THE EFFECT OF METHODS OF REHEATING UPON PALATABILITY OF PRECOOKED FROZEN BEEF ROASTS

II. ELECTRONIC RANGE AND PRESSURE STEAMER

Thesis for the Degree of M. S.

MICHIGAN STATE UNIVERSITY

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1957

THE EFFECT OF METHODS OF REHEATING UPON PALATABILITY OF PRECOOKED FROZEN BEEF ROASTS

II. ELECTRONIC RANGE AND PRESSURE STEAMER

By

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A PROBLEM

Submitted to the Dean of the College of Home Economics
of Michigan State University of Agriculture and
Applied Science in partial fulfillment of
the requirements for the degree of

MASTER OF SCIENCE

Department of Institution Administration

1957

ACKNOWLEDGMENTS

The writer wishes to express her sincere appreciation to Dr. Pearl J. Aldrich for her assistance, interest, and encouragement which made this study possible.

Grateful acknowledgment is extended also to Miss Roberta Atkinson, Miss Helen Brown, Miss Virginia Charles, and Miss Doris Downs for their participation on the taste panel.

The assistance of Dr. Donald P. Brown and Dr. J. Leon Newcomer in obtaining the electronic range from the Whirlpool Company is also gratefully acknowledged.

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INTRODUCTION

Meat is one of the most important food items in the United States. Around it menu planning is centered in the home and in institutions. Because of this, everyone is interested in methods for obtaining a highly palatable product. The eating quality or desirability of meat is largely determined by its color, aroma, flavor, tenderness, and juiciness. Each of these factors is affected by the quality of the uncooked meat and also by the method used in cooking it.

Every food manager recognizes that regardless of how carefully menu planning is done, some food will be left over after meal service is finished. Managers are faced continually with the problem of keeping leftovers at a minimum and using them promptly. However, it is not always possible to serve the leftovers again at the meal immediately following their original appearance on the menu. Freezing has proved to be a satisfactory and economical method for preserving some leftover foods for future use in institutions.

The investigation reported here follows that of a related study previously completed in the Food Service Laboratory at Michigan State University (87). Since that time the advent of new cooking equipment has presented new possibilities for reheating precooked frozen foods. The purpose of the present study was to supplement the initial study by investigating additional methods of reheating frozen beef roasts. Retaining the original palatability of the meat during the reheating was considered the primary goal. Another objective was the study of the time required to reheat the roasts to an internal temperature of 70°C and to evaluate the practicability of the methods for institutional use.

Top sirloin butts of U.S.D.A. Choice grade beef were used in this study. The meat was cooked at a constant oven temperature of 149°C to an internal temperature of 70°C. After a cooling period the roasts were sliced, reassembled, wrapped, and stored in a freezer compartment at -20°C.

Four reheating methods were investigated. A Hotpoint pressure steamer and an RCA Whirlpool electronic range were used in the reheating procedures. Control roasts were cooked by the same method used in preparing the roasts which were frozen and then later reheated.

It is hoped that the results of this study may help in the development of satisfactory methods for reheating roast beef which will retain the palatability of the freshly roasted product.

REVIEW OF LITERATURE

Factors Affecting the Palatability of Meat

As early as 1904 studies were started on the numerous factors affecting the palatability of meat. Among these factors are the composition of the meat, aging, storage conditions, and cooking methods.

Aroma and flavor

Bull (12) stated, "What we regard as flavor is primarily aroma and secondarily taste." Crocker (31) defined flavor as that property of a food or beverage which makes it stimulate the senses of taste, smell, and feeling in the mouth and nose. Because of its aroma and flavor, a properly cooked piece of meat has universal appetite appeal.

Composition of meat. From a study on the relation of the degree of finish in cattle to meat flavors, Branaman, Hankins, and Alexander (10) reported that flavor scores of lean meat improved progressively in both intensity and desirability as fat content increased.

Barbella, Hankins, and Alexander (3), from their study on the influence of retarded growth on flavor and other characteristics of lamb, stated that the lean meat from well-fed animals was strikingly superior in flavor to meat from poorly fed animals.

Mackintosh and Hall (64) concluded from their study of the effect of fat on palatability that an increasing degree of finish intensified the properties of flavor, tenderness, and juiciness. Their evidence seemed to justify the old-time belief that fat definitely improved the palatability of meat. They felt, however, that excessive fat could impair the flavor as easily as it could improve it.

Lowe (61) stated that the flavor of the fat accounts primarily for the characteristic differences in flavor among the different species such as beef, lamb, pork, chicken, or turkey.

Dunnigan (39) reported from her results on the palatability of two grades of sirloin butts that the fat roasts scored higher than the lean roasts in aroma, flavor, and tenderness.

Aging. Paul, Lowe, and McClurg (77), from their investigation on the changes in beef induced by storage, found that the greatest increase in palatability of small cuts was obtained with a 9-day storage period at 17°C. Further storage resulted in a decrease of the aroma and flavor scores and in the development of gaminess in the lean and rancidity in the fat.

Griswold and Wharton (45) also reported on the effect of storage on the palatability of beef. They observed that the aroma and flavor of meat stored 37 days at 34°F was slightly stronger than meat stored 9 days at the same temperature. Experiments with storage conditions plus ultraviolet lights were conducted also. Meat which had been stored 48 hours at 60°F under ultraviolet lights was more desirable in appearance and odor than meat held under similar conditions without ultraviolet lights. Growth of bacteria was held to a minimum by ultraviolet irradiation.

Lowe (61) found that beef aged from 20 to 40 days received optimum flavor scores. Undesirable flavor was reported on meat aged longer than 40 days.

Deatheridge and Rieman (36) studied the effect of the Tenderay process on tenderness of 82 beef animals. This process consisted of a four-way combination of temperature, humidity, air circulation, and ultraviolet ray protection against growth of microorganisms during the aging period. The tenderness of U.S. Commercial animals was comparable to the tenderness of U.S. Good animals, both unprocessed and "Tenderayed". The U.S. Commercial carcasses showed somewhat greater improvement than the U.S. Good. For the whole group, the "Tenderayed" meat scored 2.5 points higher in tenderness than the unprocessed meat, using median tenderness as a criterion for comparison. The median for the unprocessed beef was 4.54 and for the "Tenderayed" beef, 7.04.

Harrison, Lowe, McClurg, and Shearer (49) stated that there was little variation in aroma and flavor scores for roasts aged from 1 to 20 days. When roasts were aged longer than 20 days, the aroma and flavor scores were definitely lower than when they were aged less than 20 days.

Freezing. The effect of cold storage on the quality of precooked frozen beef stew, pork stew, and swiss steak was studied by Harrison and Vail (50). The products were tested for acceptability when fresh, shortly after freezing, and after 3, 6, and 9 months' storage at 0°, -10°, and -20°F. Scores for the freshly prepared products ranged from 57.8 to 54.0 for beef stew. Products tested a few days after freezing were scored lower than the freshly prepared product 32 out of 36 times. In general, it seemed that freezing, thawing, and reheating tended to decrease the overall acceptability of the precooked meat products. Storage for 3, 6, or 9 months tended to decrease further the acceptability of the three products.

Simpson and Chang (91) compared the keeping quality of hamburg, bacon, and sausage wrapped in four different packaging materials and stored at the usual home-freezer temperature of 0°F with samples stored at lower temperatures (-20°F, -30°F, and -40°F). They found that aluminum foil and glassine-laminated paper were more effective than polyethylene-coated paper or butcher wrap in retarding rancidity development.

Hiner, Gaddis and Hankins (54) observed that the original quality of the meat declined rapidly when it was cellophane wrapped, lard-coated, and stored at 18°F and 15°F. Vacuum packing resulted in no moisture loss. Temperatures of 0°F and below gave the best protection to the meat.

Methods of cooking. Clark and Van Duyne (20) reported that top round beef roasts cooked in the oven were more palatable meat than similar roasts cooked in the pressure saucepan. They stated that the judges preferred the flavor of both the lean and the fat of the meat roasted in the oven and considered the meat cooked in the pressure saucepan too dry.

Cline, Trowbridge, Foster, and Fry (24) found a definite correlation between cooking losses and flavor of the lean meat from prime ribs of beef prepared by ten methods of roasting. All roasts which ranked low in cooking weight losses rated high in palatability. They suggested that the loss of flavor was attributable to the loss of juice from the roasts.

Studies on the retention of nutritive value and the palatability of foods cooked by micro-waves have been made with the institution-type electronic oven (40). Causey and others (15) stated that the unbrowned, electronically cooked ground pork patties were scored higher in juiciness, almost as high in flavor, but lower in color than were either those prebrowned or those pan-broiled or oven-broiled.

No significant differences in flavor scores were found for frozen precooked paprika chicken, spaghetti and meat balls, or ham patties which could be attributed to electronic reheating or the four conventional methods of reheating (15). The flavor of creamed chicken on rice was scored higher when it was electronically reheated. There were no significant differences attributable to the reheating method for paprika chicken and gravy in surface appearance, color, or aroma. Thus no method of reheating resulted consistently in higher scores for all quality factors of any dish.

Tenderness

Tenderness is one quality universally desired in meat. Bratzler (11) definied it ..."as the state of being easily masticated, broken or cut". Deatheridge and Rieman (36) commented that meat which has good flavor is still undesirable if it is tough. Factors which affect the tenderness of meat have been the subject of extensive research.

Aging. Paul (73) stated that one of the very important determinants of tenderness of beef was the extent of aging after slaughter. Most beef is chilled thoroughly before marketing. This chilling usually requires 24 hours or more at temperatures slightly above freezing. Partial or complete development of rigor occurs during this time, and it is necessary to hold the meat for a longer period to allow for the dissolution of rigor so that the meat will become tender again. The length of time varies with the conditions of storage. Ten days or more at 32° to 40°F will produce an appreciable tenderizing effect.

The relation of tenderness of beef to aging time at 33° to 35°F was studied by Deatherage and Harsham (35). The results of their studies on 14 beef carcasses showed that, although the meat from some of the animals became less tender at certain times during the aging period, some of the meat increased in tenderness throughout the aging period. Tenderness of the group increased throughout 17 days of storage. At 24 days there was no further improvement, but after 31 days there was some improvement in tenderness beyond that noted at the end of the 17-day period.

Deatheridge and Rieman (36) reported that meat may be tenderized during ripening by hanging at refrigerator temperatures of 0.6 to 1.1°C for periods of time varying from 3 to 6 weeks. They emphasized that the disadvantages of this method were the danger of the development of off-flavors, the high losses due to shrinkage and trimming, and the high cost of storage. Because of these difficulties, Deatheridge and Rieman developed the Tenderay process (36).

Hoagland, McBryde, and Powick (56) found that flavor and tenderness were improved by ripening the meat for a period of 15 to 30 days at a temperature varying between 32° - 36°F. After 45 days, the meat was apt to taste moldy. In ripening, meats are affected on the surface first. The ripening process tends to penetrate as the acidity decreases.

Freezing. Paired short loins of beef were used by Hiner and Hankins (55) to determine the effect of freezing temperature. They 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 that 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° and those frozen at -10°F.

Ramsbottom (83) reported that freezer storage at temperatures of -10°F or lower for seven years did not significantly change the tenderness of beef steaks. Half were tested before freezing and the other half were tested after freezer storage of seven years.

Dahlinger (32) compared the tenderness of beef rounds which were precooked and frozen with similar cuts which were frozen in the uncooked state and then roasted the day they were served. All meat was stored for 25 days at -10°F. Results showed that the roasts which were freshly frozen and then cooked were significantly more tender than comparable cuts which were precooked and then frozen.

