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CONSUMER ACCEPTANCE AND EVALUATION OF QUALITY ATTRIBUTES OF BEEF SEMIMEMBRANOSUS ROASTS HEATED AT THREE OVEN RATES

A Thesis

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Degree

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ABSTRACT

Tenderness, an important quality attribute of meat, is affected by many factors including rate of heating. This quality attribute also has been reported as the single most important criterion for judging meat quality by the consumer. The purpose of this investigation was to evaluate selected quality attributes of beef semimembranosus roasts heated at three oven rates (93°C, 149°C, and a combination of 93°C and 149°C) using a consumer panel and instrumental measurements to determine whether tenderness is the most important meat quality attribute to the consumer and to study consumer habits and practices of meat consumption, buying, and preparation.

Roasts heated at 93°C were evaluated by the consumer panel as more tender ($P < 0.01$) than roasts heated at the other two rates. Warner Bratzler shear values showed roasts heated at the lowest temperature and at a combination of temperatures to be more tender ($P < 0.01$) than roasts heated at the highest temperature. However, treatment did not have a significant effect on overall acceptability of the roasts.

Flavor and tenderness were indicated as being equally important factors in the evaluation of beef quality by the consumer. Other quality attributes were ranked as less important by the consumer panel.

Roast beef was eaten by the consumers in the home approximately two and one half times per month. Hamburger was the most frequently served type of beef. Generally, less tender cuts of beef were served as roasts

to the family and guests. Consumers used moist heating methods more frequently than dry heating methods for preparing roasts. None used long heating times except with slow cookers, but some did use low oven temperatures. Less than half indicated that they would be willing to use long heating times to prepare a roast.

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CHAPTER I

INTRODUCTION

Tenderness of meat is a complex sensation. Heat related changes in meat tenderness result from two opposing forces—changes in connective tissue have a tenderizing effect while hardening of the myofibrillar proteins has a toughening effect (Cover, 1943; Paul, 1963). Both of these reactions are time-temperature dependent with the time factor more important for collagen softening while the temperature seems to be more important for fiber toughening (Cover, 1943; Paul, 1963; Hamm, 1966; Draudt, 1972). Therefore, the method of heating will have considerable effect on the ultimate eating quality of the meat.

Investigations have shown that roasting beef at low temperatures (66-121°C) for very long periods of time produced more tender roasts than higher oven temperatures (149-163°C) for shorter time periods (Cover, 1943; Bramblett et al., 1959; Paul, 1963; Bramblett and Vail, 1964; Bayne et al., 1969; Bayne et al., 1973).

Changes in collagen and muscle fibers during heating are related to the changes observed in tenderness of meat (Paul, 1963; Laakkonen et al., 1970; Draudt, 1972; Bayne et al., 1973; McCrae and Paul, 1974; Penfield and Meyer, 1975). However, Penfield and Meyer (1975) found that the relationship between shear values and collagen solubilization was limited. Other factors affecting tenderness such as muscle fiber hardening might overshadow collagen solubilization during long periods of heating between 60°C and 70°C.

Draudt (1972) stated that at 65.6°C the hardening reaction of the muscle fibers becomes apparent in shear data. Therefore, it seems logical that a slow rate of heat penetration to maximize collagen solubilization to an end point temperature of 65.6°C followed by an increased rate of heat penetration to minimize muscle fiber hardening to the final end point temperature would promote optimum tenderness.

Studies focusing on the effect of heating on tenderness have used trained panelists to evaluate quality attributes of meat samples (Cover, 1943; Bramblett et al., 1959; Cover et al., 1962a,b,c; Bramblett and Vail, 1964; Bayne et al., 1969; Schock et al., 1970). Studies using consumer or untrained, inexperienced panels to evaluate the tenderness and other quality attributes of meat heated at varying temperatures have not been reported. Although trained panelists have detected differences in tenderness of meat heated at two oven temperatures (Cover, 1943; Bramblett et al., 1959; Bayne et al., 1973), it has not been determined whether consumers can detect this difference in meat tenderness. Tenderness has been identified by Bailey (1972) as the single most important factor in assessing meat quality by the consumer. Studies are needed to support this generally accepted theory which fails to recognize the possible importance of other quality attributes in consumer evaluation. This study was designed to evaluate a heating method that applies the facts regarding the effects of heat on the components of meat by a consumer panel and to relate these findings to consumer meat practices and habits in order to describe the receptiveness of consumers to varying practices with regard to meat. The objectives of this study were:

1. to evaluate a method of roasting involving a combination of oven temperatures (93°C and 149°C) which should maximize collagen solubilization and minimize muscle fiber hardening resulting in a roast of optimum tenderness;

2. to compare consumer acceptance of meat heated to an end point temperature of 71°C at oven temperatures producing three rates of heat penetration—93°C, 149°C, and 93°C to an internal temperature of 65.6°C then at an increased oven temperature of 149°C to the final end point temperature;

3. to compare objective measurements and panelists' scores for the quality attributes of tenderness, color, mouthfeel, flavor, and overall acceptability of the roasts heated to 71°C at the three rates of heat penetration;

4. to relate consumer acceptance of meat heated at the three rates to consumer practices with regard to selection and preparation of beef;

5. to investigate the relative importance of various meat quality attributes in consumer evaluation of acceptability of the roasts heated by the three heating rates.

CHAPTER II

REVIEW OF LITERATURE

The most important assessment of meat quality is the one made by the consumer. Bailey (1972) has suggested that tenderness is the most important criterion of meat quality to the consumer. However, there are many ante-mortem and post-mortem factors affecting tenderness over which the consumer has no control. Paul (1972) discussed the following factors as influencing tenderness of meat: genetic factors—species, breed, and sire; animal influences—sex, age, and weight; slaughter and post-mortem treatment; composition and function of the muscle structure; and processing. Paul further stated that ultimate eating quality may be enhanced or downgraded through the consumer's choice of heating method.

I. THE EFFECT OF LONG-TIME, LOW-TEMPERATURE HEATING ON THE TENDERNESS OF BEEF

Previous investigations have shown that roasting beef at low temperatures (66-121°C) for very long periods of time produced more tender roasts than higher oven temperatures (149-163°C) for shorter time periods. Time rather than oven temperature was suggested by Cover (1943) as the important factor in determining changes in meat tenderness during heating. Roasts were always tender when the rate of heat penetration was slow enough to require 30 hours or more for the meat to be heated to the well-done stage. When the time was shorter

than 30 hours, the roasts were not always tender. Roasts cooked to the well-done stage in an 80°C oven were evaluated as being more tender by a trained panel and Warner Bratzler shear measurements than the paired roasts heated in a 125°C oven.

US Standard grade beef rounds were heated at 63°C for 30 hours and at 68°C for 18 hours in a study reported by Bramblett et al. (1959). Meat heated at the lower temperature for the longer time period was more tender than meat heated at 68°C for the shorter time period. The critical factor in the increased tenderness appeared to be the length of time the meat was held at an internal temperature range of 57-60°C. Shear values decreased as the length of time in that temperature range increased. Increased tenderness was attributed to changes in both the muscle fibers and connective tissue although specific changes were not characterized.

In a follow-up study conducted by Bramblett and Vail (1964), US Good and US Standard beef rounds were heated at 68.5°C and 93.5°C to an internal temperature of 65°C. Tenderness scores, Warner-Bratzler shear values, and L.E.E. Kramer shear press values indicated that the meat cooked at 68.5°C was more tender than paired cuts cooked at 93.5°C.

Griswold (1955) compared palatability scores and shear values of Commercial and Prime beef rounds heated by 14 different methods. One aspect of the study involved a comparison of a standard braising method with roasting at 121°C and 149°C to an internal temperature of 85°C. Shear values indicated that roasts heated at 121°C were significantly more tender than those cooked at 149°C. Panelists' scores for the roasts heated at 121°C and 149°C were generally higher than those for

braised roasts. Scores for the meat roasted at 121°C usually exceeded those for meat roasted at 149°C with the exception of juiciness. The cuts roasted at 121°C were described as having an undesirable dark, hard surface with a dry, mealy interior which was so tender that the meat was difficult to slice.

