher average press fluid yields than U. S. Good roasts at each of the internal temperatures, there were no significant differences between the grades at each

Table 6. Average of mean values for factors related to juiciness, cooking losses, and cooking time for roasts from two U. S. grades cooked to three internal temperatures.

U. S. grade	Internal temp. ° C.	Juiciness scores	Press fluid ml/25 g.	Press fluid fat, %	Total cooking losses %	Volatile losses %	Drip. losses %	Cooking time min./lb.
	80	7.2	6.36	6.52	32.13	24.28	7.84	29.2
Good	85	7.0	5.60	9.70	36.60	29.78	6.82	31.8
	90	6.2	5.30	11.38	37.95	31.52	6.42	36.8
	80	7.5	6.74	4.41	31.57	23.22	8.35	28.1
Choice	85	7.2	6.03	10.63	34.87	28.18	6.69	32.0
	90	6.8	5.64	11.70	37.67	31.30	6.37	37.2
lsd		0.6	0.49	2.07	1.61	1.83	0.94	2.3
Sig. of F values		**	***	***	***	***	***	***

1 - Maximum score possible, 10.
lsd - Least significant difference at the five per cent level.
* - Significant at the five per cent level.
** - Significant at the one per cent level.
*** - Significant at the one-tenth per cent level.

temperature comparison.

Positive correlation coefficients between juiciness scores and press fluid were observed for one-half of the six relationships investigated, and negative correlation coefficients for these two factors were observed for the other half (Table 5). A significant negative correlation coefficient for juiciness scores and press fluid was found for 80° C. U. S. Good roasts whereas a near-significant positive correlation coefficient for these same factors was found in U. S. Choice roasts cooked to 90° C. Both average juiciness scores and average press fluid tended to decrease with increasing internal temperatures (Table 6). The finding of a significant negative correlation coefficient and a near-significant positive correlation coefficient for these two factors indicated that press fluid may not have measured the same thing that was scored by a palatability panel.

In this study, the percentage of fat in the press fluid was augmented with each elevation in internal temperature for U. S. Good and U. S. Choice grades (Table 6). This rise in percentage of fat was significantly greater for roasts of both grades cooked to 85° C. than for those cooked to 80° C. The U. S. Good roasts at 80° C. yielded a significantly greater percentage of fat in the press fluid than the U. S. Choice grade roasts at the same internal temperature.

Positive correlation coefficients for juiciness scores and per cent fat in the press fluid were observed for three of the six relationships investigated, and negative correlation coefficients for these factors were observed for the remaining three relationships (Table 5). U. S. Good roasts cooked to 80° and 85° C. showed a near-significant negative correlation coefficient and a very highly significant positive correlation coefficient, respectively, for juiciness scores and per cent fat in the press fluid. From the results obtained under the conditions of this study, there appeared to be little relationship between juiciness scores and the percentage of fat in press fluid.

As shown in Table 6, the total cooking losses of the roasts became larger with each increase in end point temperature. U. S. Good and U. S. Choice roasts cooked to 85° C. showed significantly greater total cooking losses than the cuts of each grade roasted to 80° C. Total cooking losses for U. S. Choice roasts cooked to 90° C. were significantly greater than for the roasts of that grade cooked to 85° C. The U. S. Good roasts at 85° C. had significantly greater cooking losses than the U. S. Choice roasts cooked to 85° C.

As cooking losses increased, the scores for juiciness tended to decrease (Table 6). Negative correlation coefficients for juiciness scores and total cooking losses were found for all of the relationships studied, with the exception of U. S. Good roasts cooked to 80° C. (Table 7). A significant positive correlation coefficient for these factors was noted for the U. S. Good roasts at the 80° C. end point temperature. The roasts from U. S. Choice grade cooked to 85° C. had a significant negative correlation coefficient for juiciness scores and total cooking losses.

Table 7. Correlation coefficients for juiciness scores and cooking losses (total, volatile, and dripping); press fluid and cooking losses (total, volatile, and dripping); and per cent fat in press fluid and dripping losses.

Factors	80° C.	85° C.	90° C.
Juiciness scores and total cooking losses			
Good	.65*	-.11	-.07
Choice	-.15	-.71*	-.54
Juiciness scores and volatile losses			
Good	.42	-.14	-.64*
Choice	-.08	-.79**	-.45
Juiciness scores and dripping losses			
Good	.47	.21	.78**
Choice	-.10	.40	-.39
Press fluid and total cooking losses			
Good	-.72*	.24	-.32
Choice	-.67*	.27	-.84**
Press fluid and volatile losses			
Good	-.58 near*	.20	-.31
Choice	-.68*	.41	-.81**
Press fluid and dripping losses			
Good	-.30	-.11	.03
Choice	-.07	-.28	-.30
Per cent fat in press fluid and dripping losses			
Good	-.51	.08	-.14
Choice	.32	-.33	.48

* Significant at the five per cent level (8 D/F, r=.632).
** Significant at the one per cent level (8 D/F, r=.765).
*** Significant at the one-tenth per cent level (8 D/F, r=.872).