Grade and age. Lowe and co-workers (62) cooked 40 Choice, 76 Good, and 24 Commercial prime ribs at 120°C, 150°C, and 175°C oven temperatures to internal temperatures of 58°C and 75°C. Results indicated that roasts from Commercial grade beef had lower tenderness scores than those from Choice and Good grade carcasses. Choice grade was scored somewhat higher than Good.

Animals varying in age from 2.5 months to 5.5 years were used by Hiner and Hankins (55) to determine the effect of age of the animal on the tenderness of the meat. There was a decrease in tenderness with the increase in age of the animals. A comparison of Choice, Good, and Commercial grades of beef from steers which ranged from 14 to 18 months in age showed that tenderness was not associated with grade to a great extent.

Oven temperature. Vail and O'Neill (94) roasted 2 pairs of standing rib roasts at two different constant oven temperatures to an internal temperature of 57°C. Results showed that roasts cooked at 140°C were more palatable than roasts cooked at 232°C.

Cover (25) also studied the relationship of oven temperature and tenderness by comparing constant oven temperatures of 125°C with 225°C for roasting meat to an internal temperature of 80°C. 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 significant tenderness difference was shown in medium-rare rib and chuck roasts cooked at 125°C and 225°C. She reasoned that the difference in cooking time required by the different cuts may have had more influence on tenderness than did the oven temperature. In another study Cover (28) compared the effect of oven temperatures of 80°C and 125°C on the tenderness of beef. She observed that roasts were always tender when roasted at 80°C but that they were mealy and dry because of excessive evaporation. Roasts cooked at 125°C were juicier but less tender than those roasted at 80°C.

Child and Satorius (19) cooked semitendinosus muscles from the round of beef at constant temperatures of 125°C, 150°C, 175°C, and 200°C to an internal temperature of 58°C. From their results, it appeared that only at the extreme ends of the oven temperature range was the tenderness of the roasts affected. More pounds of force were required to shear samples from roasts cooked at temperatures of 200°C or higher than were needed to shear those cooked at a temperature of 125°C and lower.

Right and left rib cuts were cooked to an interior temperature of 61°C and 75°C at an oven temperature of 149°C by Noble, Halliday, and Klaas (71). They concluded from the penetrometer readings that toughening took place during the heating from 61°C to 75°C.

Latzke (58) reported that with an oven temperature of $175^{\circ}C$ a shorter total time was required for cooking a roast than with a lower temperature of $125^{\circ}C$. However, at the higher temperature the roast was much less evenly cooked and less tender.

<u>Cooking</u>. Extensive research was carried out by Ramsbottom, Strandine, and Koonz (85) on the comparative tenderness of 50 individual beef muscles. They observed that according to shear force tests and panel results, 35 of the 50 muscles were made less tender by cooking. They concluded that the decreased tenderness of certain cooked muscles might be associated with factors such as coagulation and denaturation of muscle proteins together with varying degrees of shrinkage and hardening of the muscle fibers.

Juiciness

Latzke (59) commented that the quality and palatability of a roast are largely determined by juiciness. From her studies in standardizing methods of roasting beef in experimental cookery, Latzke reported that juiciness can be measured to some extent by the amount of cooking losses in meat.

<u>Effect of cut and grade</u>. Noble, Halliday, and Klaas (71) studied different cuts of U.S. graded meats, using paired cuts from the right and left sides of the same animal.

They found that the juiciest meat was the most palatable and that rare meat (61°C interior temperature) had more juice than well done meat (75°C interior temperature).

Alexander and Clark (2) 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 Canner grade beef carcasses. They found that roasts cooked with the bone in were juicier than comparable boned and rolled roasts. Child and Esteros (17) reported similar findings.

Cline, Loughead, and Schwartz (23) found increased juiciness related to higher grades of meat in their studies of steaks from U.S. Good and Medium grades of heifers, cows, and steers.

Vail and O'Neill (94) reported results from two grades of cooked rolled rib, top round, and clod cuts. The cuts from U. S. Choice grade yielded appreciably less press fluid than did the cuts from U.S. Good. However, the palatability scores showed the roasts prepared from U.S. Choice grade were judged higher in juiciness than similar cuts from U.S. Good grade.

Little difference in average scores for juiciness of U.S. Utility, U.S. Commercial, and U.S. Good grade cuts were reported by Day (33) from her experiments with the longissimus dorsi muscle. She reported a positive correlation, significant at the 5 per cent probability level, between press fluid tests and juiciness scores.

Aging. Paul, Lowe, and McClurg (77) reported a gradual increase in juiciness scores during the 18 days of aging paired rounds from 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 membrane.

According to Griswold and Wharton (45), beef aged 9 days at 0°C was more juicy than beef stored 37 days at 0°C. Little variation in juiciness scores of roasts aged from 1 to 20 days was found by Harrison (47). After 30 days of aging, the juiciness scores dropped below those of roasts aged for shorter periods. Harrison concluded that evaporation of the fluids in the roasts during aging was probably great enough to reflect in the juiciness scores of the cooked roasts.

Mackintosh and co-workers (65) found that ripened samples of beef were scored higher in juiciness than samples which were cooked unripened.

Internal temperature. Child and Fogarty (18) observed that the semitendinosus beef muscle cooked to 58°C internal temperature at 150°C oven temperature contained approximately 11 per cent more press fluid than similar muscles cooked to 75°C. They also reported that the ratio of press fluid to dry matter is greater in muscles heated to 58°C than in those heated to 75°C.

Noble, Halliday, and Klaas (71) found that rib roasts cooked to 61°C yielded a larger quantity of juice than rib roasts heated to 75°C. Samples were subjected to a pressure of 380 pounds per square inch to determine press fluid.

Exterior temperature. Child and Satorius (19) reported that standing rib roasts heated to an internal temperature of 58°C at constant oven temperatures of 150°and 200°C and at 150°, following searing at 260°C, showed no differences in press fluid or shear force readings.

Cline and associates (24) studied the effect of high oven temperatures on the juiciness of roasts. They cooked beef at oven temperatures of 110°, 163°, 191°, and 260°C to an internal temperature of 57°C. Their results showed that high oven temperatures decreased the juiciness of roasts.

Method of cooking. No significant difference in juiciness of meats cooked in air, steam, water, or fat was reported by Harrison (47). There was no significant difference in the amount of press fluid at the center of the roasts attributable to cooking mediums; but there was a highly significant difference in the amount of press fluid from samples taken one-half inch from the surface. Meats cooked in air had the most press fluid. The cuts cooked in steam contained the smallest amount of press fluid. Fat and water, as cooking mediums, produced roasts with press fluid between the amounts found in those cooked in air and steam.

Freeman (42) reported that the pressure cooked pot roasts yielded significantly greater amounts of press fluid than pot roasts cooked by the conventional method.

Fenton (40) found that electronic cooking of meat usually resulted in more cooking drip than did conventional methods. Causey and associates (14) substantiated her findings.

Factors Affecting the Cooking Weight Losses of Meat

As a result of intensive investigations of meat cookery during the last decade, many factors have been shown to affect the extent of cooking losses. Lowe (61) stated that the total losses occurring during the cooking of meat may vary from 5 to more than 50 per cent. The cooking losses are divided into volatile and dripping losses. The volatile loss is mainly due to the evaporation of water, whereas the dripping loss includes fat, water, salts, and extractives.

Composition of meat

In the United States one of the earliest investigations on the cooking losses of meat was reported by Grindley and his associates (43) at the University of Illinois. Their results showed the chief loss in weight during cooking of beef by pan-broiling, boiling, and stewing was the result of the evaporation of water and that the amount of water lost during cooking varied inversely to the fatness of the meat. In 1904 Grindley and Mojonnier (44) commented that the losses in roasting of meat were attributable chiefly to the removal of fat and water from the meat.

Helser, Nelson, and Lowe (52) reported that the nature and extent of the cooking losses were directly influenced by the composition of the meat. They found that roasts with high fat content had a greater total cooking loss and also a higher dripping loss than lean roasts. The average total cooking losses for the rib roasts were 11 per cent from feeders and 15 per cent from fattened animals; the dripping losses were 1 per cent and 7 per cent, respectively.

According to Black, Warner, and Wilson (6), meat from supplement-fed steers showed less evaporation loss during cooking than did meat from grass-fed cattle. However, the dripping loss of the fatter rib samples was proportionately more than that of the thinner ones.

The composition of meat was one of the three principal factors which affected the nature and extent of cooking losses in the research studies conducted by Bevier, Grindley, and their associates (43). Other important factors were the cooking temperature and the internal temperature to which the meat was cooked.

Standing ribs of beef were cooked at 210°C oven temperature to an internal temperature of 65°C by Thille, Williamson, and Morgan (93). Their findings showed the average total weight loss for lean roasts to be 28.6 per cent and the average total weight loss for fat covered roasts to be 32.9 per cent. They attributed the difference in total weight losses to the rendering of surface fat.

Dunnigan (39) investigated the cooking weight losses of two grades of sirloin butts. Her results showed that the losses were directly related to the composition of the meat and that the cooking losses were greater in the fatter roasts.

According to studies by Alexander (1) on rib roasts ranging from Choice to Canner grade beef, the well-fattened, high-grade beef ribs lost more by drippings and less by evaporation than lean, low-grade ribs. She found that the amount of drippings of rib roasts cooked at an oven temperature of 125°C to an internal temperature of 58°C varied from 3.7 per cent for the Choice grade to 0.4 per cent for the Canner grade. The evaporation losses ranged from 6.5 per cent for Choice to 10.9 per cent for the Canner grade.

Grade

Alexander and Clark (2) found that among roasts classified according to grade, those in the higher grades usually showed smaller evaporation losses and larger dripping losses, regardless of the style of cutting or the method of cooking. Helser, Nelson, and Lowe (52) reported similar findings.

A difference in total cooking losses of 5.74 per cent between Choice and Utility sirloin butts bone-in and 2.36 per cent difference in the same grades boneless was reported by Dunnigan (39).

Day (33) found no significant differences attributable to grade in her study of U.S.D.A. Good, Commercial, or Utility beef loins in the average total cooking weight losses, volatile losses, or drip losses.

Masuda (66) reported no significant difference in volatile losses attributable to the grade of beef. There were significant differences in dripping losses attributable to cuts at each of the internal temperatures studied; but the differences in dripping losses attributable to grade were significant only at 90°C internal temperature. The average dripping losses at 90°C for Good and Choice grade were significantly higher than those of Commercial grade. No significant difference between average total cooking losses due to grade was shown at any of the internal temperatures.

Degree of ripening

Alexander and Clark (2), in cooking legs of lamb after aging 2 to 24 days, found that increasing the ripening period decreased the cooking losses. Moran and Smith (68) found the average cooking losses of top round, bottom round, and loin, ripened 3, 7, and 16 days, to be 29.5, 24.1 and 23.0 per cent, respectively.

Surface area

Grindley, McCormack, and Porter (43) observed that, as a rule, larger pieces of meat cooked by boiling and roasting showed lower cooking losses than did comparable cuts of smaller size.

Lowe (62) stated that the surface area of a cut of meat of a given weight depends upon its shape. Compact pieces with correspondingly small surface have smaller cooking losses than irregular-shaped pieces with greater surface area.

Oven temperature

In general, the higher cooking temperatures have been found to result in greater cooking losses. Child and Satorius (19) reported the cooking losses in beef were greater when the meat was prepared by roasting at constant temperatures of 200°C 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.

Three-rib beef cuts were roasted to medium stage by Latzke (58). Weight loss for seared roasts ranged from 13.52 per cent when finished at 110°C oven temperature to 22.40 per cent when finished at 175°C.