The effects of specific cooking temperatures and time on tenderness of semimembranosus muscle were determined by Tuomy et al. (1963). Meat "logs" (3.8 x 3.8 x 20.3 cm^3) were heated in a water bath held at various temperatures, 60°C, 71°C, 82°C, 88°C, and 99°C, for a seven hour period. Tenderness was evaluated by means of panel scores for palatability and a L.E.E. Kramer shear press model. It was found that the initial effect of heat was toughening which increased as the temperature increased. Tenderness of meat held below 82°C was dependent upon temperature with time having little or no effect. When the meat was held at 82°C or above, the meat became tender at a rate and to a degree dependent upon both time and temperature.

Simmers (1965) compared tenderness of 5.5 kg top round roasts heated at 93.5°C and 149°C to end point temperatures of 68°C and 70°C respectively. The 93.5°C roasts were significantly more tender than those heated at 149°C as indicated by both shear values and sensory scores.

The effect of low oven temperatures on the tenderness of 8.8 kg beef rib roasts was studied by Fugate (1967). Paired roasts were heated at 107°C and 163°C to end point temperatures of 60°C, 70°C, or 76.5°C. Shear values indicated that ribs cooked at 107°C to end point temperatures

of 70°C and 76.5°C were significantly more tender than those heated by all other heat-treatment combinations.

Paired top round roasts were heated at 93.5°C and 149°C to an end point temperature of 67°C (Whetstone, 1969). Semimembranosus roasts heated at the lower temperature for a longer time were more tender than roasts heated at 149°C.

Bayne et al. (1969) studied the effect of two heating rates on paired large and small rib and top round roasts. Roasts were heated at oven temperatures of 93.5°C and 149°C to end point temperatures of 66.5°C and 70°C respectively. The slower rate of heat penetration produced a roast that was more tender than those heated at 149°C. Both shear values and panel scores for tenderness showed this difference. The authors postulated that the slower rate of heat penetration produced by the 93.5°C oven could have promoted increased degradation of collagen resulting in a more tender product.

In a later study conducted by Bayne et al. (1973), beef rib cuts were roasted at 107°C and 163°C to end point temperatures of 60°C, 70°C, and 77°C. Warner-Bratzler shear values indicated that roasts heated at 107°C to end points of 70°C or 77°C were more tender than all other heat treatment combinations. Shear values were unaffected by end point temperature when roasts were cooked at 163°C. Panelists rated the roasts heated at 107°C to each end point temperature and those heated at 163°C to 60°C more tender than those cooked by other heat treatments.

Bouton and Harris (1972) used compression, shear, and tensile testing methods in an investigation of the effects of heating selected bovine muscles. They reported that changes in tenderness produced by

heating meat at 90°C were dependent on animal age and heating time. At 50°C, 60°C, or 70°C the effect of time was much reduced. Temperatures up to 50°C had a toughening effect reflecting changes in water-holding capacity. They speculated that changes during heating in the 50-60°C range were probably related to connective tissue changes. The increase in toughness on heating at temperatures between 60°C and 75°C was attributed to increased moisture loss and fiber shortening with concomitant changes in the properties of the connective tissue.

Laakkonen et al. (1970) devised a model system to simulate heating 15.7 kg rounds at 121°C in an institutional gas heated oven. The rate of heat penetration in small samples (100-130 g) in vacuumized plastic bags in a water bath heated from 30°C to 60°C was 0.1°C per minute. Under these conditons, samples were heated for 10 hours (well-done). These samples were compared to quickly heated control samples that were tempered for 60 minutes at 30°C in a water bath, then heated to 80°C in 60 minutes and held at that temperature for an additional 60 minutes. Slower rates of heat penetration produced more tender meat and total heating time was an important factor. Meat heated for 6 hours (rare) had lower shear values and was only slightly more tender than the control. However, meat heated for 10 hours (well-done) was noticeably more tender than the control as shown by decreased shear values (Laakkonen, 1973).

Changes in collagen and muscle fibers during heating are related to the changes observed in tenderness of meat (Paul, 1963; Laakkonen et al., 1970; Draudt, 1972; Bayne et al., 1973; McCrae and Paul, 1974; Penfield and Meyer, 1975). Long-time, low-temperature oven cookery (66-121°C)

generally produced tender products because of the time that the internal temperature of the meat was within the range of 57°C to 60°C which promoted collagen solubilization without muscle fiber hardening (Paul, 1963; Penfield and Meyer, 1975). Bayne et al. (1969) suggested that the slower rates of heat penetration contributed to greater degradation of collagen resulting in increased tenderness.

Changes in the various muscle components during heating are reflected by changes in shear values at various temperatures (Draudt, 1972). At 40°C there has been no significant change in the mechanical properties of meat. At 50°C denaturation of most of the contractile proteins has occurred without collagen solubilization or muscle fiber hardening. Therefore, shears have reached a maximum prior to collagen shrinkage. Shear values at 60°C reflect the collagen shrinkage reaction without an appreciable hardening of the myofibrillar proteins. In the range of 70°C to 75°C, the hardening reaction reaches its maximum peak.

In a study by Penfield and Meyer (1975), tenderness increased as collagen solubilization increased during heating and the extent of collagen solubilization was influenced more by a rate of heat penetration comparable to roasting in a 93°C oven than a rate comparable to roasting in a 149°C oven. This relationship, however, was found to be limited. At the 70°C end point temperature collagen solubilization differed significantly between the two heating rates but shear values failed to differ significantly. This indicated that increased collagen solubilization in the samples heated by the slow rate might have been overshadowed by other factors affecting tenderness such as muscle fiber hardening

during the long period of heating between 60°C and 70°C. Curves derived from the data suggest that an increase in shear values occurs at approximately 67°C even though collagen solubilization was increasing at that point. Draudt (1972) found that at 65.6°C the hardening reaction of the muscle fibers becomes apparent in shear data.

II. USE OF SENSORY PANELS IN MEAT EVALUATION

The tenderizing effect of long-time, low-temperature heating has been one of the major concerns of many investigators since 1937. To study tenderness, many investigators have used sensory evaluation panels in addition to instrumental measurements. Sensory evaluation of meat tenderness and other attributes offers the advantage of approximating the actual evaluation of quality encountered under normal conditions of eating. Small-scale laboratory-type panels have been used extensively in assessing meat tenderness (Pearson, 1963).

Trained Panels

Scales of descriptive terms describing degrees of tenderness and lack of tenderness have been used by Cover (1943), Griswold (1955), Bramblett et al. (1959), Fugate (1967), Bayne et al. (1969 and 1973), and Cross et al. (1973). Intensity scales ranging from extremely desirable or good to extremely undesirable or poor were used by Visser et al. (1960), Marshall et al. (1960), Schock et al. (1970), Baldwin et al. (1972), and Shaffer et al. (1973). Simmers (1965) and Whetstone (1969) evaluated tenderness using chew counts in addition to intensity scales.

Cover et al. (1962a) identified the six components of tenderness as: softness to tongue and cheek, softness to tongue pressure, ease of fragmentation, mealiness, adhesion, and tenderness of connective tissue. Each component was weighted so that highest scores would indicate increasing tenderness.

In the study by Schock et al. (1970), the effects of dry and moist heat treatments on selected characteristics of cooked beef top rounds were studied. Correlation coefficients indicated that of the four palatability factors studied tenderness had the most influence in the overall acceptability scores. Flavor had the next greatest influence, and juiciness and apparent degree of doneness the least. A survey of the palatability panel also indicated that the judges based their overall acceptability scores mostly on tenderness and flavor. Some judges stated that flavor was most important in assignment of the overall acceptability scores. Juiciness seemed to be an important factor to most judges only when extremely low levels were noted.

Consumer Panels

Consumer panels frequently have been involved in investigations of the relationship between preference and grades of beef (Dunsing, 1959; Naumann et al., 1961) or preference and beef from animals of different ages (Jullerat and Kelly, 1971). In a study conducted by Hunt et al. (1963), an untrained panel evaluated top round roasts for tenderness, juiciness and flavor. These evaluations were made irregularly and therefore insufficient ratings for statistical analysis were obtained.