Negative correlation coefficients between press fluid and total cooking losses were observed for four of the six relationships investigated (Table 7). Roasts of both U. S. Good and U. S. Choice grades cooked to 80° C. had a significant negative correlation for these two factors; whereas, the 90° C. U. S. Choice roasts had a highly significant negative correlation coefficient for the same factors.

The mean volatile losses generally rose with each elevation in internal temperature from 80° to 85° to 90° C. (Table 6). U. S. Good and U. S. Choice roasts cooked to 85° C. had significantly greater volatile losses than cuts of the same grade roasted to 80° C. The U. S. Choice cuts roasted to 90° C. were noted to have significantly greater volatile losses than roasts of that grade cooked to 85° C. Even though further increases in volatile losses were noted for 90° C. roasts of U. S. Good grade, these losses were not significant. No significant differences in volatile losses attributable to grade were found at any of the internal temperature comparisons.

Negative correlation coefficients between juiciness scores and volatile losses were observed for the same end point temperatures within each grade that showed negative correlation coefficients for juiciness scores and total cooking losses (Table 7). U. S. Good roasts cooked to 90° C. had a significant negative correlation coefficient for juiciness scores and volatile losses, whereas U. S. Choice roasts at 85° C. had a highly significant negative correlation coefficient for these two factors.

All of the correlation coefficients for press fluid and volatile losses found in the six relationships studied were similar to the correlation coefficients observed for press fluid and total cooking losses (Table 7). U. S. Good roasts at 80° C. end point temperature showed a near-significant negative correlation coefficient for press fluid and volatile losses; whereas U. S. Choice roasts cooked to 80° and 90° C. had significant and highly significant negative correlation coefficients, respectively, for these two factors.

The mean dripping losses tended to become lower as the internal temperature rose for all of the roasts prepared in this study (Table 6). These decreases in dripping losses were significant for roasts of both U. S. Choice and U. S. Good grades as the internal temperature was raised from 80° to 90° C. Similarly, the 85° C. roasts within each grade had a significantly smaller percentage of dripping losses than those roasts cooked to 80° C. end point temperature. For cuts roasted to each internal temperature, no significant differences in dripping losses that could be attributed to grade were found.

Positive correlation coefficients for juiciness scores and dripping losses were observed for four of the six relationships investigated (Table 7). The positive correlation coefficient for these factors was noted to be highly significant for U. S. Good roasts cooked to 90° C. Negative correlation coefficients for press fluid and dripping losses were found in all but one of the relationships (Table 7); however, none were significant. The per cent of fat in the press fluid and dripping losses were not significantly correlated in any of the relationships studied (Table 7).

Mean cooking times in minutes per pound for all roasts increased with each rise in internal temperature from 80° to 90° C. as shown in Table 6. These increases in cooking time were significant between each of the end point temperatures within each grade. There were no significant differences in cooking time between roasts of U. S. Good or U. S. Choice grade at each end point temperature.

Generally, the total cooking losses and volatile losses of meat are greater as the cooking time in minutes per pound increases (Table 6). In this study, positive correlation coefficients for cooking time and total cooking losses were observed for four out of the six relationships (Table 5). The positive correlation coefficients for these two factors were found at the 85° C. and 90° C. end point temperatures for U. S. Good and U. S. Choice grades, whereas the 80° C. roasts in both grades showed negative correlation coefficients between cooking time and total cooking losses. The positive correlation coefficients for these two factors were nearly significant for U. S. Good roasts cooked to 85° and 90° C.

The correlation coefficients between cooking time and volatile losses were similar to those observed for cooking time and total cooking losses in this study (Table 5). Near-significant and highly significant positive correlation coefficients for cooking time and volatile losses were noted for U. S. Good roasts at 85° and 90° C. end point temperatures, respectively. The 80° C. roasts of both grades showed negative correlation coefficients for these factors.

As the mean cooking time, in minutes per pound, increased, the dripping losses for all roasts tended to decrease (Table 6). In all of the relationships between cooking time and dripping losses, negative correlation coefficients were found (Table 5). None of these correlation coefficients were significant; although the U. S. Good roasts at 85° C. showed a near-significant negative correlation for the two factors.

Cost

In this study, the degrees of doneness employed and the A. P. costs per pound for the U. S. grades were found to affect the cost per pound of the cooked meat (Table 8). Within both U. S. Good and U. S. Choice grades, the average percentage yield of cooked meat decreased and the average cost per pound increased with each rise in end point temperature from 80° to 90° C.

From September 1957 through January 1958, the wholesale costs per pound for U. S. Good and U. S. Choice top round roasts were $0.69 and $0.79, respectively. This difference ($0.10) in price per pound was reflected in the costs per pound of the cooked meat when U. S. Good and U. S. Choice roasts were compared at each internal temperature. The actual costs of the U. S. Good roasts cooked to 80°, 85°, and 90° C. averaged $0.138, $0.123,

Table 8. Average percentage yields and average costs per pound (cooked weight) of two U. S. grades of top round roasts cooked to three internal temperatures.