Cover (25) found that cooking losses for paired three-rib roasts, cooked medium rare, averaged 7.1 per cent when a

125°C oven was used and 20.2 per cent when a 225°C oven temperature was used. For three-rib beef cuts cooked to the well done stage at the same temperatures, Cover reported the cooking losses to be 23.0 and 37.5 per cent, respectively.

The effect of various oven temperatures upon cooking losses and palatability of several types of beef roasts was reported by Cline and co-workers (24). They concluded that an oven temperature of 125°C, as compared with 165°C, decreased the cooking losses but increased the time required to reach a given internal temperature.

McCann and Ship (67) compared the effect of temperature upon the cooking losses in loin, liver, kidney, tripe, and brain of beef. The pieces of meat were cooked in steam at 80°, 100°, and 120°C. Increase of temperature increased both the rate and the extent of the cooking loss.

Method of cooking

Lowe (61) stated that the method of cooking influences not only the total but also the relative proportions of the different constituants lost during cooking. Meat may be cooked in water, in steam, in air, and in fat.

Grindley and Mojonnier (44) experimented on changes occurring in meat cooked by different methods. The meats cooked in hot water had the highest average total weight loss and the roasted meats had the lowest average cooking weight loss. Sautéed meats showed a slightly higher weight loss than pan-broiled meats.

Results of ten methods of roasting beef were reported by Cline and associates (22). Prime ribs of beef were first seared and then finished at different oven temperatures; one beef cut was started in a cold oven and then was seared and finished in a 149°C oven; several different constant oven temperatures were also used. From this study it was concluded that searing increases the cooking weight losses and that low oven temperatures were correlated with low cooking losses.

Several investigators (26, 69) reported that the use of skewers reduced the cooking time and thus lowered the cooking losses. Morgan and Nelson (69) were among the first investigators to report the uses of skewers in meat roasting. They found that the total loss of weight in skewered roasts averaged 27.3 per cent as compared with 31.5 per cent in unskewered roasts. Cover (26) reported similar findings.

Clark and VanDuyne (20) reported on cooking losses as they were affected by roasting, pressure saucepan, and broiling. Twelve comparable top round beef roasts were cooked in the pressure saucepan or roasted in the oven to an internal temperature of 82°C. The greater proportion of weight loss of meat cooked in the oven was the result of evaporation. Roasts cooked in the pressure saucepan had significantly greater losses in drip and in total cooking losses than those roasted in the oven.

Bollman, Brenner, Gordon, and Lambert (8) found that the weight loss in roasts prepared in the electronic range was approximately 20 per cent greater than that occurring in roasts prepared by the conventional roasting method. Fenton (40), in a more recent study, reported that moisture loss in microwave cooking is low both because of the short cooking time and the coolness of the oven air. It may, however, be high when foods are overcooked.

Freezing

Cline and co-workers (23) have shown that both the total cooking losses and cooking time were affected by the initial temperature of roasts when they were put into the oven. Roasts with low initial internal temperatures ($1^{\circ}C$) at the beginning of the cooking period showed greater cooking losses than did roasts with higher internal temperatures ($8^{\circ}C$ and $12^{\circ}C$) when cooking began.

Ramsbottom and Koonz (84) reported that in small steaks, where the area of cut surface was large in relation to volume of meat, the amount of drip depended to a large extent on the freezing temperature. When small steaks were rapidly frozen intrafiber freezing occurred; and when these steaks were defrosted, the fluids were retained for the most part by the fibers and the drip was relatively small. If the steaks were slowly frozen, extrafiber freezing took place; and when these steaks were defrosted, more of the fluid was lost as drip before it could be reabsorbed by the partially dehydrated muscle fibers.

Hiner and Hankins (55) found that meat frozen at +18^{o}C had greater weight loss than meat frozen at -40^{o}F. Drip loss for those samples frozen at +18^{o}C was greatest and for those frozen at -114^{o}F the least.

Paul and Bratzler (74) compared the effects of various cold storage, freezing, and thawing treatments on cooking time and cooking losses. Steaks which had been frozen required slightly longer to cook and had higher cooking losses than those which had not been frozen. The frozen steaks cooked without thawing had the highest cooking time and losses. The high correlation between cooking time and losses indicated that one of the major factors affecting cooking loss was the time required to cook the steak.

Lowe and co-workers (62) compared the effect of four methods of defrosting meat and the manner and temperature of cooking upon weight loss and palatability of the roasts. Frozen cuts of meat required a longer time to reach the same internal temperature than did comparable cuts which were thawed. Data for 41 groups of roasts showed that the frozen cuts did not always have greater cooking weight losses than the defrosted meat. In 31 of these groups the cooking weight loss was greater for those roasts which were frozen when cooking began. Opposite findings were reported for the other 10 groups of roasts.

Methods of Evaluating Palatability of Meats

Investigators interested in studying the palatability characteristics of meats have used taste panels, mechanical devices, or combinations of subjective and objective methods of evaluation.

Subjective method

According to Lowe and Stewart (63), subjective tests measure the qualities of food as they make their impression individually on the sensory organs. They are subjective because the individual is required to go through a mental process in giving his opinion about the qualitative and quantitative value of the characteristics under study. They classify subjective tests into two categories: preference or acceptance tests and difference or psychometric tests. The psychometric tests are used to determine quantitative differences and deal with rating and scoring food quality factors. This makes them especially useful for statistical analysis and for the evaluation of quality changes in a specific food during processing treatments.

Problems involved in subjective testing have been discussed extensively in the published literature (7, 72). Boggs and Hanson (7) stated that one of the serious limitations of subjective tests is the variability of individual response to a given stimulus and of individual response at different times. Individuals vary in their threshold levels, in degrees of difference they can distinguish, in ability to reproduce scores at different times, and in ability to identify one flavor in the presence of others. These variations can be decreased by training and selecting judges, checking their performance on tests, maintaining interest of the judges in the work, and minimizing the effects of prejudice and fatigue. Clauss, Ball, and Stier (21) emphasized that organoleptic tests lacked precision but they reported that they gave information of value after consistency of performance was developed in the judges.

An Acceptance Testing Methodology Symposium was held in 1953 at Chicago under the joint sponsorship of the National Research Council and the Quartermaster Food and Container Institute. Dr. H. Schlosberg (80), Brown University, reported that apparently the best or only way to obtain stable and sensitive measurements of responses to foods is to increase panel size. His conclusion was based on a long-term study of the problem of selecting and training panels. Harrison and Elder (48) support his findings. When panel members had immediate knowledge of the results of their efforts, their performance as judges improved. This, Dr. Carl Pfaffman, Brown University, attributed to increased interest of the panel member.

Foster (41) reported that there is a need for standardization of nomenclature, methods, and interpretation in the field of panel study of foods. He predicted a reduction in duplication of research effort and the possibility of intralaboratory test comparisons if standardization were accomplished.

Peryam and Swartz (70), also aware of the need of objectivity in the field of flavor measurement, presented three tests designed for difference testing. In the triangle test three samples were presented to the judges at the same time. They were asked to identify the sample which differed from the other two identical samples. In the duo-trio test a control was presented first and then two samples were given. The judges were asked to select the sample which differed from the control. In the dual standard test two odor samples were presented to the judges. They were asked to study them and note differences. A second pair of samples were given and the judges were asked which sample matched each of the first samples. Peryam and Swartz (70) recommended the triangle tests for discrimination, the duo-trio test for taste, and the dual standard test for odor.

The hedonic scale method has become a very useful tool in food research. The essential features of the scale are its assumption of a continuum of preference and the direct way it defines the categories of response in terms of like and dislike. It was developed by the Quartermaster Food and Container Institute in 1947. A 7-point scale expressed in terms of like and dislike was used in a survey to evaluate consumer preference of foods. Peryam and Giradot (78) used the hedonic scale to measure group responses. They pointed out that, although the method has proven extremely useful, it cannot be considered for quality control of flavor in food production.

The need for preliminary training has been mentioned by investigators. Boggs and Hanson (7) stated that training should include the presentation of series of samples differing in all of the characteristics of importance in the investigation. Harrison and Elder (48) also discussed the need for preliminary training.

The selection of a judge for use on a panel is usually made on the basis of relatively few trials. For this reason and also because there is no assurance that consistency will continue, it is advisable to check the performance of the judges. The method of checking depends on the design of the experiment. Overman and Li (72) used a comparison of the average range scores for each judge and a comparison of the number of times each judge duplicated his score. They concluded that a high ability to detect differences, together with a low variability in duplicating judgments, are indications of good judging. Lowe and Stewart (63) suggested the use of deviations of the scores of an individual from his own mean score for each sample.

Although limitations of subjective testing are recognized, it is still considered an important method in determining food acceptability.

Objective Method

Chemical and physical tests on foods are valuable supplements to panel tests. Usually it is desirable to show that a chemical or physical test measures a characteristic that correlates with something detected by panels. (7)

In the field of meat research, considerable work has been done in an effort to correlate physical measurements of tenderness, texture, and juiciness with the panel scores for the same qualities. Many devices for measuring tenderness have been proposed, but the one which has shown the most reliable results is the Warner-Bratzler shearing apparatus (11). This device measures the force required to cut across a cylinder of meat of known diameter. A high degree of negative correlation between taste panel scores for tenderness and shear force readings has been reported by several investigators. (6, 88).

Noble, Halliday, and Klaas (71), 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. Lowe (63) used the dynamometer and penetrometer to measure the tenderness of rare and well-done beef roasts from carcasses graded Choice and Medium. The results obtained with the dynamometer showed close agreement with the subjective scores and the grade of animal; results with the penetrometer were less consistent.

Deatherage and Garnatz (34) found that the difference in shear force readings were not as great as differences in taste panel scores. They stated that, although, shear strengths appeared to measure fairly satisfactorily a property of meat, these values were not closely related to tenderness of broiled steaks as determined by a trained sensory panel.

Child and Baldelli (16) reported an apparatus called the Pressometer and standardized a method for determining the percentage of press fluid. Studies (17, 33) have shown correlation between pressometer readings and juiciness scores by taste panels. Satorius and Child (89) found no correlation between press fluid and juiciness scores.

From the results of the work in which an apparatus operated by hydraulic pressure was used, Tanner, Clark and Hankins (92) reported that the correlations between the scores of the judges and the percentage of expressible juice of three groups of samples were not significantly high.

The limited examples cited here suggest the need to develop additional tests to supplement the subjective methods now used for testing.

Objective and subjective method

Examples of the combined uses of the subjective and objective methods have been reported on tenderness and juiciness by many investigators (60, 57). Dove (37) commented, "The use of these two terms in combination now becomes necessary since the trend in research has been to depend solely upon the objective approach." He added that the subjective-objective approach is the first step to be taken in reorientation before food acceptance tests can be developed.

Lowe and Stewart (63) emphasized that objective tests for organoleptic qualities must measure characteristics which can be correlated with subjective evaluations of acceptability. They discussed 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.

Today many investigators have combined the two methods of determining the acceptability of food because of the limitations recognized in using subjective and objective tests separately.

METHOD OF PROCEDURE

Top sirloin butts of U.S.D.A. Choice grade beef were purchased in groups of four for four consecutive weeks. The meat was delivered to the Food Service Laboratory by the Food Stores just prior to each roasting period. The cooked roasts were sliced, wrapped, and frozen for one week. They were then reheated for taste panel testing. A single roast[1] was prepared as a control and presented along with samples from the reheated roasts at each judging period.

Roasting Process

Each beef cut was placed with the fat side up on a wire rack in a separate aluminum roasting pan, 18" x 12" x 2 3/4". The meat was then roasted without a cover in a preheated two-deck Hotpoint electric oven to an internal temperature of 70°C at a constant oven temperature of 149°C. No seasonings were used in the preparation of the roasts.