In general, studies using consumer or untrained, inexperienced panels to evaluate the tenderness and other quality attributes of meat heated at varying temperatures have not been reported. Trained panelists have detected differences in tenderness of meat heated at two oven temperatures (Cover, 1943; Bramblett et al., 1959; Griswold, 1955; Simmers, 1965; Whetstone, 1969; Bayne et al., 1973). It has not been determined whether consumers can detect such differences in meat tenderness. Studies are needed to determine if tenderness as affected by cooking methods is the single most important quality attribute to the consumer.

III. CONSUMER PRACTICES

Many factors influence the consumers' decisions in purchasing meat. Woods and Jenkins (1963) investigated motivations in consumer purchases of beef in Louisiana. Cost, appearance of the lean (amount, color, and texture), general appearance of the cut, and the nutritive value of meat were listed as factors influencing choices of beef. Reasons for buying various cuts of beef were cost, flavor, versatility, ease of preparation, family preparation, and expected tenderness. Families that purchased meat at one particular store did so because of quality, economy, and convenience of location.

Weidenhamer et al. (1969) found that the homemakers considered the assurance of good quality when buying meat. Beef was found also to be the most frequently eaten meat and was characterized by a substantial majority of consumers as tasty, easily digested, versatile, healthful, providing little waste, and not being tiresome. Part of the versatility

attributed to beef appears to be derived from the number of different forms available, each of which satisfies various needs.

Neigh and Trotter (1970) studied the relationship between selected socioeconomic factors (income, size and composition of households, occupational status of household head, and education, age, religious preference of the homemaker) and consumers' responses to retail meat-price specials and the effect of selected shopping habits on the purchase of meat-price specials in Pennsylvania. Households most responsive to meat specials were those with incomes in the range of $3,000-$7,999, with four and five family members, and with children less than 17 years of age. No significant relationships were found between the socioeconomic factors and responses to meat-price specials. The authors concluded that factors other than socioeconomic factors were important in determining consumer response to meat-price specials, and believed that impulse buying may influence food purchasing behavior.

CHAPTER III

PROCEDURES

Roasts heated at oven temperatures of 93°C, 149°C, and a combination of 93°C and 149°C were evaluated by a consumer panel and several instrumental methods. In addition, data concerning habits and practices of meat consumption, buying, and cookery methods of the panel were collected.

I. SOURCE OF MEAT

Four USDA Choice top round roasts weighing 4.09-5.45 kg were purchased from a local supermarket to simulate consumer buying practices. The center section of the top round was requested when each order for a replication was placed. The roast, purchased a week prior to cooking, was cut by the processor into three roasts weighing from 1.37 kg to 1.96 kg. The roasts were assigned randomly to each of the three heat treatments to constitute one replication. Then they were wrapped in moisture-proof freezer paper, frozen, and stored at -15°C.

The middle section of the top round roasts was requested since the center section of the semimembranosus muscle was reported by Rogers (1969) as being relatively uniform in tenderness. Although it is not the most uniformly tender muscle, semimembranosus muscle was used in order to have sufficient sample for sensory and instrumental measurements.

II. SELECTION OF PANELISTS

The consumer panel was selected randomly from graduate students, faculty members, and staff members in the College of Home Economics with little or no previous experience in meat evaluation. The proportion of graduate students, faculty members, and staff members in this total population was 70 percent, 20 percent, and 10 percent, respectively. Based on these proportions, nine graduate students, three faculty members, and two staff members totaling 14 panelists for each block or 56 total were invited to participate. A letter of explanation (Appendix A) and consent form (Appendix B) were sent to each prospective panelist 12 days prior to the appointed tasting session. Positive responses made it possible to have four panels consisting of ten panelists each. The 40 panelists represented the following proportions within the total panel: graduate students, 58 percent; faculty members, 22 percent; and staff members, 20 percent.

III. QUESTIONNAIRE

Each judge was given a questionnaire concerning his meat purchasing, preparation, and consumption habits and practices. The questionnaire was to be completed before coming to the tasting session. (The questionnaire and responses are summarized in tables in the results and discussion.) Each individual drew a set of labels having the same random number prior to entering the testing area and was instructed to place a label on each score card and questionnaire. Since each individual's questionnaire

and score cards were coded with the same random number, the questionnaire could be identified in relation to the corresponding score card for statistical analysis without identification of the individual.

IV. COOKING PROCEDURE

Each roast was thawed at a combination of room and refrigerator temperatures for two days prior to cooking. During heating, meat temperatures and oven temperatures were monitored by copper-constantan thermocouples and recorded by a Honeywell multipoint temperature recorder.

On the day of cooking, the roasting pans, racks, and roasts were weighed to the nearest gram on a Sartorius balance and weights were recorded for calculation of cooking losses. Roasts were placed fat-side up on racks in weighed pans. A thermocouple was inserted into the geometric center of the semimembranosus muscle.

Roasts were cooked in three household electric ranges. Ovens were preheated prior to cooking. Cooking periods were initiated so that all roasts would be ready for sensory evaluation at approximately the same time. Roasts were cooked to an end point temperature of 71°C at 93°C, 149°C, and 93°C to an internal temperature of 65.6°C then at an increased oven temperature of 149°C to the final end point temperature. These heating rates henceforth will be referred to as slow, fast, and combination treatments. When the specified end point temperature was reached, the roasts were removed and allowed to cool for 30 minutes. Appropriate weights were taken for the determination of evaporation and drip losses. The sum of evaporation and drip losses expressed as a percentage total cooking loss.

V. METHODS OF EVALUATION

Sensory

Five slices, approximately 3.8 x 7.6 x 0.6 cm^3 were removed from each roast, trimmed, and halved for sensory evaluation. Each judge received one sample at a time from the center portion of the semimembranosus muscle beginning with a warm-up sample. The warm-up sample was obtained from the residual meat from the largest semimembranosus muscle and was used to prevent first sample bias and to familiarize the panelists with the score card and evaluation procedure (Baldwin et al., 1972). Later this procedure provided an indication as to whether the panelist scored the warm-up sample significantly different from the corresponding sample. The other samples were presented in random order to each panelist.

The remaining meat from each roast and the corresponding sheared cores were ground once through the grinding attachment of a Hobart N-50 mixer with a plate having 4 mm holes and mixed well prior to sampling for color and juiciness determinations.

Tenderness

Following cooling and weighing, the semimembranosus muscle was separated from the other muscle(s) in the roasts and used for subjective and instrumental measurements. Two to four 2.54 cm cores were taken parallel to the muscle fibers. These cores were taken in the region adjacent to the area where the samples for sensory evaluation were taken later. Six shears per roast were made on room temperature cores with the Warner-Bratzler shearing apparatus.

Expressible-Liquid Index

Measurements of water holding capacity (WHC) were made on three 0.3g samples for each replication using the Harco Press (Anonymous, 1972). Values for WHC were obtained by subtracting the expressible-liquid index (ratio of the area of pressed muscle to the area of expressed liquid marked on the filter paper on which the sample was pressed) from 1.0 (Shaffer et al., 1973). The value 1.0 was arbitrarily chosen by Shaffer et al. (1973) as the maximum expressible-liquid index. All triplicate values were averaged and the single value was used in statistical analysis.

Color

Color of the ground meat samples was evaluated with the Kollmorgan Color Eye. The use of ground meat allowed a homogeneous sample from each heat treatment to be presented to the instrument. Each sample was packed with a spatula into a 7.6 x 6.4 x 1.6 cm^3 cuvette with as few air spaces as possible. Readings were taken on two sides of the cuvette.

Kollmorgan Color Eye readings for the settings X, Y, Z, and X' were converted to C.I.E. readings for the chromaticity coordinates x and y. Replicate values for coordinates x and y were averaged and used to determine the dominant wave length for each sample.

VI. STATISTICAL ANALYSIS

The experiment consisted of four blocks or replications with each muscle constituting one block. Analysis of variance was used to evaluate the effect of heating rate and to evaluate consumer acceptability of the

meat. When significant differences were found, the Student-Newman-Keuls Range test was performed. Paired "t" tests were made on the panel's scores for warm-up samples and the corresponding samples to determine whether a difference existed in the scores for two samples from the same roast. Selected correlation coefficients were calculated between panelists' scores and instrumental measurements and between consumer acceptance scores and selected consumer practices.