Internal temperature ° C.	U. S. Good grade			U. S. Choice grade		
		Cost per pound*			Cost per pound*	
	Yield Per cent	Actual	Per cent increase	Yield Per cent	Actual	Per cent increase
80	67.9	$1.018	148	68.4	$1.156	146
85	63.4	1.091	158	65.1	1.214	154
90	62.1	1.113	161	62.3	1.270	161

* Costs per pound (actual and per cent) based on yield and A. P. cost per pound.

and $0.157 less per pound, respectively, than U. S. Choice roasts cooked to the same end point temperatures. The U. S. Good roasts at each internal temperature yielded lower average costs per pound than U. S. Choice roasts cooked to 80° C., the lowest internal temperature employed in the study.

SUMMARY

U. S. Good and U. S. Choice beef top round roasts were obtained to study the effect of grade and internal temperature on palatability and cooking losses. The meat was cooked to three internal temperatures, 80° C. (176° F.), 85° C. (185° F.), and 90° C. (194° F.), all representing well-done beef. The data were analyzed in a randomized complete block design.

The roasts were cooked in a gas-fired institutional roast oven preheated to 300° F. Internal temperature rise of the roasts was recorded at 15-minute intervals during cooking. Storage

losses and volatile, dripping, and total cooking losses were determined. Press fluid, shear values on one-inch cores of meat, and palatability scores were obtained. The data were subjected to analyses of variance and, where appropriate, least significant differences were determined.

Following an 18-hour refrigerated storage period, the mean storage losses were 0.47 per cent for both U. S. Good and U. S. Choice roasts. After the first hour of cooking, the average internal temperature of all roasts tended to rise rapidly until the temperature reached 70° C. Thereafter, the rate of rise in internal temperature gradually became slower until the end point temperatures were obtained. No particular difference was noted in the rate of internal temperature rise between U. S. Good and U. S. Choice roasts cooked to each internal temperature. The 90° C. roasts had the longest total cooking times and these times were similar for both grades. Fifteen of the 60 roasts prepared registered a slight increase in internal temperature after removal from the oven.

For flavor and aroma mean scores, tenderness scores, and shear force values, no significant differences attributable to either grade or internal temperature were found. Negative correlation coefficients between shear force values and tenderness scores were found in all of the relationships and a majority of these coefficients were significant.

For both U. S. Good and U. S. Choice roasts, juiciness scores, press fluid, and dripping losses diminished significantly;

whereas, cooking time in minutes per pound, volatile and total cooking losses, and per cent fat in the press fluid increased significantly with rise in internal temperature from 80° to 90° C. Few differences attributable to grade were found at the internal temperature comparisons.

The correlation coefficients for juiciness scores and press fluid were divided equally between positive and negative values. Similarly, the correlation coefficients for juiciness scores and per cent fat in press fluid showed no definite trend. Four of the six grade-temperature relationships showed positive correlation coefficients for cooking time and cooking losses (total and volatile). Cooking time and dripping losses were not significantly correlated in any of the relationships. A majority of the correlation coefficients for juiciness scores and total cooking losses were negative; however, only one coefficient was significant. A similar trend of negative correlation coefficients was observed for juiciness scores and volatile losses. Juiciness scores and dripping losses were positively correlated in four of the six relationships. Negative correlation coefficients for press fluid and total and volatile cooking losses were observed for both grades of meat at the 80° and 90° C. end point temperatures and most of these coefficients were significant. Press fluid and dripping losses and per cent fat in the press fluid and dripping losses were never significantly correlated.

The average cost per pound of cooked meat for both U. S. Good and U. S. Choice grades increased with each rise in internal temperature from 80° to 90° C. At each internal temperature, U. S. Choice roasts yielded higher average costs per pound than U. S. Good roasts. On the basis of cost per pound, the U. S. Good top round roasts appeared to be more economical than the U. S. Choice top round roasts.

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APPENDIX

Form 1.

SCORE CARD FOR MEAT

Judge ____________ Sample No. ______ Kind __________ Date __________

FACTOR	10	9	8	7	6	5	4	3	2	1	I	II	III
Aroma	Extremely Good	Very Good	Good	Plus	Medium	Minus	Fair	Poor	Very Poor	Extremely Poor			
Flavor of Lean	Extremely Good	Very Good	Good	Plus	Medium	Minus	Fair	Poor	Very Poor	Extremely Poor			
Tenderness	Extremely Tender	Tender	Tender	Plus	Medium	Minus	Fair	Tough	Very Tough	Extremely Tough			
Juiciness	Extremely Juicy	Very Juicy	Juicy	Plus	Medium	Minus	Fair	Dry	Very Dry	Extremely Dry			

Table 9. Eighteen-hour refrigerated storage losses for two U. S. grades of top round roasts.