The internal temperature was closely watched by means of straight-type thermometers, with temperatures engraved on glass and calibrated from 0° to 105° in 1°C intervals. The thermometers were inserted so that the bulb was as near the center of the roast as possible. Since the oven doors were equipped with glass windows, it was not necessary to open the doors to check the temperature of the roasts.

[1]See Table 4 for initial weight and cooking losses

Temperatures of the roasts were recorded every 20 minutes from the beginning of the roasting period until the roasts reached 60°C. After an interval temperature of 60°C was reached, the temperatures were read every 5 minutes until the roasting period was terminated when the internal temperature of each roast reached 70°C.

Cooking Losses

Approximately one-half hour after the roasts were removed from the oven, the weight of each roast with its drippings was recorded. Next the dripping losses were determined by subtracting the weight of the rack and pan from the weight of the rack, pan, and drip. Volatile losses were obtained by subtracting the combined weight of the cooked roast and its drippings from the weight of the uncooked roast. The roasts were then removed from the roasting pans and placed on separate weighed, foil-covered trays. Total cooking losses were obtained by subtracting the cooked weight of each roast from its raw weight.

Samples for Shear Force and Panel Testing

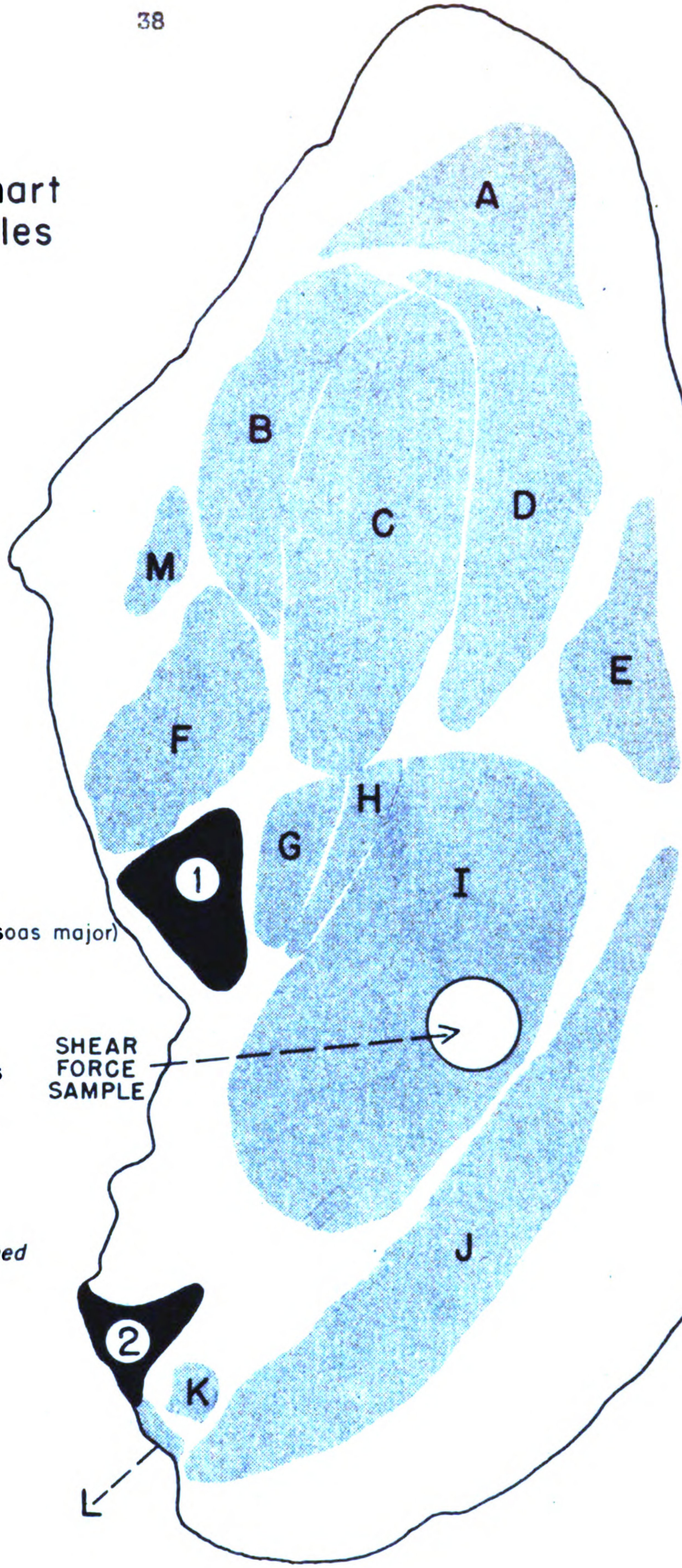
After the roasts had cooled for an additional half hour, the covering of fat and the biceps femoris muscle were removed from each roast by separating the sheaths of connective tissue. The end of each roast was then squared by cutting off the end slice with a sharp knife so that cross-grain samples for judges and with-grain samples for shear test could be obtained. Removing this end slice also helped to identify the muscles more easily and to determine the direction of fibers accurately.

A slice, approximately $2\frac{1}{2}$ inches thick, was then cut from the roast across the grain and paralleled with the first cut. Next a sample for testing tenderness on the Warner-Bratzler shear machine was obtained by rotating the special sharp, hollow metal cylinder gently clockwise and counter-clockwise with the grain of the gluteus medius muscle. (See Plate 1 for identification). The samples or cores were 1-inch in diameter and approximately $2\frac{1}{2}$ inches long. Each sample was then wrapped separately in aluminum foil and frozen with the roast. The $2\frac{1}{2}$ inch slice was then sliced on a manual slicer for taste panel samples of 3/4-inch thickness. The slices were arranged as cut, and each roast was reassembled to approximate its original shape.

Handling Losses

After the roasts were reassembled, each tray with foil and roast was weighed to determine handling losses which occurred during the slicing process. The handling losses were calculated by subtracting the weight of the tray, foil, and roast after samples were prepared from the first weight of tray, foil, and roast.

Plate I. Beef chart identifying muscles used in study



MUSCLES

A, E Tensor fasciae latae
B Vastus medialis
C Rectus femoris
D Vastus lateralis
F Ilio-psoas (Iliacus and Psoas major)
G Gluteus accessorius
H Gluteus profundus
*I Gluteus medius
J Biceps femoris
K Sacrococcygeus lateralis
L Multifidus dorsi
M Sartorius

BONES

1 Shaft of ilium
2 Sacral vertebra
**Muscle primarily concerned with in study*

Preparation for Freezing

After the handling loss was determined, the aluminum foil was molded around the roast to make an air tight covering. Each foil-covered roast was wrapped in a polyethylene bag from which as much of the air was removed as possible. The wrapped roast was secured with elastic bands to which a code number was attached. The roast was then placed in a freezer at -20°C temperature for one week.

Preliminary Investigations

Preliminary tests were made by Ronald (87) to determine the length of the reheating period required to bring the cooked, frozen roasts to serving temperature in a conventional roasting oven and in a standard steamer. For the present study similar procedures had to be developed for the use of an RCA Whirlpool electronic range and a Hotpoint pressure steamer. Therefore, trial investigations were made to determine the approximate time necessary to reheat the roasts to an internal temperature of 70°C.

Trial tests

Two roasts were removed from the freezer approximately 27 hours before reheating time, weighed, placed in the weighed pans in which they were to be reheated, and stored in a refrigerator at 4°C. The remaining roasts were removed from the freezer immediately before they were reheated.

The roasts reheated by the Hotpoint pressure steamer were placed in deep aluminum pans, 12 3/4" x 1½" x 4", with their foil wrap left in place. The use of the deep aluminum pans was necessary because of limited space in the steamer for reheating the two roasts simultaneously so that the reheated samples could be presented at a uniform temperature to the taste panel.

The two roasts reheated by the electronic range were placed in pyrex pans, 13 3/4" x 9¼" x 2", with the foil removed because metal utensils and foil reflect microwaves and, therefore, slow the cooking process (81).

After the roasts had been reheated to an internal temperature of 70°C, they were removed from the electronic range and the pressure steamer. The losses which occurred during reheating were calculated in the same manner as those calculated after the first cooking process.

<u>Time results</u>

From the trial investigations it was found that the frozen sample reheated in the electronic range required 5.4 minutes per pound to reach a desirable temperature for serving; the sample reheated in the steamer required 13.5 minutes per pound. The defrosted samples reheated in the electronic range required 3.9 minutes per pound; the sample reheated in the steamer required 12.4 minutes per pound.

Trial taste panel

Previous to the actual scoring of the roasts used in the experimental study, a trial period was set aside for the six panelists. This period served to familiarize them with the scoring methods. They were given typed instructions as well as an oral introduction to the taste panel procedure. For practice, they scored four samples which had been reheated by the electronic range. Two of these samples were reheated from the frozen stage, and the remaining two were reheated from the defrosted stage.

Test Procedures

Four replications of each reheating method were carried out. Roasts prepared by the four methods of reheating together with a control were scored at each test period. The control roasts were cooked by the same method used initially in preparing the roasts which were frozen and then later reheated.

Presentation of samples

The reheating of the roasts for the taste panel was done at the same time of day and on the same day of the week for four consecutive weeks.

Five coded samples of meat were prepared for the panelists at each scoring period. The five coded samples were placed on plates on individual trays for each of the six judges.

Each judge received the slice cut from the same relative position in each roast.

The panelists were seated at separate tables in the same location at each scoring period. Water at room temperature was supplied along with the samples to be tested.

<u>Shear force tests</u>

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 prepared according to standard procedure. Samples for testing may be either one-half or one inch in diameter.

The cylinders used for tenderness tests were reheated with the roasts from which they were taken. They were marked with the code number of the reheated roast and stored overnight in a refrigerator at $4^{\circ}C$. The following morning three readings were made on a cylinder of cooked meat previously removed from each roast. Each sample was inserted in a triangular opening in a metal blade of 1 mm thickness. Shearing bars were started downward by an automatic switch and an electric motor; the pounds of force necessary to shear the meat were recorded automatically on the gauge. Three readings were averaged to obtain the tenderness rating of the sample.

Subjective tests

Each of the six judges scored a sample slice from each roast. These slices included the same muscle from which the samples for the shear force tests were taken. Scores were based on a scale ranging from 1 to 10 for aroma, flavor, tenderness, and juiciness. A score of 10 indicated extremely desirable quality and 1 represented undesirable. The score sheets also included descriptive terms for the palatability characteristics. Judges were requested to check these terms if they gave a score of 7 or less to a sample.

RESULTS AND DISCUSSION

The results of this study are discussed in reference to palatability and cooking losses. Statistical analysis was omitted because of the small number of samples studied. Discussion of the results is based on the mean or average values for four replications.