The relative importance of the quality attributes of the roasts to the panelists was estimated by the use of simple correlation coefficients.

CHAPTER IV

RESULTS AND DISCUSSION

Data concerning consumer habits and practices of meat consumption, buying, and cookery methods have been grouped according to family size—one, two or three or more members—for convenience of discussion. Of the total consumer panel, 17 were from one member families, 12 were from two member families, and 11 were from three or more member families.

I. CHARACTERISTICS OF PANELISTS BY FAMILY SIZE

Sex, professional status, educational level, and total income of the consumer panel are presented in Table 1. The consumer panel was composed of more females than males. Proportions of faculty, graduate students, and supporting staff on the panel were predetermined as explained in the preceding chapter. The educational level of the panelists was high as expected in a group selected from this population. The smallest percentage of panelists reported income in the middle category ($9,000-$15,000) with larger percentages reporting incomes on either side of this category.

II. EFFECT OF HEATING RATES ON SUBJECTIVE AND INSTRUMENTAL EVALUATION OF QUALITY ATTRIBUTES OF SEMIMEMBRANOSUS MUSCLE

Consumer panels evaluated selected quality attributes of semimembranosus muscles heated at three rates and also a warm-up sample as explained in the preceding chapter. Paired "t" tests showed no significant difference between scores for the warm-up samples and the

TABLE 1

CHARACTERISTICS OF PANELISTS BY FAMILY SIZE

	Family Size			Total
	1 (n=17)	2 (n=12)	3 or more (n=11)	(n=40)
Sex of panelists, percent in each family group				
Male	12	17	64	28
Female	88	83	36	72
Status of panelists, percent in each family group				
Faculty	24	8	36	22
Graduate student	65	67	36	58
Supporting staff	12	25	28	20
Educational level of panelists, percent in each family group				
0 - 7 years	--	--	--	--
8 - 12 years	6	--	9	5
$\geq$ 13 years	94	100	91	95
Total income ranges of household units, percent in each family group				
< $9,000	65	50	9	45
$9,000-$15,000	--	33	27	18
> $15,000	29	17	64	35
No response	6	--	--	2

paired samples for any of the quality attributes, which indicated the panelists' consistency in evaluating the samples.

Tenderness

Shear values and tenderness scores for the four replications of each treatment are shown in Tables 2 and 3 respectively. Results of analysis of variance of these values are presented in Tables 4 and 5 respectively. Shear values indicated that roasts subjected to the slow and combination heat treatments were more tender ($P < 0.01$) than those heated by the fast treatment. Tenderness scores, however, showed that roasts heated by the slow rate were more tender ($P < 0.01$) than those heated by the combination and fast rates. A nonsignificant relationship ($r = 0.02$) was found between panelists' scores and Warner-Bratzler shear values.

These findings showed that consumer panels can detect differences in tenderness of meat heated at varying rates. Other investigators using trained panels and Warner-Bratzler shear values also have reported that differences in tenderness between bovine muscles heated at two different rates could be detected (Griswold, 1955; Visser et al., 1960; Bramblett and Vail, 1964; Fugate, 1967; Bayne et al., 1969; Cross et al., 1973; Bayne et al., 1973).

Significant carcass variation as well as a significant interaction between treatment and carcass was found. These findings suggest that consumers purchasing meat from the same supplier can expect variation in tenderness of like cuts from different carcasses as well as variation in response to heating by the same method.

TABLE 2

CHARACTERISTICS OF SEMIMEMBRANOSUS ROASTS HEATED AT THREE RATES

Characteristics	Replication	Treatment Scores		
		Slow	Combination	Fast
Shear Values, kg	I	6.4	10.0	12.0
	II	7.5	9.4	11.1
	III	11.8	11.6	12.0
	IV	8.0	7.4	9.9
Mean		8.4[b]	9.6[b]	11.2[c]
Total Cooking Loss, percent	I	34.38	30.60	27.12
	II	31.42	30.73	26.45
	III	20.73	28.91	26.45
	IV	40.67	36.10	28.19
Mean		31.80	31.58	27.05
Expressible-Liquid Index	I	0.72	0.75	0.80
	II	0.77	0.78	0.81
	III	0.83	0.81	0.83
	IV	0.73	0.75	0.80
Mean		0.76	0.77	0.81
Dominant Wave Length, nm	I	578	582	582
	II	582	581	581
	III	587	583	585
	IV	582	580	582
Mean		582	582	582

[b], [c]Means with like superscripts on the same line do not differ ($P < 0.01$).

TABLE 3

PANELISTS' SCORES FOR QUALITY ATTRIBUTES OF SEMIMEMBRANOSUS ROASTS HEATED AT THREE RATES

Quality Attributes	Replication	Treatment Scores[a]		
		Slow	Combination	Fast
Tenderness[d]	I	5.4	5.3	3.2
	II	6.0	3.4	4.6
	III	6.3	4.4	4.6
	IV	3.5	3.0	4.5
	Mean	5.3[b]	4.0[c]	4.2[c]
Juiciness[d]	I	4.2	4.8	4.5
	II	3.3	2.6	5.6
	III	5.4	4.2	4.9
	IV	2.3	3.4	5.0
	Mean	3.8[b]	3.8[b]	5.0[c]
Mouthfeel[e]	I	2.0	1.5	1.4
	II	2.1	2.3	1.5
	III	1.4	2.4	1.7
	IV	2.3	2.4	1.1
	Mean	2.0[b]	2.2[b]	1.4[c]
Flavor[e]	I	5.3	5.1	5.2
	II	5.1	3.9	5.1
	III	5.3	4.8	5.1
	IV	4.0	4.3	4.8
	Mean	4.9	4.5	4.8
Color[d]	I	4.6	5.5	5.1
	II	4.7	4.1	4.9
	III	5.0	4.9	5.4
	IV	4.0	4.0	5.6
	Mean	4.6	4.6	5.2

TABLE 3 (continued)

Quality Attributes	Replication	Treatment Scores[a]		
		Slow	Combination	Fast
Overall Acceptability[f]	I	3.8	3.8	3.2
	II	3.7	2.9	3.5
	III	3.8	3.3	3.5
	IV	2.6	2.6	3.6
Mean		3.5	3.2	3.4

[a]Means of ten scores.

[b,c]Means with like superscripts do not differ ($P < 0.01$).

[d]Very tender, juicy, or desirable = 7; very tough, dry or undesirable = 1.

[e]Very mealy = 4; not mealy = 1.

[f]Very good = 5; very poor = 1.

TABLE 4

MEAN SQUARES FROM ANALYSIS OF VARIANCE OF SHEAR VALUES OF SEMIMEMBRANOSUS ROASTS HEATED AT THREE RATES

Source of Variation	Degrees of Freedom	Mean Squares
Treatment	2	52.8200***
Carcass	3	40.2607***
Treatment x Carcass	6	8.0115*
Residual	60	2.6541

*P < 0.05; ***P < 0.001.

TABLE 5

MEAN SQUARES FROM ANALYSIS OF VARIANCE OF QUALITY ATTRIBUTES OF SEMIMEMBRANOSUS ROASTS HEATED AT THREE RATES

Source	Freedom	Mean Squares					
		Tenderness	Juiciness	Mouthfeel	Flavor	Color	Overall Acceptability
Treatment	2	18.8084***	20.0334***	5.6084***	3.0084	5.6584	1.3084
Carcass	3	10.9889**	10.2556**	0.6750	4.2445	2.8556	2.6972*
Treatment x Carcass	6	10.0972***	9.1889***	1.6750**	1.3861	2.4472	1.8639*
People/Carcass[a]	36	1.0997	2.6630	0.9065	2.1648	2.5389	0.7917
Treatment x People/Carcass[b]	72	1.6546	1.4741	0.4454	1.6898	79.75	0.7111

[a]Error term for carcass.

[b]Error term for all sources except carcass.

*P < 0.05; **P < 0.01; ***P < 0.001.