U. S. Good			U. S. Choice		
	18-hour storage loss			18-hour storage loss	
	g.	%		g.	%
	19	0.30		11	0.21
	12	0.23		11	0.21
	24	0.60		27	0.45
	11	0.17		18	0.37
	17	0.29		21	0.37
	17	0.29		25	0.44
	17	0.34		19	0.25
	17	0.34		25	0.42
	29	0.45		28	0.45
	21	0.36		35	0.56
	13	0.23		58	1.00
	14	0.25		11	0.18
	28	0.52		30	0.62
	9	0.19		22	0.34
	9	0.16		30	0.49
	13	0.35		23	0.46
	38	1.14		21	0.39
	20	0.37		33	0.66
	22	0.43		89	1.40
	19	0.34		43	0.82
	22	0.46		23	0.43
	60	1.06		13	0.26
	33	0.76		21	0.39
	127	2.54		25	0.48
	23	0.45		12	0.21
	16	0.27		28	0.51
	16	0.34		20	0.44
	12	0.25		28	0.49
	16	0.32		14	0.27
	17	0.32		23	0.49
Avg.	24	0.47	Avg.	26	0.47

Table 10. Maximum internal temperature rise ($^{\circ}$ C.) of two U. S. grades of top round roasts after cooking process was stopped.

U. S. Grade	Internal temperature 80° C.	85° C.	90° C.
	0.5	0.5	0.0
	0.2	0.0	0.0
	0.0	0.0	0.0
Good	0.0	0.0	0.0
	0.0	0.0	0.0
	0.0	0.0	0.5
	0.5	0.0	0.0
	0.5	0.0	0.0
	1.0	0.0	0.0
	0.0	0.0	0.0
Avg.	0.30	0.10	0.10
	1.0	0.0	0.0
	0.0	0.0	0.0
	0.0	0.5	0.0
	0.0	0.5	0.0
Choice	0.0	0.0	0.0
	1.0	0.0	0.0
	0.5	0.0	0.0
	1.0	0.0	0.0
	1.5	0.0	0.0
	0.0	0.0	0.0
	0.5	0.0	0.0
Avg.	0.60	0.10	0.00

Table 11. Mean values for factors related to aroma, flavor, tenderness, and juiciness of U. S. Good top round roasts.

Internal temperature	Aroma*	Flavor*	Tenderness*	Shear/lbs.	Juiciness*	Press fluid ml./25 g.
80° C. (176° F.)	8.0	7.9	7.9	20.58	7.0	6.50
	8.2	8.2	7.8	34.92	7.2	6.60
	8.6	8.4	7.8	17.90	8.0	6.40
	7.5	7.2	7.8	17.13	7.7	6.05
	8.3	7.2	7.0	20.13	6.8	7.40
	7.2	6.7	7.2	27.05	5.8	7.00
	8.8	7.3	7.3	21.53	7.3	6.15
	8.4	8.6	7.4	18.23	7.8	5.60
	7.7	7.9	7.7	20.72	7.6	5.80
	8.3	8.0	7.7	15.63	7.3	6.05
Avg.	8.1	7.7	7.6	21.38	7.2	6.36
85° C. (185° F.)	7.8	7.9	7.7	19.48	7.3	5.35
	7.9	7.9	7.3	18.45	6.4	5.30
	8.8	8.4	8.4	12.33	8.0	4.60
	8.8	8.6	8.6	13.53	6.8	5.70
	7.8	7.5	8.0	17.47	6.5	6.35
	8.5	7.8	8.5	14.70	7.0	6.80
	8.8	7.2	7.2	15.88	7.0	5.70
	8.0	6.4	6.6	26.02	6.8	6.25
	8.0	7.2	7.2	17.48	7.3	4.80
	8.3	8.0	7.9	15.32	6.7	5.15
Avg.	8.3	7.7	7.7	17.07	7.0	5.60

Table 11 (concl.).

Internal temperature	Aroma*	Flavor*	Tenderness*	Shear/lbs.	Juiciness*	Press fluid ml./25 g.
	7.7	7.4	6.9	21.20	5.7	4.75
	7.2	7.3	7.3	12.80	5.9	5.35
	7.8	7.4	7.6	17.87	5.7	4.95
	7.5	6.7	7.7	14.78	5.8	6.10
	8.3	8.5	8.5	15.87	7.5	5.60
90° C. (194° F.)	8.0	7.7	8.0	15.95	6.7	5.30
	6.8	5.3	7.0	17.75	5.0	5.15
	8.4	7.8	7.0	17.22	6.8	5.30
	8.0	7.8	8.6	16.23	6.0	5.65
	7.8	7.0	7.2	19.47	6.6	4.80
Avg.	7.8	7.3	7.6	16.91	6.2	5.30

* Palatability scores.
Maximum score possible, 10.

Table 12. Mean values for factors related to aroma, flavor, tenderness, and juiciness of U. S. Choice top round roasts.