Palatability Factors

Aroma and flavor

Aroma and flavor are considered important factors in judging the acceptability of meat. The average scores for aroma and flavor are shown in Table 1 and Figure 1 and 2. Aroma and flavor of the control samples were given the highest scores with the exception of Replication II, in which both palatability factors scored below the defrosted samples reheated by the electronic range. In general, however, aroma of samples reheated by the pressure steamer received slightly higher scores than did the samples reheated by the electronic

Table 1. Average aroma and flavor scores

	Control	Steamer		Electronic Range	
		Defrosted	Frozen	Defrosted	Frozen
Aroma	7.3	5.7	5.7	5.3	5.0
Flavor	7.1	5.0	5.1	5.3	4.9

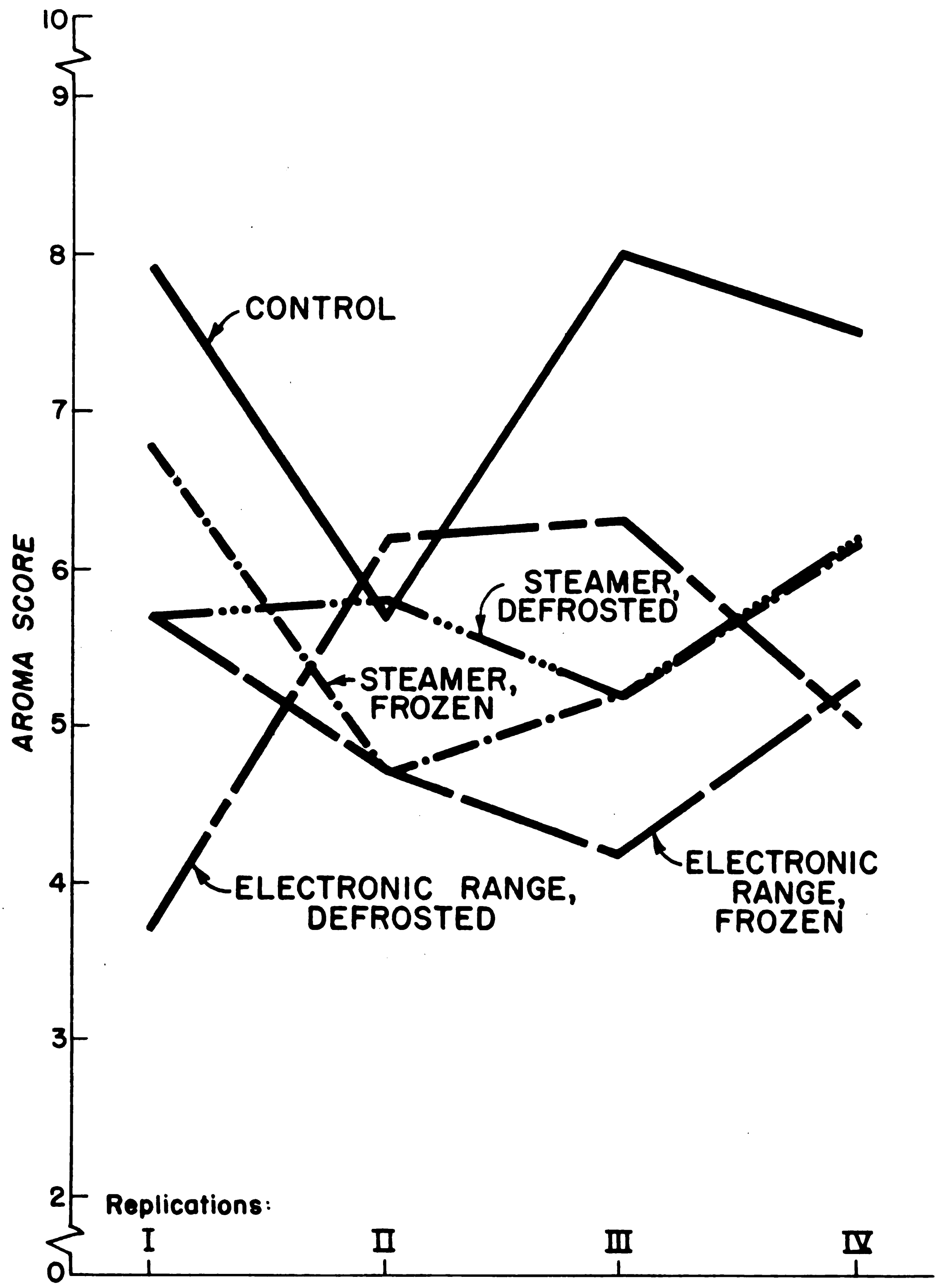


Figure 1. Average aroma scores

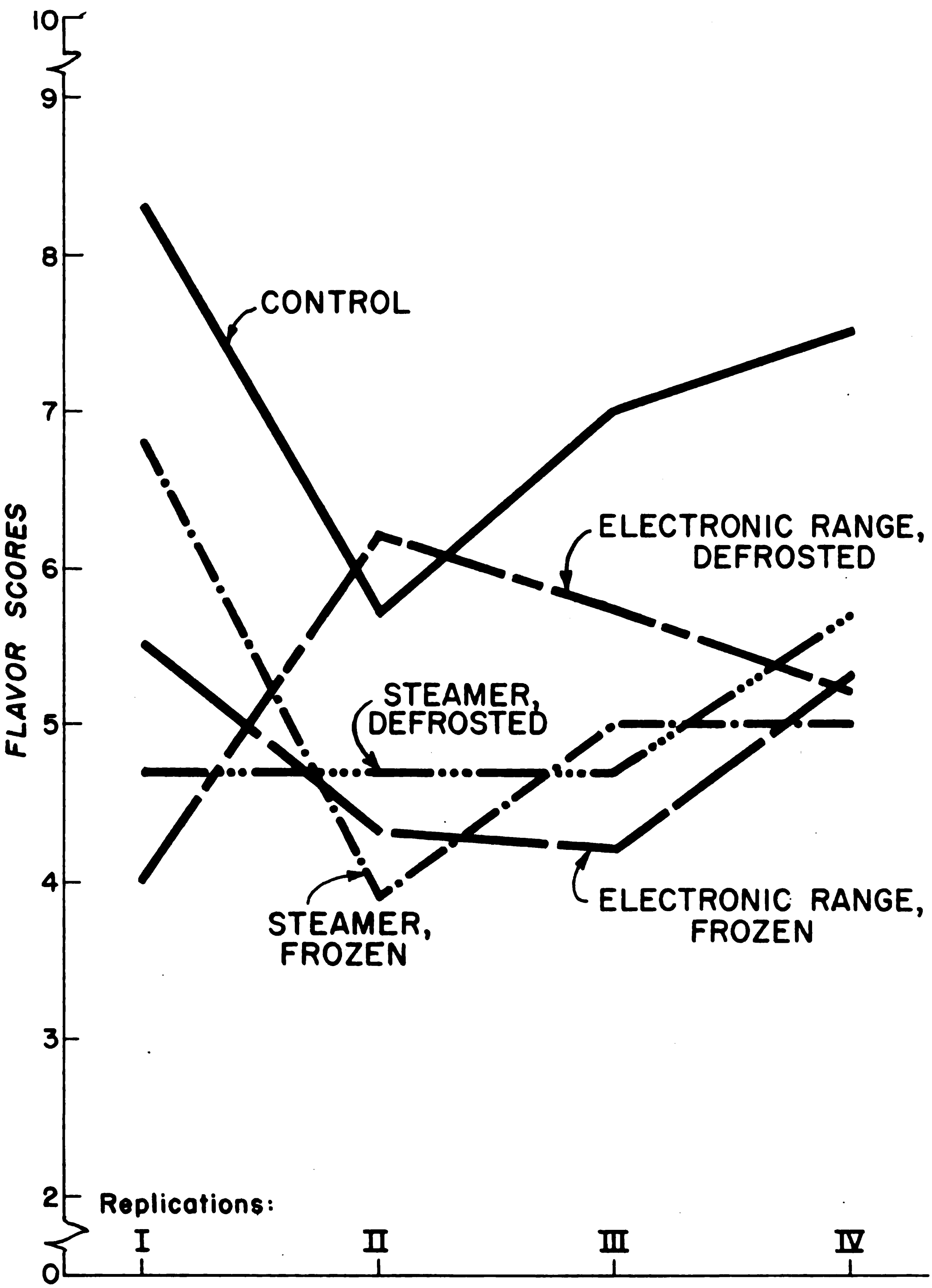


Figure 2. Average flavor scores

range. The frozen samples reheated in the electronic range without defrosting were scored the lowest both for flavor and aroma.

Adjectives used by the judges to describe the samples scored below 7 were: warmed-over, old, washed-out, gamey, dark, dry, and shriveled. All samples were marked by one or more of these adjectives. Half of the control roasts received one or two of the remarks. The dark, dry and shriveled appearance was used to describe the frozen samples reheated by the electronic range.

The average scores for flavor did not favor either the electronic range or pressure steamer method for reheating. No appreciable differences were shown between the roasts reheated from the defrosted or frozen stage.

Tenderness and shear force

Table 2 and Figures 3 and 4 show the average scores for tenderness according to the panelists and the shear force

Table 2. Average tenderness scores and shear force readings

	Control	Steamer		Electronic Range	
		Defrosted	Frozen	Defrosted	Frozen
Tenderness	6.0	5.4	4.9	5.0	5.3
Shear force	14.7	15.2	13.5	11.6	14.8