Various authors (Paul, 1963; Penfield and Meyer, 1975) have postulated that tenderness is related to the length of time the internal temperature of the meat is within certain temperature ranges. Minutes that the roasts were within selected internal temperatures ranges (°C) for the slow, combination, and fast heat treatments are presented in Table 6. According to Draudt (1972) denaturation of most of the contractile proteins has occurred without either collagen solubilization or muscle fiber hardening at 50°C. The collagen shrinkage reaction without an appreciable hardening of the myofibrillar proteins becomes evident at 60°C (Draudt, 1972). Paul (1963) and Penfield and Meyer (1975) stated that collagen solubilization increased with time that the internal temperature of the meat was in the 57°C to 60°C range. Although collagen solubilization continues, it is overshadowed by the hardening reaction of the muscle fibers at an internal temperature of 65.6°C as apparent in shear data (Draudt, 1972). Therefore, the total length of time that the internal temperature of the meat is within the ranges of 57°C to 65.6°C and 65.6°C to 71°C is important. The longer the meat remains within these internal temperature ranges, the greater the amount of collagen solubilization. Since the combination heat treatment had the longest time periods in the 57°C to 65.6°C range (146 minutes), greater collagen solubilization should have occurred in that temperature range with this treatment. The fast heat treatment, having the shortest time period (17 minutes), should have had the least amount of collagen solubilized in that temperature range. Longer time within the 65.6°C to 71°C range should promote a more extensive muscle fiber hardening reaction. Although

TABLE 6

TIME WITHIN SELECTED TEMPERATURE RANGES FOR EACH TREATMENT OF SEMIMEMBRANOSUS ROASTS

Treatment	Replication	Minutes Within Range			
		0-57°C	57-65.6°C	65.6-71°C	Total
Slow	I	145	90	266	501
	II	190	178	246	614
	III	238	63	112	413
	IV	89	65	354	508
	Mean	166	99	244	509
Combination	I	151	106	32	289
	II	240	162	39	441
	III	223	84	17	324
	IV	190	234	15	439
	Mean	201	146	26	373
Fast	I	85	21	17	123
	II	84	16	12	112
	III	84	16	12	112
	IV	62	16	11	89
	Mean	79	17	13	109

the fast heat treatment had the shortest time period (13 minutes) within the 65.6°C to 71°C range, since it did not have the benefit of long time periods within the ranges that promote collagen solubilization, this treatment should not produce meat as tender as the other two treatments. The combination heat treatment had the benefit of a longer time period in the 57°C to 65.6°C range to promote collagen solubilization and a shorter time period for muscle fiber hardening reaction. However, the slow heat treatment which was judged to be the most tender by the consumer panel was within the 65.6°C to 71°C range for the longest period of time (244 minutes) suggesting that collagen solubilization during the long time period within this range is the important factor in increased tenderness of meat heated for long periods of time at low temperatures. Muscle fiber hardening apparently did not overshadow the enhanced tenderness as theorized in earlier work (Penfield and Meyer, 1975).

Results from this investigation suggest that still another method should be tested. Perhaps since neither collagen shrinkage reaction nor muscle fiber hardening reaction has an appreciable effect prior to 57°C, heating at a high temperature (149°C) to an internal temperature of 57°C and then at a low temperature (93°C) to the final end point temperature would allow the full benefit of collagen solubilization.

Juiciness

Panelists' mean scores and analysis of variance for juiciness are shown in Table 3, page 24 and Table 5, page 27, respectively. Juiciness

scores show that roasts heated by the slow and combination heat treatments were less juicy ($P < 0.01$) than roasts heated by the fast heat treatment. Panelists rated the roasts heated by the slow and combination heating methods between "slightly dry" and "neither juicy nor dry," while rating the roasts heated by the fast method as "slightly juicy." Other studies regarding the effect of low oven temperatures on juiciness on beef were not in complete agreement. Nielson and Hall (1965), Fugate (1967), Davenport (1968), and Bayne et al. (1969) reported that juiciness score for roasts cooked at 93.5°C to 107°C differed significantly from those at 149°C to 163°C. In contrast, Griswold (1955), Bramblett et al. (1964), and Simmers (1965) found that lower oven temperatures and longer cooking times yielded meat which was less juicy than meat cooked at higher temperatures.

Cooking temperature did not significantly affect total cooking losses or expressible liquid indices (Appendix C). Results from previous studies suggested that cooking losses were greater from boneless rounds heated at low temperatures than from those heated at high temperatures. Bayne et al. (1969), Simmers (1965), Griswold (1955), and Bramblett and Vail (1964) reported that cooking losses for roasts heated at low temperatures were significantly greater than those heated at higher temperatures. Disagreement among the many investigations with regard to trends of cooking losses may have resulted from the variability in size and shape of the roasts which is dependent upon the muscles involved. Evidence that cooking losses vary with different muscles was found by Bramblett and Vail (1964) who reported a significant difference in total cooking losses from different muscles for rounds heated at 68.5°C and 93.5°C.

Significant carcass variation and interaction between treatment and carcass were found. The significance of these findings suggests that consumers purchasing meat from the same supplier can expect variation in juiciness of like cuts from different carcasses as well as variation in response to heating by the same method.

Mouthfeel

Mean scores and analysis of variance for mouthfeel are found in Table 3, page 24, and Table 5, page 27, respectively. Mouthfeel was explained to panelists in terms of mealiness which was described by Cover et al. (1962a) as a special kind of fragmentation (small, dry fragments, clinging to the cheeks, gums, and tongue). Mouthfeel scores indicated that roasts subjected to the slow and combination heat treatments were more mealy ($P < 0.01$) than those heated by the fast treatment. Scores for slow and combination heating methods indicated that panelists rated the meat between "slightly mealy" and "mealy" while meat heated by the fast method was rated between "slightly mealy" and "not mealy."

A significant ($P < 0.01$) negative relationship ($r = -0.41$) existed between tenderness and mouthfeel (Table 7). However, Cover, et al. (1962c) found that mealiness was associated positively with selected components of tenderness (ease of fragmentation, lack of adhesion, and softness to tooth pressure). Cover et al. (1962c) found that trends toward increased mealiness indicated a tenderizing response to heat.

A significant interaction between treatment and carcass existed with the effect of treatment dependent upon carcass again suggesting that the mouthfeel obtained with a cooking method is dependent upon carcass.

TABLE 7

SIMPLE CORRELATION COEFFICIENTS BETWEEN VARIOUS QUALITY ATTRIBUTES OF SEMIMEMBRANOSUS ROASTS

	Overall Acceptability	Mouthfeel	Tenderness	Juiciness	Flavor	Color
Overall Acceptability	---	-0.46**	0.71**	0.52**	0.70**	0.60**
Mouthfeel	---	---	-0.41**	-0.47**	-0.42**	-0.36**
Tenderness	---	---	---	0.45**	0.51**	0.29**
Juiciness	---	---	---	---	0.51**	0.44**
Flavor	---	---	---	---	---	0.46**
Color	---	---	---	---	---	---

**P < 0.01.

Flavor

Flavor mean scores and analysis of variance are presented in Table 3, page 24, and Table 5, page 27, respectively. Treatment had no effect on panelists' scores. Other researchers (Bayne et al., 1969; Schock et al., 1970) have found that oven temperature had no effect on flavor scores of trained panelists. In this study, all roasts were rated between "neither desirable nor undesirable" and "slightly desirable."

Color

Panelists' scores for color and analysis of variance are presented in Table 3, page 24, and Table 5, page 27, respectively. Treatment had no significant effect on color scores or on dominant wave length values (Appendix C). Although all roasts were heated to an end point temperature of 71°C or medium-done beef, panelists' scores showed that the color of the meat for slow and combination heat treatments was rated as less desirable than that for meat heated by the fast treatment. Bayne et al. (1969) found that heating both round and rib roasts at two rates to different end point temperatures resulted in the appearance of medium-done meat to a trained panel.

The preference and practice of the panelists regarding degree of doneness of beef also were investigated (Table 8). Although medium-done beef was preferred and prepared by one-half of the panelists, well-done beef was preferred and prepared by many. Results suggested that meat was prepared as the panelist preferred it.