Internal temperature	Aroma*	Flavor*	Tenderness*	Shear/lbs.	Juiciness*	Press fluid ml./25 g.
	7.7	7.1	7.4	18.72	6.9	6.50
	8.4	7.1	8.2	14.86	6.3	6.00
	8.3	7.3	7.3	18.10	6.4	6.25
	8.0	7.8	6.3	26.63	8.3	7.10
80° C. (176° F.)	8.1	7.4	6.3	25.58	7.3	6.50
	8.2	7.8	7.8	18.97	7.5	7.95
	8.4	8.4	7.4	22.00	7.6	6.15
	8.0	8.2	7.4	19.02	8.2	5.80
	7.7	8.0	6.3	24.87	8.5	7.55
	7.5	7.5	6.5	23.60	8.0	7.55
Avg.	8.0	7.7	7.1	21.24	7.5	6.74
	8.1	8.0	7.7	18.70	7.6	5.45
	8.3	7.5	7.8	16.00	6.5	6.40
	8.5	8.8	8.5	14.15	7.5	6.75
	9.0	8.2	8.2	14.15	7.6	6.35
85° C. (185° F.)	8.6	7.8	8.8	17.27	8.0	5.70
	8.6	7.8	7.4	21.47	6.6	5.70
	8.3	7.5	6.3	24.70	7.3	5.70
	8.5	7.8	7.5	16.90	6.7	5.85
	7.7	7.8	7.2	16.65	6.0	6.15
	8.3	7.8	7.0	23.65	7.7	6.25
Avg.	8.4	7.9	7.6	18.36	7.2	6.03

Table 12 (concl.).

Internal temperature	Aroma*	Flavor*	Tenderness*	Shear/lbs.	Juiciness*	Press fluid ml./25 g.
	8.8	8.0	7.7	15.27	6.7	5.50
	7.7	7.6	6.6	29.60	5.9	5.85
	8.8	8.8	8.5	14.50	6.8	5.60
	8.5	8.3	8.5	20.65	8.0	5.95
90° C. (194° F.)	6.8	7.0	6.8	20.42	7.0	6.45
	9.0	7.5	8.2	22.53	6.4	5.60
	7.5	7.3	8.5	13.82	8.5	5.90
	8.3	8.5	8.5	14.80	7.0	5.40
	8.3	7.7	6.5	19.23	5.2	4.75
	7.6	6.6	6.8	24.72	6.0	5.35
Avg.	8.1	7.7	7.7	19.55	6.8	5.64

* Palatability scores.
Maximum score possible, 10.

Table 13. Mean values for factors related to cooking time and cooking losses of U. S. Good top round roasts.

Internal temperature	Cooking time	Cooking losses					
		Total		Volatile		Dripping	
	Min./lb.	g.	%	g.	%	g.	%
	29	1747	33.7	1383	26.7	364	7.0
	30	1242	31.0	1007	25.1	235	5.9
	27	2173	34.0	1565	24.5	608	9.5
	26	1745	30.4	1302	22.7	443	7.7
80° C. (176° F.)	32	1077	28.7	770	20.5	307	8.2
	34	949	28.8	709	21.5	240	7.3
	30	1820	34.1	1397	26.2	423	7.9
	27	2138	36.0	1600	26.9	538	9.1
	28	1572	31.9	1106	22.4	466	9.4
	29	1718	32.7	1383	26.3	335	6.4
Avg.	29.2	1618	32.1	1222.2	24.3	396	7.8
	31	2395	36.5	1965	30.0	430	6.5
	33	1766	35.9	1397	28.4	369	7.5
	30	1751	34.7	1328	26.3	423	8.4
	32	2051	35.4	1652	28.5	399	6.9
85° C. (185° F.)	28	1915	34.0	1481	26.3	434	7.7
	31	1807	35.4	1371	26.8	436	8.5
	32	1746	36.4	1461	30.5	285	5.9
	34	2229	45.7	2056	42.2	173	3.5
	35	1866	36.5	1527	29.9	339	6.6
	32	1728	35.5	1404	28.9	324	6.7
Avg.	31.8	1925	36.6	1564	29.8	361	6.8

Table 13 (concl.).

Internal temperature	Cooking time	Cooking losses					
		Total		Volatile		Dripping	
	Min./lb.	g.	%	g.	%	g.	%
	35	2324	37.5	2013	32.5	311	5.0
	40	2379	40.8	2042	35.0	337	5.8
	37	2176	37.2	1803	30.8	373	6.4
	35	1902	34.5	1607	29.1	295	5.3
90° C. (194° F.)	32	2101	39.3	1496	28.0	605	11.3
	34	1647	33.9	1346	27.7	301	6.2
	41	2223	40.1	1930	34.9	293	5.3
	34	2139	38.1	1783	31.7	356	6.3
	38	1658	38.4	1449	33.6	209	4.8
	42	1873	39.7	1507	31.9	366	7.8
Avg.	36.8	2042	37.9	1698	31.5	345	6.4

Table 14. Mean values for factors related to cooking time and cooking losses of U. S. Choice top round roasts.