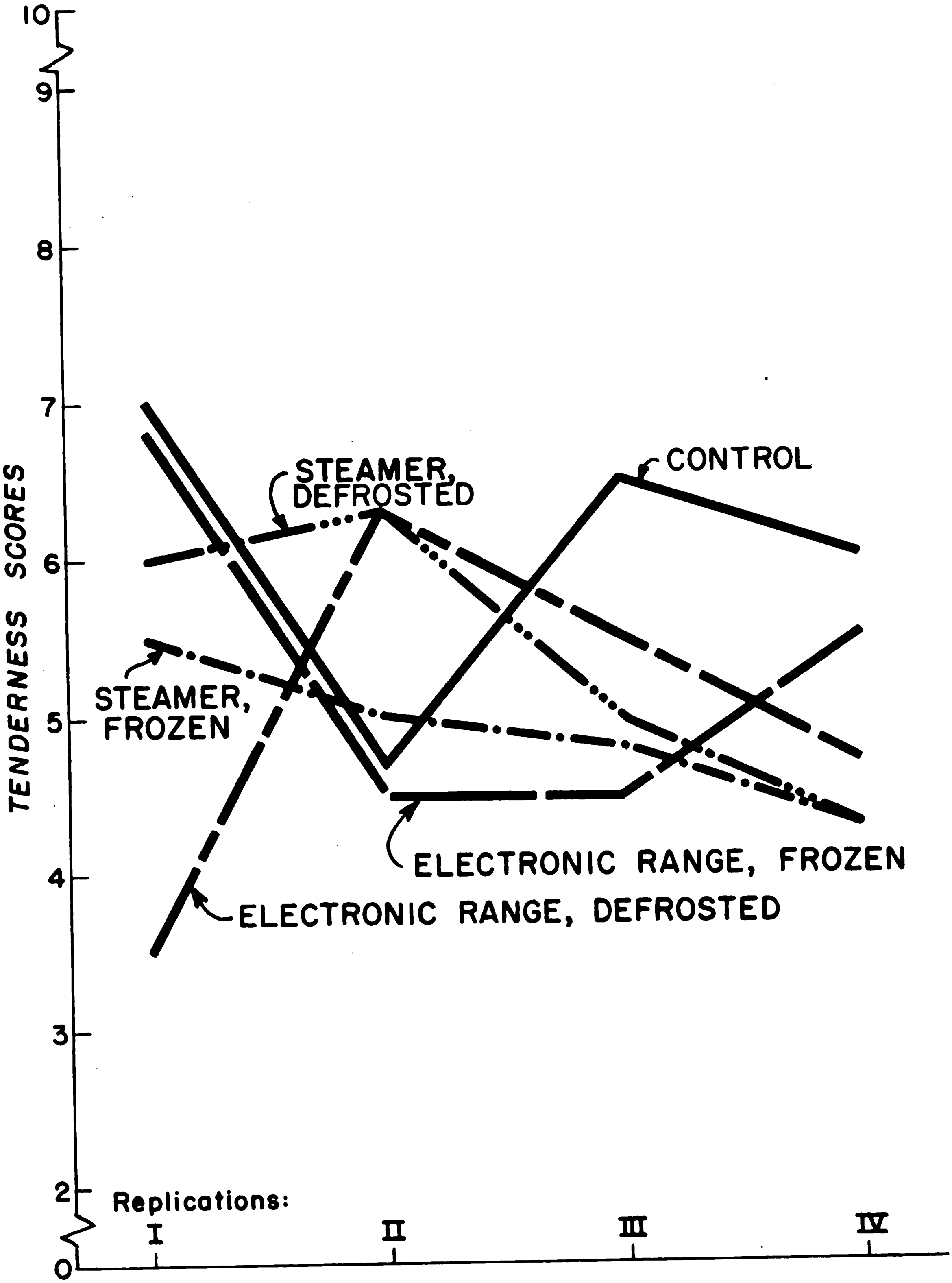


Figure 3. Average tenderness scores

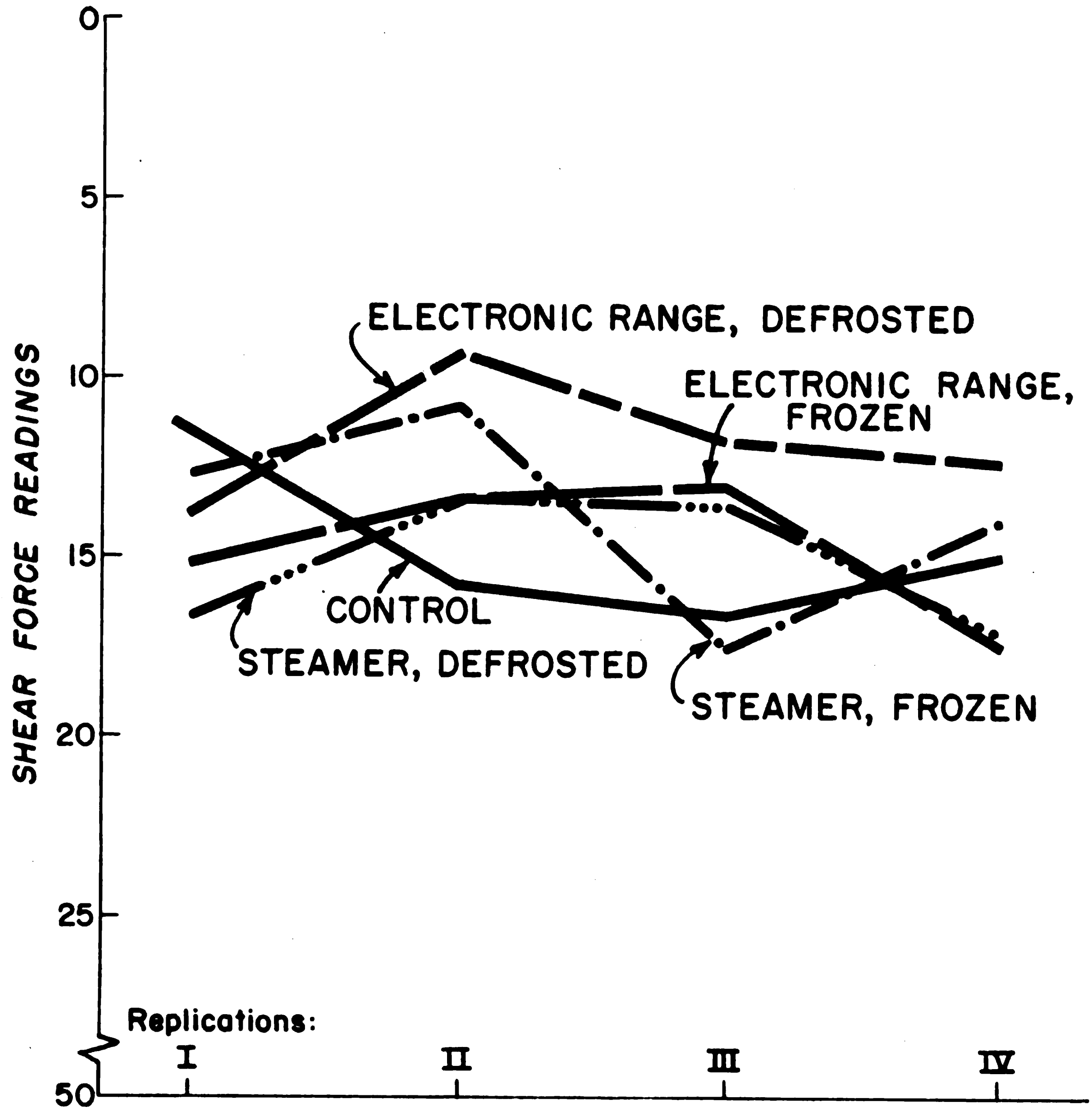


Figure 4. Average shear force readings

readings. Again, the control roasts received the highest scores with the exception of Replication II, where the score of the control fell below that of the defrosted samples reheated by the steamer and the electronic range. Study of the shear force readings and tenderness scores indicated no apparent relationship between them. The control roasts were rated highest in average score by the panelists. Shear force readings for the defrosted roasts reheated by the electronic range indicated that these roasts were the most tender. The frozen roasts reheated by the steamer followed next, then the control roasts, the frozen roasts reheated by electronic range, and the defrosted roasts reheated by the steamer. Although the defrosted roasts reheated by the electronic range were the most tender according to the shear force readings, they were not the most desirable products from the standpoint of other palatability factors.

Juiciness

The average juiciness scores are shown in Table 3 and Figure 5. In general, the control samples received the

Table 3. Average juiciness scores

	Control	Steamer		Electronic Range	
		Defrosted	Frozen	Defrosted	Frozen
Juiciness	6.2	4.9	4.6	4.5	4.8

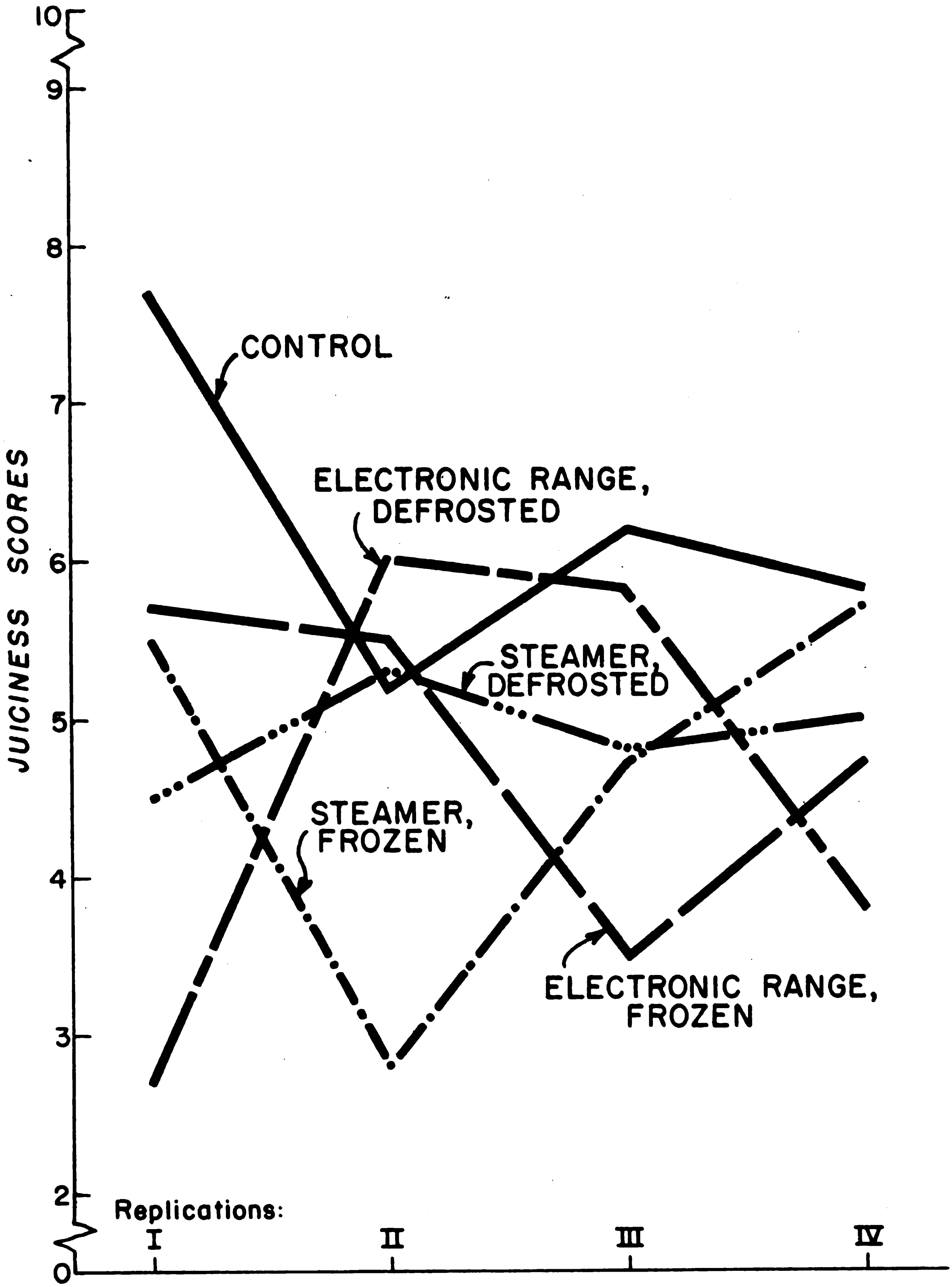


Figure 5. Average juiciness scores

highest average scores. The samples reheated in the electronic range from the defrosted stage received the lowest scores. However, the averages for roasts reheated by the other three methods had very similar scores: no one method of reheating could be considered the best from the standpoint of conserving juices during reheating.

Figure 6 shows the comparative average palatability scores discussed so far.

General appearance

Although general appearance was not scored separately, several judges commented on the samples reheated by the electronic range. These samples were not only smaller in comparison with the samples reheated by the pressure steamer but also showed dark brown, dried-out edges.