TABLE 8

PANELISTS' PREFERENCE AND PRACTICE REGARDING DEGREE OF DONENESS OF BEEF

	Family Size			
	1 (n=17)	2 (n=12)	three or more (n=11)	Total (n=40)
Panelists' preference as to degree of doneness for roast beef, percent in each family group				
Rare	29	--	9	15
Medium	47	58	46	50
Well-done	24	42	45	35
Degree of doneness of roast beef prepared in the home, percent in each family group				
Rare	24	--	9	12
Medium	40	58	46	48
Well-done	24	42	45	35
No response	12	--	--	5

Overall Acceptability

Treatment had no significant effect on overall acceptability of the roasts (Table 5, page 27). Mean scores for the roasts heated by the three heat treatments (Table 3, page 24) indicated that panelists rated the samples between "fair" and "good." This evaluation of the samples by the panelists should reflect the characteristics by which the individual panelist would evaluate a food. Significant carcass variation and interaction between treatment and carcass were found. These findings suggest that consumers purchasing meat from the same supplier can expect variation in overall acceptability of like cuts from different carcasses as well as variation in response to heating by the same method.

Importance of Quality Attributes

Correlation coefficients (Table 7, page 33) indicated that of the quality attributes evaluated by the consumer panel, tenderness ($r = 0.71$) and flavor ($r = 0.70$) had the most influence on the overall acceptability of the samples. Color, juiciness, and mouthfeel were less influential quality attributes. Schock et al. (1970) used correlation coefficients to indicate the influence of the studied palatability factors on overall acceptability scores. Correlation coefficients in the study by Schock et al. (1970) indicated that tenderness had the most influence in the overall acceptability scores. Flavor had the next greatest influence, and juiciness and apparent degree of doneness the least.

Each panelist also ranked selected meat quality attributes as to their importance in the evaluation of roast beef (Table 9). No significant

TABLE 9

QUALITY ATTRIBUTES OF ROAST BEEF AS RANKED BY THE CONSUMER PANEL

Replication	Quality Attributes[a,b]			
	Flavor	Tenderness	Mouthfeel	Color
I	1.4	1.8	3.4	3.4
II	1.4	1.8	2.4	3.2
III	1.1	1.6	2.9	3.2
IV	1.5	1.6	3.2	3.5
Mean	1.4[c]	1.7[c]	3.0[d]	3.3[d]

[a]Means of ten rankings.

[b]Lowest values equals attribute of greatest importance.

[c,d]Means with like superscripts do not differ ($P < 0.01$).

difference (Appendix D) was found between flavor and tenderness rankings indicating that these attributes are equally important factors in the evaluation of roast beef quality by the consumer. These results are similar to the findings by Schock et al. (1970) suggesting that tenderness as cited by Bailey (1972) is not the single most important factor to the consumer in assessing meat quality. Mouthfeel and color ranking did not differ significantly from each other, yet they differed significantly ($P < 0.01$) from tenderness and flavor ranking as to their importance as meat quality attributes.

III. HABITS AND PRACTICES OF MEAT CONSUMPTION, BUYING, AND COOKERY METHODS OF THE CONSUMER PANEL

Eating Habits

The consumer panel indicated that the frequency of eating roast beef in the home was approximately two and one-half times per month (Table 10). Little difference in the number of times of serving roast beef per month was seen in averages for families of different sizes. However, roast beef was not the type of beef served most frequently in the home. Hamburger was served by the majority of the panelists while roast beef was served by few. The popularity of roasts as the most frequently served type of beef, seemed to decrease as family size increased while use of hamburger increased as family size increased. In another study, Snell (1972) also found that as family size increased, more ground beef was purchased. Although hamburger was a popular beef item with one member families, steak was equally popular. Stew meat was served by more household units than roast.

TABLE 10

EATING HABITS OF THE CONSUMER PANEL

	Family Size			
	1 (n=17)	2 (n=12)	three or more (n=11)	Total (n=40)
Frequency of eating roast beef in the home, average times per month	2.3	2.4	2.8	2.6
The most frequent type of beef served in the home, number of responses				
Hamburger	9	10	10	29
Roast	2	1	--	3
Steak	9	--	--	9
Stew meat	2	3	1	6
Reasons for serving most frequent type of beef, number of responses				
Low cost	7	9	6	22
Family preference	1	3	5	9
Your preference	13	5	1	19
Most readily available	1	1	3	5
Easy to prepare	11	7	6	24
Meats other than beef used as main dish items, average times per month				
Chicken	4.2	7.3	3.3	4.9
Lamb	1.3	0.3	---	0.7
Pork and/or processed pork products	3.5	6.3	5.1	5.0
Seafood	3.2	3.6	3.6	3.6
Wild game	---	---	0.5	0.2
Frequency of eating meat, average times per day	1.6	1.8	1.8	1.7

Reasons for serving the different types of beef were varied. One member families listed preference, ease of preparation and low cost as reasons for serving hamburger and steak. Hamburger was the most frequent type of beef served by two and three or more member families because of "low cost" and "easy to prepare." "Your preference" and "most readily available" were not listed as frequently in these groups. However, "family preference" was important in three or more member families, but not in two member families. Woods and Jenkins (1963) found that versatility and economy were reasons given by almost half of all respondents for purchasing ground beef. Other less influential factors reported in the study were family preference, ease of preparation, flavor, and quickness of preparation.

Choices of meats other than beef served as main dish items include chicken or turkey, lamb, pork, seafood, and wild game. Families in all groups served chicken, pork, and seafood more frequently than roast beef.

Meat was consumed at approximately two meals per day. More meals were eaten with meat as the day progressed. All panelists responded that they ate meat with the dinner meal.

Purchasing Practices

The amount of money spent per week on beef per family and per individual is reported (Table 11). One member families spent the most on beef per week on both a per family and per person basis. Families of two or greater spent less money on beef on a per person basis, although their total income (Table 1, page 21) would be similar to that

TABLE 11

PURCHASING PRACTICES OF THE CONSUMER PANEL

	Family Size			
	1 (n=17)	2 (n=12)	three or more (n=11)	Total (n=40)
Amount spent on beef per week				
Average/family unit	$5	$4	$14	$9
Average/family member	$5	$2	$ 3	$3
Frequency of buying specially priced meat, number of responses				
Never	2	1	---	3
Seldom	2	2	---	4
Sometimes	6	6	5	17
Frequently	6	3	5	14
Only	1	---	1	2
Influence of meat ads on family meat buyer, number of responses				
Never	4	3	1	8
Seldom	5	2	1	8
Sometimes	4	6	5	15
Frequently	3	1	2	6
Always	1	---	2	3
Buy meat primarily at one store, percent in each family group				
Yes	64	83	73	73
No	35	8	18	23
No response	---	8	9	5
Reasons for buying meat primarily at one store, number of responses				
Convenience	13	6	3	22
Good buys	9	4	3	16
High quality meat	5	7	7	19
No response	---	1	1	2

Table 11 (continued)

	Family Size			
	1 (n=17)	2 (n=12)	three or more (n=11)	Total (n=40)
Selection of meat cuts, percent in each family group				
Top Round Roast @ $1.59/lb.	47	42	54	48
Boneless Rib Roast @$2.05/lb.	47	50	46	48
No response	6	8	---	5
Top Round Roast @ $1.48/lb.	47	67	91	65
Bottom Round Roast @ $1.48/lb.	18	8	---	10
Either	29	17	---	18
No response	6	8	9	7

of one member families when calculated on a per person basis. Possible reasons for one member families spending more for beef than families of two or greater members might include: greater frequency of eating at commercial establishments; retail meat packaging for multi-membered families; purchasing of more expensive cuts of beef; and availability of meat "specials" in larger quantities.

Specially priced meat was purchased "sometimes" or "frequently" by the majority of the consumer families participating in this study with advertisements "sometimes" influencing many of the purchasers' decisions. However, the influence of specially priced meat varied within family sizes. Shopping for specials appeared to be more important among women representing larger households (Weidenhamer et al., 1969). In this investigation, advertisements seemed to have a greater influence on families larger than one member. The family meat buyer for two and three or more family members was more likely to be influenced "sometimes" by meat advertisements than the meat buyer for one member families. Meat advertisements that "sometimes" influence meat purchases coincided with the number of family meat buyers "sometimes" buying specially priced meat. However, the influence of factors other than meat advertisements was indicated by the smaller numbers of panelists buying specially priced meat "frequently" and/or "only." The influence of meat advertisements on the buying practices in one member families was diversified.