Internal temperature	Cooking time	Cooking losses					
		Total		Volatile		Dripping	
	Min./lb.	g.	%	g.	%	g.	%
	29	1624	31.4	1186	22.9	438	8.5
	28	2009	33.6	1536	25.7	473	7.9
	31	1483	30.4	1084	22.2	399	8.2
	29	1789	31.4	1322	23.2	467	8.2
80° C. (176° F.)	26	2671	34.8	1709	22.2	962	12.5
	27	1281	26.8	904	18.9	377	7.9
	25	2176	34.5	1707	27.1	469	7.4
	29	1684	31.6	1292	24.3	392	7.4
	28	1778	31.6	1250	22.2	528	9.4
	29	1695	29.6	1345	23.5	350	6.1
Avg.	28.1	1819	31.6	1334	23.2	486	8.4
	32	1739	33.7	1404	27.2	335	6.5
	31	2215	35.6	1791	28.8	424	6.8
	28	2137	35.0	1731	28.4	406	6.7
	32	1878	34.8	1553	28.8	325	6.0
85° C. (185° F.)	31	1593	31.9	1246	24.9	347	6.9
	31	1818	34.8	1459	27.9	359	6.9
	33	1985	36.6	1444	26.6	541	10.0
	31	1857	35.5	1531	29.3	326	6.2
	37	1984	36.6	1761	32.5	223	4.1
	34	1772	34.2	1419	27.4	353	6.8
Avg.	32.0	1898	34.9	1534	28.2	364	6.7

Table 14 (concl.).

Internal temperature	Cooking time	Cooking losses					
		Total		Volatile		Dripping	
	Min./lb.	g.	%	g.	%	g.	%
	34	2149	38.1	1821	32.2	328	5.8
	39	2389	40.4	1968	33.3	421	7.1
	33	2296	37.2	1870	30.3	426	6.9
	43	1709	35.3	1446	29.9	263	5.4
90° C. (194° F.)	32	1862	31.4	1457	24.6	405	6.8
	35	2355	36.4	2027	31.3	328	5.1
	37	1865	37.5	1545	31.1	320	6.4
	37	1965	39.4	1643	32.9	322	6.5
	41	1917	42.3	1538	33.9	379	8.4
	41	1798	38.7	1554	33.4	244	5.3
Avg.	37.2	2031	37.7	1687	31.3	344	6.4

Table 15. Mean press fluid values for two U. S. grades of top round roasts cooked to three internal temperatures.

U. S. grade	80° C.			85° C.			90° C.		
		Fat			Fat			Fat	
	Total	ml.	%	Total	ml.	%	Total	ml.	%
Good	6.50	.40	6.2	5.35	.50	9.3	4.75	.55	11.6
	6.60	.45	6.8	5.30	.30	5.7	5.35	.50	9.3
	6.40	.30	4.7	4.60	.90	19.6	4.95	.35	7.1
	6.05	.35	5.8	5.70	.50	8.8	6.10	.45	7.4
	7.40	.45	6.1	6.35	.45	7.1	5.60	.55	9.8
	7.00	.65	9.3	6.80	.55	8.1	5.30	.80	15.1
	6.15	.35	5.7	5.70	.45	7.9	5.15	.70	13.6
	5.60	.45	8.0	6.25	.70	11.2	5.30	.85	16.0
	5.80	.25	4.3	4.80	.60	12.5	5.65	.70	12.4
	6.05	.50	8.3	5.15	.35	6.8	4.80	.55	11.5
Avg.	6.36	.42	6.5	5.60	.53	9.7	5.30	.60	11.4
Choice	6.50	.20	3.1	5.45	.40	7.3	5.50	.65	11.8
	6.00	.25	4.2	6.40	.85	13.3	5.85	.85	14.5
	6.25	.25	4.0	6.75	.45	6.7	5.60	.50	8.9
	7.10	.25	3.5	6.35	.60	9.4	5.95	1.40	23.5
	6.50	.50	7.7	5.70	.80	14.0	6.45	.56	7.0
	7.95	.20	2.5	5.70	.70	12.3	5.60	.45	8.0
	6.15	.40	6.5	5.70	.50	8.8	5.90	.75	12.7
	5.80	.50	8.6	5.85	.60	10.3	5.40	.65	12.0
	7.55	.15	2.0	6.15	.85	13.8	4.75	.35	7.4
	7.55	.15	2.0	6.25	.65	10.4	5.35	.60	11.2
Avg.	6.74	.29	4.4	6.03	.64	10.6	5.64	.67	11.7

Table 16. Raw weights, cooked weights, and cooking weight losses of U. S. Good top round roasts.