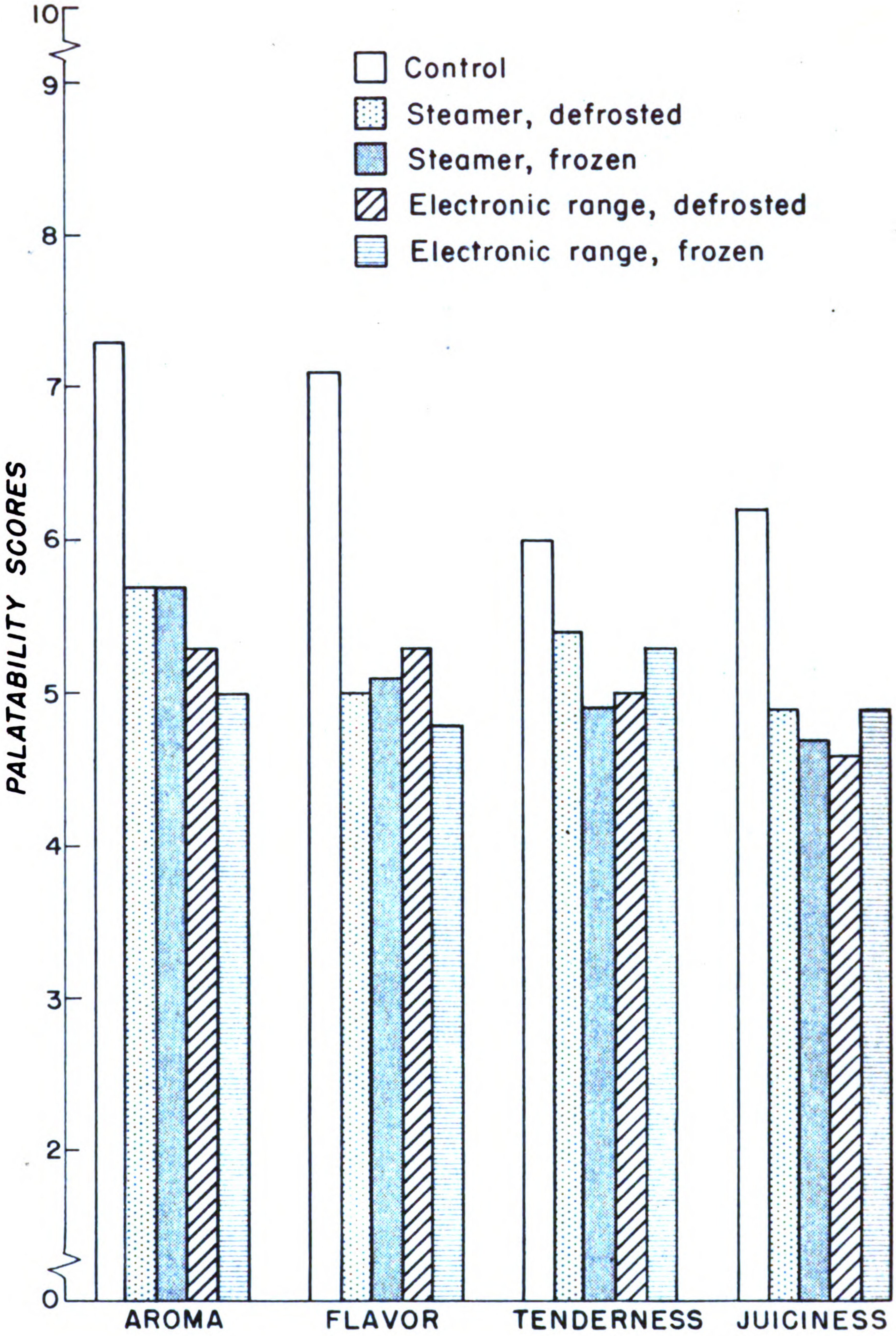


Figure 6. Comparison average palatability scores

Cooking Weight Losses

As stated previously, both volatile and dripping losses are included in the total cooking losses. The volatile loss consists chiefly of the evaporation of water, whereas the drippings contain fat, water, and extractives. Heavy cooking losses result in smaller amounts of cooked meat for serving, and the quality deteriorates as cooking losses are increased above normal.

Total cooking losses

The average total cooking losses are shown in grams in Table 4 and in percentages in Table 5 and Figure 7. The average percentages for total cooking and reheating losses were: 29.6 per cent for steamer, defrosted; 32.2 per cent steamer, frozen; 40.5 per cent electronic range, defrosted; and 47.6 per cent electronic range, frozen. Ronald (87) reported 32.1 per cent for oven, defrosted; 33.3 per cent for oven, frozen; 33.2 per cent steamer, defrosted; and 34.5 per cent steamer, frozen. The roasts and procedures of her investigations were similar to those reported in this study.

Volatile cooking losses

Volatile cooking losses for each roast are recorded in Tables 4 and 5 and Figure 7. Because of condensation during the reheating of roasts in the steamer, it was not possible to obtain separate figures for dripping and volatile losses.

Table 4. Cooking, handling, and reheating losses (grams)

Methods of Reheating	Roast Code No.	Initial wt. of roasts in gms.	INITIAL COOKING Volatile loss	Drip loss	Total loss	Handling loss
Control	J 94	5028	313	155	468	125
	H115	4316	450	281	731	135
	T 47	4508	466	244	710	126
	Y125	4341	545	510	1055	93
Average		4548	443	297	741	119
Steamer, defrosted	R127	5271	556	288	844	151
	A102	4906	460	441	901	90
	O 74	5401	390	214	604	158
	B 64	4364	389	249	638	96
Average		4985	448	298	746	123
Steamer, frozen	V 89	5143	410	279	689	119
	X 59	4150	409	171	580	66
	E 10	4754	448	309	757	97
	R 52	4498	300	291	591	130
Average		4636	391	262	654	103
Electronic range, defrosted	C 63	4639	618	231	849	105
	M 31	5308	522	543	1065	99
	K 23	5200	441	204	645	112
	H 11	4639	300	187	487	88
Average		4946	470	291	761	101
Electronic range, frozen	L 46	4920	561	296	857	87
	S 84	5023	489	299	788	108
	G 96	4479	450	211	661	135
	N133	4496	539	348	887	74
Average		4729	509	288	798	101

REHEATING			GRAND TOTAL			
Volatile loss	Drip loss	Total loss	Volatile loss I & II	Drip loss I & II	Reheat-ing	Total
-	-	-	313	280	-	593
-	-	-	450	416	-	866
-	-	-	466	370	-	836
-	-	-	545	603	-	1148
-	-	-	443	417	-	860
-	-	485	556	439	485	1480
-	-	708	460	531	708	1699
-	-	818	390	372	818	1580
-	-	417	389	345	417	1151
-	-	607	448	421	607	1477
-	-	599	410	398	599	1407
-	-	851	409	237	851	1497
-	-	651	448	406	651	1505
-	-	801	300	421	801	1522
-	-	725	391	365	725	1482
430	606	1036	1048	942	-	1990
282	756	1038	804	1398	-	2202
359	696	1055	800	1012	-	1812
372	1038	1410	672	1313	-	1985
360	774	1134	831	1166	-	1997
418	809	1227	979	1192	-	2171
488	1018	1506	977	1425	-	2402
522	771	1293	972	1117	-	2089
572	793	1365	1111	1215	-	2326
500	847	1347	1009	1237	-	2247

Table 5. Cooking, handling, and reheating losses (percentages)

Methods of Reheating	Roast Code No.	Initial wt. of roasts in gms.	INITIAL COOKING Volatile loss	Drip loss	Total loss	Handling loss
Control	J 94	5028	6.23	3.08	9.30	2.48
	H115	4316	10.43	6.51	16.93	3.12
	T 47	4508	10.34	5.41	15.74	2.79
	Y125	4341	12.55	11.74	24.29	2.14
Average		4548	9.88	6.68	16.56	2.63
Steamer, defrosted	R127	5271	10.54	5.46	16.00	2.86
	A102	4906	9.37	8.98	18.35	1.83
	O 74	5401	7.22	3.96	11.18	2.92
	B 64	4364	8.91	5.70	14.61	2.19
Average		4985	9.01	6.02	15.03	2.45
Steamer, frozen	V 89	5143	7.97	5.42	13.39	2.31
	X 59	4150	9.85	4.12	13.97	1.59
	E 10	4754	9.42	6.49	15.91	2.04
	R 52	4498	6.66	6.46	13.12	2.89
Average		4636	8.47	5.62	14.09	2.20
Electronic range, defrosted	C 63	4639	13.32	4.97	18.29	2.26
	M 31	5308	9.83	10.22	20.05	1.86
	K 23	5200	8.48	3.92	12.40	2.15
	H 11	4639	6.46	4.03	10.49	1.89
Average		4946	9.52	5.78	15.30	2.04
Electronic range, frozen	L 46	4920	11.40	6.01	17.41	1.76
	S 84	5023	9.73	5.95	15.68	2.15
	G 96	4479	10.04	4.71	14.75	3.01
	N133	4496	11.98	7.74	19.72	1.64
Average		4729	10.78	6.10	16.89	2.14

REHEATING			GRAND TOTAL			
Volatile loss	Drip loss	Total loss	Volatile loss I & II	Drip loss I & II	Reheating	Total
-	-	-	6.22	5.56	-	11.78
-	-	-	10.42	9.63	-	20.05
-	-	-	10.33	8.20	-	18.53
-	-	-	12.55	13.88	-	26.43
-	-	-	9.88	9.31	-	19.19
-	-	9.20	10.54	8.32	9.20	28.06
-	-	14.43	9.37	10.81	14.43	34.61
-	-	15.14	7.22	6.88	15.14	29.25
-	-	9.55	8.91	7.90	9.55	26.36
-	-	12.08	9.01	8.47	12.08	29.56
-	-	11.64	7.97	7.73	11.64	27.34
-	-	20.50	9.85	5.71	20.50	36.06
-	-	13.69	9.42	8.54	13.69	31.65
-	-	17.80	6.66	9.35	17.80	33.81
-	-	15.90	8.47	7.83	15.90	32.20
9.26	13.06	22.32	22.58	20.29	-	42.87
5.31	14.24	19.55	15.14	26.32	-	41.46
6.90	13.38	20.28	15.38	19.45	-	34.83
8.01	22.37	30.38	14.47	28.29	-	42.76
7.37	15.76	23.13	16.89	23.58	-	40.48
8.49	16.44	24.93	19.89	24.21	-	44.10
9.71	20.26	29.97	19.45	28.36	-	47.81
11.65	17.21	28.86	21.69	24.93	-	46.62
12.72	17.63	30.35	24.70	27.01	-	51.71
10.64	17.88	28.52	21.43	26.12	-	4756

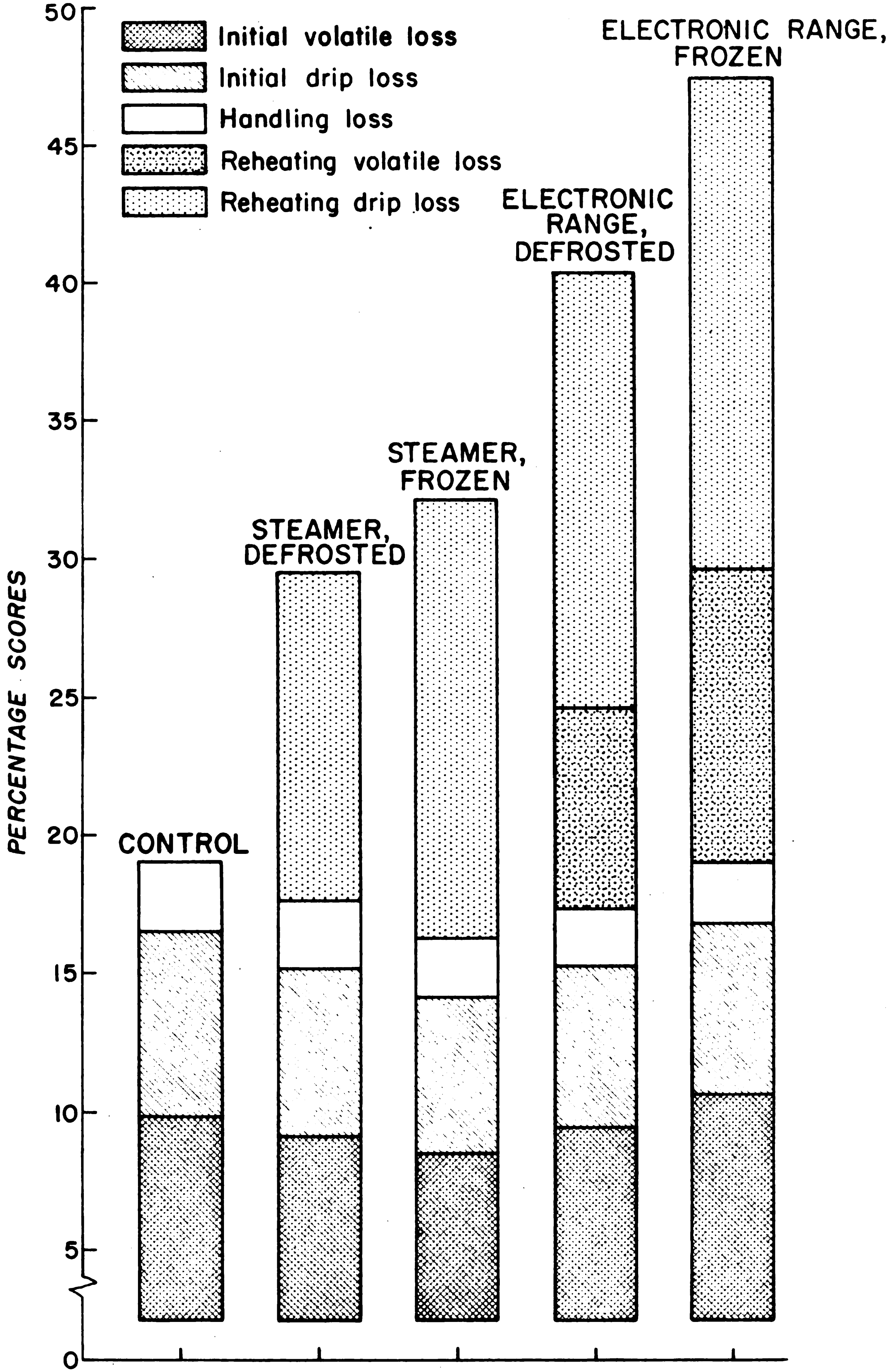


Figure 7. Average cooking losses

Therefore, volatile losses for the reheating periods were determined for the electronic reheating methods only.