Meat was purchased a majority of the time at one store by families of all sizes. "Convenience," "high quality meat," and "good buys"

were indicated by many of the panelists. The responses varied with family size. One member families were influenced primarily by "convenience" and "good buys." "Convenience" and "high quality meat," however, were the most frequently listed factors which influenced two member families. The major concern for most of the families with three or more members was "high quality meat."

The panelists were asked to choose the cut of meat they would purchase in specified situations. An equal percent of panelists selected top round at $1.59/lb. and rib roasts at $2.05/lb. Generally, as family size increased, top round was selected more often. Price seemed to be the major reason for the selection of top round while others felt that top round was more flavorful and had a better yield than rib roasts. Would-be-purchasers of the rib roast, however, indicated that although this cut was more expensive it was more tender and flavorful. When presented with the choice of purchasing either top or bottom round roasts at the same price, top round roasts were preferred over bottom round roasts. This choice was based on the belief that top round roast is more tender and versatile, of higher quality and better flavor than bottom round roasts. However, some panelists responded that they would purchase either cut basing their decision on appearance because they believed little difference existed between the two cuts.

Beef Cuts Served as Roasts

Roast was not the type of beef served most frequently by the consumer panel as indicated on Table 10, page 39. Few panelists listed

roast as the most frequently served type of beef. Beef cuts served as roasts in the home to family and guests are listed in Tables 12 and 13 respectively. In general, the overall number of positive responses decreased as the frequency of serving that was specified in the questionnaire increased. Arm, blade, and boneless chuck pot roasts were the cuts served to the family most frequently by household units of all sizes. Cuts served to company were generally arm chuck roast, rump roast, and sirloin tip roast. In a nationwide survey conducted by Weidenhamer et al. (1969), beef rounds were the leading choice for guests. In this study, the more tender cuts were selected to serve to guests more frequently or as frequently as the less tender cuts.

Thawing Practices

Consumer practices with regard to the methods of thawing meat and the temperature of the meat when placed in the oven were studied also (Table 14). Overall responses indicated that the most popular method of thawing was either "room temperature" or "refrigerator temperature." This coincides with the temperature of the meat being at either refrigerator or room temperature when placed inside the oven. This implies that proper methods of thawing meat need to be re-emphasized. As indicated in this study, many consumers hold meat at temperatures conducive to microbial growth for excessive time during the thawing process.

Cooking Practices

The different methods of meat cookery that were described to the consumer panel are tabulated in Table 15. Each panelist was asked to

TABLE 12

BEEF CUTS SERVED AS ROASTS IN THE HOME

Frequency of serving cuts as roasts in the home, number of responses[a]	Family Size 1 (n=17)	2 (n=12)	three or more (n=11)	Total (n=40)
Eye of the Round Roast or Eye Round Pot-Roast				
Never	9	7	4	20
Seldom	5	5	5	15
Sometimes	2	--	2	4
Frequently	1	--	--	1
No response	--	--	--	--
Arm Chuck Roast or Beef Chuck Arm Pot-Roast or Boston Cut				
Never	6	4	1	11
Seldom	6	4	4	14
Sometimes	3	1	2	6
Frequently	2	3	3	8
No response	--	--	1	1
Blade Chuck Pot-Roast or Beef Chuck Blade Roast				
Never	6	3	3	12
Seldom	5	5	3	13
Sometimes	4	1	1	6
Frequently	2	3	2	7
No response	--	--	2	2
Boneless Chuck Pot-Roast or Beef Chuck Eye Edge Pot-Roast or Boneless English Roast or Beef Chuck Shoulder Pot-Roast, Boneless				
Never	8	3	4	15
Seldom	7	5	2	14
Sometimes	--	2	2	4
Frequently	2	2	3	7
No response	--	--	--	--

TABLE 12 (continued)

Frequency of serving cuts as roasts in the home, number of responses[a]	Family Size 1 (n=17)	2 (n=12)	three or more (n=11)	Total (n=40)
Bottom Chuck				
Never	13	7	6	26
Seldom	3	2	2	7
Sometimes	--	1	1	2
Frequently	1	--	--	1
No response	--	2	2	4
Bottom Round Roasts				
Never	14	6	2	22
Seldom	2	2	3	7
Sometimes	--	3	2	5
Frequently	1	--	1	2
No response	--	1	3	4
Center Cut Pot-Roast				
Never	11	7	3	21
Seldom	3	2	4	9
Sometimes	2	2	3	7
Frequently	1	--	--	1
No response	--	1	2	3
Heel of the Round				
Never	16	11	4	31
Seldom	--	1	3	4
Sometimes	--	--	--	--
Frequently	1	--	1	2
No response	--	--	3	3
Rib Roast, Boneless				
Never	9	6	4	19
Seldom	7	5	4	16
Sometimes	--	--	1	1
Frequently	1	--	--	1
No response	--	1	2	3
Rump Roast or Beef Bottom Round Rump Roast				
Never	10	5	3	18
Seldom	4	4	2	10
Sometimes	2	2	4	8
Frequently	1	--	1	2
No response	--	1	1	2

TABLE 12 (continued)

Frequency of serving cuts as roasts in the home, number of responses[a]	Family Size 1 (n=17)	2 (n=12)	three or more (n=11)	Total (n=40)
Standing Rib Roasts				
Never	9	8	6	23
Seldom	5	3	2	10
Sometimes	2	--	1	3
Frequently	1	--	--	1
No response	--	1	2	3
Top Round Roast or Beef Round Top Round Roast				
Never	10	6	1	17
Seldom	4	2	4	10
Sometimes	2	3	4	9
Frequently	1	--	--	1
No response	--	1	2	3
Sirloin Tip Roast				
Never	5	5	3	13
Seldom	6	5	4	15
Sometimes	3	2	1	6
Frequently	3	--	1	4
No response	--	--	2	2

[a]Never = 0 times; Seldom = less than 12 times per year; Sometimes = 12 times per year; Frequently = 2 or more times a month.

TABLE 13

BEEF CUTS SERVED AS ROASTS TO GUESTS

Cuts served as roasts to guests, number of responses	Family Size 1 (n=17)	2 (n=12)	three or more (n=11)	Total (n=40)
Eye of the Round Roast or Eye Round Pot-Roast	2	1	3	6
Arm Chuck Roast or Beef Chuck Arm Pot-Roast or Boston Cut	5	2	--	7
Blade Chuck Pot-Roast or Beef Chuck Blade Roast	7	2	--	9
Boneless Chuck Pot-Roast or Beef Chuck Eye Edge Pot-Roast or Boneless English Roast or Beef Chuck Shoulder Pot-Roast, Boneless	2	--	2	4
Bottom Chuck	1	2	--	3
Bottom Round Roast	1	1	2	4
Center Cut Pot-Roast	1	1	1	3
Heel of the Round	1	--	1	2
Rib Roast, Boneless	1	--	1	2
Rump Roast or Beef Bottom Round Rump Roast	4	2	4	10
Standing Rib Roast	4	1	2	7
Top Round Roast or Beef Round Top Round Roast	1	2	2	5
Sirloin Tip Roast	10	5	4	19
None	4	3	1	8

TABLE 14

THAWING PRACTICES OF THE CONSUMER PANEL

	Family Size			
	1 (n=17)	2 (n=12)	three or more (n=11)	Total (n=40)
Methods of thawing meat, number of responses				
Room temperature	10	7	5	22
Room temperature, then refrigerator	2	2	2	6
Refrigerator	10	7	7	24
Hot water	1	1	1	3
Microwave oven	--	--	--	--
Do not thaw before cooking	2	2	2	6
Temperature of meat when placed in the oven, number of responses				
Refrigerator temperature	9	9	4	22
Room temperature	10	5	7	22
Frozen	2	--	1	3
No response	--	--	1	1