Internal temperature	Raw weight g.	Raw weight lbs.	Cooked weight g.	Cooked weight lbs.	Total weight loss g.	Total weight loss %
	5183	11.4	3436	7.6	1747	33.7
	4004	8.8	2762	6.1	1242	31.0
	6387	14.1	4214	9.3	2173	34.0
	5745	12.7	4000	8.8	1745	30.4
80° C. (176° F.)	3748	8.3	2671	5.9	1077	28.7
	3296	7.3	2347	5.2	949	28.8
	5332	11.7	3512	7.7	1820	34.1
	5941	13.1	3803	8.4	2138	36.0
	4932	10.9	3360	7.4	1572	31.9
	5261	11.6	3543	7.8	1718	32.7
Avg.	4983	11.0	3365	7.4	1618	32.1
	6557	14.4	4162	9.2	2395	36.5
	4916	10.8	3150	6.9	1766	35.9
	5052	11.1	3301	7.3	1751	34.7
	5800	12.8	3749	8.3	2051	35.4
85° C. (185° F.)	5633	12.4	3718	8.2	1915	34.0
	5110	11.3	3303	7.3	1807	35.4
	4791	10.6	3045	6.7	1746	36.4
	4875	10.7	2646	5.8	2229	45.7
	5111	11.3	3245	7.2	1866	36.5
	4866	10.7	3138	6.9	1728	35.5
Avg.	5271	11.6	3346	7.4	1925	36.6

Table 16 (concl.).

Internal temperature	Raw weight		Cooked weight		Total weight loss	
	g.	lbs.	g.	lbs.	g.	%
	6189	13.6	3865	8.5	2324	37.5
	5828	12.8	3449	7.6	2379	40.8
	5855	12.9	3679	8.1	2176	37.2
	5518	12.2	3616	8.0	1902	34.5
90° C. (194° F.)	5352	11.8	3251	7.2	2101	39.3
	4859	10.7	3212	7.1	1647	33.9
	5538	12.2	3315	7.3	2223	40.1
	5618	12.4	3479	7.7	2139	38.1
	4314	9.5	2656	5.9	1658	38.4
	4720	10.4	2847	6.3	1873	39.7
Avg.	5379	11.9	3337	7.4	2042	38.0

Table 17. Raw weights, cooked weights, and cooking weight losses of U. S. Choice top round roasts.

Internal temperature	Raw weight		Cooked weight		Total weight loss	
	g.	lbs.	g.	lbs.	g.	%
	5171	11.4	3547	7.8	1624	31.4
	5983	13.2	3974	8.8	2009	33.6
	4888	10.8	3405	7.5	1483	30.4
	5693	12.5	3904	8.6	1789	31.4
80° C. (176° F.)	7684	16.9	5013	11.0	2671	34.8
	4779	10.5	3498	7.7	1281	26.8
	6301	13.9	4125	9.1	2176	34.5
	5323	11.7	3639	8.0	1684	31.6
	5621	12.4	3843	8.5	1778	31.6
	5732	12.6	4037	8.9	1695	29.6
Avg.	5718	12.6	3899	8.6	1819	31.6
	5160	11.4	3421	7.5	1739	33.7
	6218	13.7	4003	8.8	2215	35.6
	6100	13.4	3963	8.7	2137	35.0
	5389	11.9	3511	7.7	1878	34.8
85° C. (185° F.)	4996	11.0	3403	7.5	1593	31.9
	5223	11.5	3405	7.5	1818	34.8
	5424	12.0	3439	7.6	1985	36.6
	5232	11.5	3375	7.4	1857	35.5
	5416	11.9	3432	7.6	1984	36.6
	5180	11.4	3408	7.5	1772	34.2
Avg.	5434	12.0	3536	7.8	1898	34.9

Table 17 (concl.).

Internal temperature	Raw weight g.	Raw weight lbs.	Cooked weight g.	Cooked weight lbs.	Total weight loss g.	Total weight loss %
	5636	12.4	3487	7.7	2149	38.1
	5907	13.0	3518	7.8	2389	40.4
	6180	13.6	3884	8.6	2296	37.2
	4839	10.7	3130	6.9	1709	35.3
90° C. (194° F.)	5935	13.1	4073	9.0	1862	31.4
	6467	14.2	4112	9.1	2355	36.4
	4967	10.9	3102	6.8	1865	37.5
	4991	11.0	3026	6.7	1965	39.4
	4534	10.0	2617	5.8	1917	42.3
	4645	10.2	2847	6.3	1798	38.7
Avg.	5410	11.9	3380	7.5	2031	37.7

Table 18. Percentage yields and costs per pound (cooked weight) of two U. S. grades of top round roasts cooked to three internal temperatures.