The average volatile loss for the defrosted roasts reheated in the electronic range was 7.4 per cent and the loss for the frozen roasts reheated by the electronic range was 10.6 per cent.

Dripping losses

The average total drip loss percentages are shown in Table 5 and Figure 7. Average drip loss percentages for the reheating period were obtained only for the roasts reheated by the electronic methods.

The averages were: 23.1 per cent for electronic range, defrosted; and 29.0 per cent for electronic range, frozen. The combined average of volatile and drip loss percentages for the defrosted roasts reheated by the steamer were 12.0; for the frozen roasts reheated by the steamer 15.9. Ronald (87) reported 10.8 per cent for steamer, defrosted; 12.0 per cent for steamer, frozen; 8.6 per cent for oven, defrosted; and 11.2 per cent for oven frozen. Her roasts, however, were cooked to an internal temperature of 80°C.

Results of the study indicate that roasts reheated from the frozen stage by either reheating method, consistently showed greater cooking losses than the roasts reheated from the defrosted stage. However, in comparing the reheating methods, it is apparent that the roasts reheated by the pressure steamer from the defrosted or frozen stage showed much lower losses than similar roasts reheated in the steamer.

Cooking Time Required to Reach Certain Internal Temperatures*

The time required for each roast to reach 50°C, 60°C, and 70°C is recorded in Table 6 in the Appendix. The average time for the twenty roasts was as follows: 24.9 minutes per pound to reach 50°C, 31.0 minutes per pound to reach 60°C, and 39.6 minutes per pound to reach 70°C. Ronald (87) reported 18.3 minutes per pound to reach 60°C, 22.3 minutes per pound to reach 70°C, and 28.4 minutes per pound to reach 80°C.

*Thermostats were operating at a low oven temperature which may explain the difference in minutes per pound reported by Ronald (87) and this study.

SUMMARY AND CONCLUSIONS

The objective of this study was to investigate four methods of reheating precooked frozen beef roasts. Retaining the original palatability characteristics of the meat during the reheating process was considered to be of primary importance.

Top sirloin butts of U.S.D.A. Choice grade beef were cooked at a constant oven temperature of 149°C to an internal temperature of 70°C. The cooked roasts were sliced, wrapped, and stored for one week in a freezer compartment at -20°C. Samples of the cooked beef were reheated and scored by six judges for aroma, flavor, tenderness, and juiciness. The scoring sheet was scaled from 1 to 10, with 10 being the most desirable and 1 the least desirable. Objective tests were also used for determining tenderness.

Four reheating methods were investigated. A Hotpoint pressure steamer and an RCA Whirlpool electronic range were used in reheating the roasts. Control roasts were cooked by the same method used in preparing the roasts which were frozen and then later reheated.

The summary of results of the palatability scores for aroma, flavor, tenderness, and juiciness follows:

1. Aroma and flavor of the control roasts were not equaled by scores of roasts reheated by any of the methods used for reheating precooked roasts in this study.

2. Shear force readings for tenderness indicated that there was no apparent relationship between the taste panel scores and the shear force. Although the defrosted roasts reheated by the electronic range were the most tender according to the shear force readings, they were not the most desirable products from the standpoint of other palatability factors.

3. From the taste panel scores, it appeared that there was little difference in juiciness among the four methods of reheating.

The secondary objective of this study was to study the cooking time required to reheat the roasts to an internal temperature of 70°C and to evaluate the results for possible institutional use. The results indicated that the time required was too long to make the method practical for use for situations in which preparation time was limited. The time for reheating the roasts in the electronic range was considerably less than in the steamer. However, because of the great amount of cooking losses, it would not seem satisfactory or economical for use in any institutional food service operation.

Research on methods of reheating upon the palatability of precooked beef roasts is only in its beginning stages. More work needs to be done to establish methods which will retain, as far as possible, the original palatability characteristics.

Results of this study suggest that further studies on reheating with the electronic range seem questionable because of the poor quality of the final product. However, the products reheated in the steamer seemed to be somewhat more acceptable. It would seem possible that more palatable products might result from reheating the cooked roasts in the steamer if the methods of procedure were modified. Reheating roasts without previous slicing might be more satisfactory in retaining quality of the product than has been shown by methods used in this study.

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APPENDIX

Table 6. Cooking time required to roast meat to 50°C, 60°C, and 70°C internal temperature

Roast Code No.	Minutes per pound		
	50°C	60°C	70°C
V 89	25.4	31.7	39.8
L 46	24.0	28.6	36.0
C 63	25.0	32.3	44.0
R127	23.7	29.6	38.2
J 94*	23.5	28.0	32.0
M 31	22.6	29.1	36.3
A102	21.1	26.0	32.4
X 59	24.9	31.7	41.1
S 84	24.2	30.7	38.8
H115*	22.6	28.4	36.8
K 23	25.0	30.3	35.1
E 10	23.9	29.6	36.7
O 74	24.1	30.2	38.7
G 96	24.3	31.4	42.6
T 47*	23.6	29.2	38.8
B 64	26.5	33.7	44.6
N133	25.2	31.6	42.2
H 11	33.3	40.2	51.5
R 52	34.0	42.4	55.5
Y125*	21.9	26.1	31.9
Total Average	24.9	31.0	39.6

* represent control roasts

Table 7. Average scores for aroma, flavor, tenderness, shear force, and juiciness for each roast.

Methods of Reheating	Roast Code No.	Aroma	Flavor	Tenderness	Shear Force	Juiciness
Control	J 94	7.9	8.3	7.0	11.3	7.7
	H115	5.7	5.7	4.7	15.9	5.2
	T 47	8.0	7.0	6.5	16.7	6.2
	Y125	7.5	7.5	6.0	15.0	5.8
Average		7.3	7.1	6.0	14.7	6.2
Steamer, defrosted	R127	5.7	4.7	6.0	16.6	4.5
	A102	5.8	4.7	6.3	13.3	5.3
	O 74	5.2	4.7	5.0	13.5	4.8
	B 64	6.2	5.8	4.3	17.2	5.0
Average		5.7	5.0	5.4	15.2	4.9
Steamer, frozen	V 89	6.8	6.8	5.5	12.6	5.5
	X 59	4.7	3.9	5.0	10.9	2.8
	E 10	5.2	5.0	4.8	16.5	4.7
	R 52	6.2	5.0	4.3	14.0	5.7
Average		5.7	5.1	4.9	13.5	4.7
Electronic range, defrosted	C 63	3.7	4.0	3.5	12.8	2.7
	M 31	6.2	6.2	6.3	9.4	6.0
	K 23	6.3	5.7	5.5	11.8	5.8
	H 11	5.0	5.2	4.7	12.4	3.8
Average		5.3	5.3	5.0	11.6	4.6
Electronic range, frozen	L 46	5.7	5.5	6.8	15.2	5.7
	S 84	4.7	4.3	4.5	13.3	5.5
	G 96	4.2	4.2	4.5	13.0	3.5
	N133	5.3	5.3	5.5	17.5	4.7
Average		5.0	4.8	5.3	14.8	4.9

GUIDE FOR TASTE PANEL

1. Smell each sample first and score aroma.

2. Rate each sample as you test it.

3. Do not change rating once it has been made.

4. Keep hands away to avoid ever-present skin odors from interferring with judgment.

5. Be careful to avoid comparing samples with your own preferences.

6. Tasting should be done slowly. Allow at least one minute before determining score. Take a sip of water and wait another minute before beginning next sample.

7. Use sample size [box] cut from approximately same position in each slice. Count number of chews necessary to masticate it completely.

8. Please do not exchange opinions or comments with other panel members.

General Instructions:

A. Please check appropriate descriptive terms for flavor and aroma if you score these characteristics below 7.

B. Please count and record number of chews under tenderness. Indicate numerical score by referring to your own score range for tenderness.

SCORE SHEET FOR ROASTS

FACTOR	10	9	8	7	6	5	4	3	2	1	REMARKS
AROMA	Extremely Desirable	Very Desirable	Desirable Plus	Moderately Desirable Minus			Slightly Desirable	Neutral	Slightly undesirable	Undesirable	___ stale ___ moldy ___ old ___ strong ___ warmed-over
FLAVOR	Extremely Desirable	Very Desirable	Desirable	Moderately Desirable Plus		Minus	Slightly Desirable	Neutral	Slightly undesirable	Undesirable	___ old ___ gamey ___ fishy ___ rancid ___ tainted ___ warmed-over ___ washed-out
TENDERNESS	Extremely Tender	Very Tender	Tender	Moderately Tender Plus		Minus	Fair	Tough	Very Tough	Extremely Tough	Number of Chews ___
JUICINESS	Extremely Juicy	Very Juicy	Juicy	Moderately Juicy Plus		Minus	Fair	Dry	Very Dry	Extremely Dry	

Sample Number ____________ Name of Scorer ____________ Date ________

(7943)

ABSTRACT

Meat is one of the most important food items around which menu planning is centered in the home and in institutions. Because of this, there is much interest in methods of preparation which will produce a highly palatable product. The "eating quality" of meat depends on the appearance, aroma, flavor, tenderness, and juiciness of the cooked product.

In this study four methods for reheating precooked frozen beef roasts were investigated. Retaining the original palatability of the meat during the reheating was a primary consideration. A Hotpoint pressure steamer and an RCA Whirlpool electronic range were used in reheating the roasts. Control roasts were cooked by the same method used in preparing the roasts which were frozen and then later reheated.

Top sirloin butts of U.S.D.A. Choice grade beef were cooked at a constant oven temperature of 149°C to an internal temperature of 70°C. The cooked roasts were sliced, wrapped and stored for one week in a freezer compartment at -20°C. The cooked beef roasts were reheated and samples were scored by six judges for aroma, flavor, tenderness, and juiciness. Warner-Bratzler shear tests were also used for determining tenderness.

The results of the palatability scores indicated that the aroma and flavor of the control were most desirable and

were not equaled by scores of roasts reheated by any of the methods studied. Although the defrosted roasts reheated by the electronic range were scored the most tender, they were not the most desirable products from the standpoint of other palatability factors. Juiciness did not vary greatly among the four methods of reheating.

In evaluating the time required to reheat the roasts to an internal temperature of 70°C, it was observed that the period was too long to make the method practical for institutional use. The time for reheating the roasts in the electronic range was considerably less than the period for reheating the roasts by the pressure steamer. However, on the basis of palatability, the roasts which were reheated electronically were not the most desirable products.

PROBLEM M.S. 1957

ZIMMERMANN, Hanna-Rose

The Effect of Methods of Reheating Upon Palatability of Precooked Frozen Beef Roasts.

II. Electronic Range and Pressure Steamer.