Internal temp. °C.	U. S. Good grade Yield %	Cost per lb.* Actual	Cost per lb.* % incr.	U. S. Choice grade Yield %	Cost per lb.* Actual	Cost per lb.* % incr.
	66.3	$1.041	151	68.6	$1.152	146
	69.0	1.000	145	66.4	1.190	151
	66.0	1.045	151	69.6	1.135	144
	69.6	0.991	144	68.6	1.152	146
80	71.3	0.968	140	65.2	1.212	153
	71.2	0.969	140	73.2	1.079	137
	65.9	1.047	152	65.5	1.206	153
	64.0	1.078	156	68.4	1.155	146
	68.1	1.013	147	68.4	1.155	146
	67.3	1.025	149	70.4	1.122	142
Avg.	67.9	1.018	148	68.4	1.156	146
	63.5	$1.087	158	66.3	$1.192	151
	64.1	1.076	156	64.4	1.227	155
	65.3	1.057	153	65.0	1.215	154
	64.6	1.068	155	65.2	1.212	153
85	66.0	1.045	151	68.1	1.160	147
	64.6	1.068	155	65.2	1.212	153
	63.6	1.085	157	63.4	1.246	158
	54.3	1.271	184	64.5	1.225	155
	63.5	1.087	158	63.4	1.246	158
	64.5	1.070	155	65.8	1.201	152
Avg.	63.4	1.091	158	65.1	1.214	154
	62.5	$1.104	160	61.9	$1.276	162
	59.2	1.166	169	59.6	1.326	168
	62.8	1.099	159	62.8	1.258	159
	65.5	1.053	153	64.7	1.221	155
90	60.7	1.137	165	68.6	1.152	146
	66.1	1.044	151	63.6	1.242	157
	59.9	1.152	167	62.5	1.264	160
	61.9	1.115	162	60.6	1.304	165
	61.6	1.120	162	57.7	1.369	173
	60.3	1.144	166	61.3	1.289	163
Avg.	62.1	1.113	161	62.3	1.270	161

* Cost per pound based on yield and A. P. cost per pound.
U. S. Good - A. P. cost = $0.69 per pound.
U. S. Choice - A. P. cost = $0.79 per pound.

EFFECT OF GRADE AND INTERNAL TEMPERATURE ON PALATABILITY AND COOKING LOSSES OF TOP ROUND ROASTS COOKED IN A GAS-FIRED INSTITUTIONAL ROAST OVEN

by

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Since meat is the most expensive item in the budget, the food service manager is interested in meat cookery methods that will yield palatable servings at the lowest possible cost. From the economic standpoint, the initial cost of the meat is important, also. For a given cut of beef, the variation in cost per pound is primarily dependent upon grade; higher grades commanding higher prices.

U. S. Good and U. S. Choice beef top round roasts were obtained to study the effect of grade and internal temperature on palatability and cooking losses. The meat was cooked to three internal temperatures, 80° C. (176° F.), 85° C. (185° F.), and 90° C. (194° F.), all representing well-done beef. The data were analyzed in a randomized complete block design.

The roasts were cooked in a gas-fired institutional roast oven preheated to 300° F. Internal temperature rise of the roasts was recorded at 15-minute intervals during cooking. Storage losses and volatile, dripping, and total cooking losses were determined. Press fluid, shear values on one-inch cores of meat, and palatability scores were obtained. The data were subjected to analyses of variance and, where appropriate, least significant differences were determined.

Following an 18-hour refrigerated storage period, the mean storage losses were 0.47 per cent for both U. S. Good and U. S. Choice roasts. After the first hour of cooking, the average internal temperature of all roasts tended to rise rapidly until the temperature reached 70° C. Thereafter, the rate of rise in internal temperature gradually became slower until the end point temperatures were obtained. No particular difference was noted in the rate of internal temperature rise between U. S. Good and U. S. Choice roasts cooked to each internal temperature. The 90° C. roasts had the longest total cooking times and these times were similar for both grades. Fifteen of the 60 roasts prepared registered a slight increase in internal temperature after removal from the oven.

For flavor and aroma mean scores, tenderness scores, and shear force values, no significant differences attributable to either grade or internal temperature were found. Negative correlation coefficients between shear force values and tenderness scores were found in all of the grade-temperature relationships and a majority of these coefficients were significant.

For both U. S. Good and U. S. Choice roasts, juiciness scores, press fluid, and dripping losses diminished significantly; whereas, cooking time in minutes per pound, volatile and total cooking losses, and per cent fat in the press fluid increased significantly with rise in internal temperature from 80° to 90° C. Few differences attributable to grade were found at the internal temperature comparisons.

The correlation coefficients for juiciness scores and press fluid were divided equally between positive and negative values. Similarly, the correlation coefficients for juiciness scores and per cent fat in the press fluid showed no definite trend. Four of the six grade-temperature relationships showed positive correlation coefficients for cooking time and cooking losses (total and volatile). Cooking time and dripping losses were not significantly correlated in any of the relationships. A majority of the correlation coefficients for juiciness scores and total cooking losses were negative; however, only one coefficient was significant. A similar trend of negative correlation coefficients was observed for juiciness scores and volatile losses. Juiciness scores and dripping losses were positively correlated in four of the six relationships. Negative correlation coefficients for press fluid and total and volatile cooking losses were observed for both grades of meat at the 80° and 90° C. end point temperatures, and most of these coefficients were significant. Press fluid and dripping losses and per cent fat in the press fluid and dripping losses were never significantly correlated.

The average cost per pound of cooked meat, for both U. S. Good and U. S. Choice grades increased with each rise in internal temperature from 80° to 90° C. At each internal temperature, U. S. Choice roasts yielded higher average costs per pound than U. S. Good roasts. On the basis of cost per pound, the U. S. Good top round roasts were more economical than the U. S. Choice top round roasts when cooked to each internal temperature.