TABLE 15

COOKING PRACTICES OF THE CONSUMER PANEL

Cooking Methods	Familiar with Method (N)	Used Method (N)	Cuts of Meat: Eye of the Round Roast	Arm Chuck Roast	Blade Chuck Pot-Roast	Boneless Chuck Pot-Roast	Chuck Pot-Roast	Bottom Round Roast	Rib Roast, Boneless	Rump Roast	Standing Rib Roast	Top Round Roast	Sirloin Tip Roast	Weight Range (hrs)	Cooking Range: Time (lbs)	Cooking Range: Temperature (°F)
Browned; placed within a covered roasting pan and cooked inside the oven.	30	15			X		X	X	X	X		X	X	2-8	1/2-3	200 - 425
Placed in a covered roasting pan without browning and cooked inside the oven.	23	4					X			X		X		2-3	3/4-3	325 - 350

TABLE 15 (continued)

Cooking Methods	Familiar with Method (N)	Used Method (N)	Cuts of Meat: Eye of the Round Roast	Arm Chuck Roast	Blade Chuck Pot-Roast	Boneless Chuck Pot-Roast	Chuck Pot-Roast	Bottom Round Roast	Rib Roast, Boneless	Rump Roast	Standing Rib Roast	Top Round Roast	Sirloin Tip Roast	Weight Range (lbs)	Cooking Range: Time (hrs)	Cooking Range: Temperature (°F)
Browned; placed in a covered roasting pan with water or other liquid and cooked inside the oven.	32	21	X	X	X		X	X		X	X	X	X	1-7	3/4-4	250 - 425
Placed in a covered roasting pan with water or other liquid and cooked inside the oven.	22	13	X	X	X		X				X		X	1/2-5	3/4-5	250 - 400

TABLE 15 (continued)

Cooking Methods	Familiar with Methods (N)	Used Method (N)	Cuts of Meat: Eye of the Round Roast	Arm Chuck Roast	Blade Chuck Pot-Roast	Boneless Chuck Pot-Roast	Chuck Pot-Roast	Bottom Round Roast	Rib Roast, Boneless	Rump Roast	Standing Rib Roast	Top Round Roast	Sirloin Tip Roast	Weight Range (lbs)	Cooking Range: Time (hrs)	Cooking Range: Temperature (°F)
Placed in an open pan on a rack and cooked inside the oven.	29	18	X				X		X	X	X	X	X	1-5	3/4-4-1/2	175-450
Placed in an open pan without a rack and cooked inside the oven.	17	5	X							X	X	X	X	1-10	3/4-4	325-425
Placed in a roasting bag or aluminum foil and cooked inside the oven.	26	16	X	X	X		X	X		X	X		X	2-1/2-4	3/4-5	250-425

TABLE 15 (continued)

Cooking Methods	Familiar with Methods (N)	Used Methods (N)	Cuts of Meat: Eye of the Round Roast	Arm Chuck Roast	Blade Chuck Pot-Roast	Boneless Chuck Pot-Roast	Chuck Pot-Roast	Bottom Round Roast	Rib Roast, Boneless	Rump Roast	Standing Rib Roast	Top Round Roast	Sirloin Tip Roast	Weight Range (lbs)	Cooking Range: Time (hrs)	Cooking Range: Temperature (°F)
Placed in a crock pot and cooked.	27	16		X			X			X	X		X	1-5	4-14	Low - High
Placed in a microwave oven and cooked.	19	0														

check whether or not he was familiar with the cooking method. If the cooking method was used by the panelist, information was requested about cuts of meat, weight of the cuts, and cooking time and temperature. All cooking methods except "placed in an open pan without a rack and cooked inside the oven" and "placed in a microwave oven and cooked" were familiar to over half of the panelists.

Oven temperature ranges varied with panelists using low temperatures as well as high temperatures. Cooking times were restricted to less than five hours with the exception of slow cookers where fourteen hours was the highest cooking time. Although heating time is dependent upon temperature and weight of the meat, panelists heated meat longer than five hours only when using a slow cooker. Some panelists reported using low temperatures for heating meat but not for extended periods of time.

The method used by over half of the panelists was "browned; placed in a covered roasting pan with water or other liquid and cooked inside the oven." Tender cuts of meat as well as less tender cuts were heated using this method. For purposes of this discussion, cuts considered to be tender were boneless rib roasts, standing rib roasts, and sirloin tip roasts. All other cuts listed were categorized as less tender cuts. Placing the roast in an open pan on a rack and heating inside the oven was the method used in this study and by almost half of the panelists. More tender cuts and fewer less tender cuts were cooked by this method. Few people used methods involving heating without a rack, placing in a covered roasting pan without browning and heating in the oven, and microwave cookery. Other cooking methods presented were used by less than half of the panelists.

Receptiveness to Long-Time, Low-Temperature Cookery

Long-time, low-temperature cookery might involve leaving an unattended oven for long period of time. Overall panelists' response indicated that over half would not leave an unattended oven because of safety reasons and/or energy consumption. This trend was evident in the various family sizes. When asked if they would cook a roast between six and nine hours, over half stated that they would not. Most panelists stated that the time was too long because: the roast would be too done, too dry, lose flavor, and become discolored; too much energy would be required; too expensive; inconvenient; and/or unsafe. However, when asked if they would leave a slow cooker unattended for long periods of time, over half stated that they would. A few stated that they would not because it would be a safety hazard (Table 16). Most of the consumer panel members would not prepare a roast using either the slow or combination heat treatment used in the present investigation for the previously stated reasons.

TABLE 16

WILLINGNESS OF THE CONSUMER PANEL TO USE
LONG-TIME, LOW-TEMPERATURE COOKERY

	Family Size			
	1 (n=17)	2 (n=12)	three or more (n=11)	Total (n=40)
Willingness to leave oven on unattended for six to nine hours, percent in each family group				
Yes	41	42	36	35
No	59	75	64	63
No response	--	8	--	2
Willingness to cook a roast six to nine hours, percent in each family group				
Yes	41	42	45	42
No	59	58	55	58
Information concerning slow cookers, percent in each family group				
Own a type of slow cooker				
Yes	41	42	36	40
No	59	58	64	60
Own and use a slow cooker				
Yes	86	100	100	96
No	14	--	--	6
Leave a slow cooker unattended for long periods of time				
Yes	41	50	73	53
No	18	17	--	12
No response	41	33	27	35

CHAPTER V

SUMMARY

I. SCOPE OF THE STUDY

The effects of three rates of heat application produced by heating at oven temperatures of 93°C, 149°C, and a combination of 93°C and 149°C to an end point temperature of 71°C on selected quality attributes, overall acceptability, shear values, cooking losses, dominant wave length, and expressible liquid index were investigated. For each of four replications, a center portion of semimembranosus muscle was purchased at a local supermarket and divided into three roasts. Roasts were heated at the designated temperature and evaluated by a consumer panel and instrumental measurements. Consumption, buying, and preparation habits and practices of the consumer panel were studied also.

II. PRINCIPAL FINDINGS

Treatment had no significant effect on overall acceptability. Tenderness and flavor were found to have the greatest influence on overall acceptability. Flavor was not affected by treatment. However, tenderness was affected by treatment. Roasts heated at the slow rate were judged by the consumer panel to be more tender ($P < 0.01$) than roasts heated at the other two heating rates. Warner-Bratzler shear values showed roasts heated at the slow and combination rates to be more tender ($P < 0.01$) than roasts heated at the fast rate. Time within certain

temperature ranges is related to tenderness. The long period of time the roasts heated at the slow rate were within the 65.6°C to 71°C range, along with the results with regard to tenderness, suggested that collagen solubilization which was previously shown to occur during this period was an important factor in increased tenderness of meat heated at the slow rate. Significant carcass variations and carcass treatment interactions suggested that consumers purchasing meat from the same supplier can expect variation in quality of like cuts from different carcasses as well as variation in response to heating by the same method.

The consumer panel indicated that roast was the least frequently served type of beef. Less tender cuts of beef were prepared as roasts more often than tender cuts; a moist heating method was used more frequently than a dry heat method; and a medium done stage was the most frequently used end point. Many consumers indicated a willingness to try long-time, low-temperature heating methods.

Hamburger was the most frequently served type of beef in the home because of low cost and ease of preparation. Many of the consumers purchased meat at one store because of high quality meat. Pre-cooking practices indicated a need for re-emphasis on proper methods of thawing meat.

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APPENDIXES

APPENDIX A

THE UNIVERSITY OF TENNESSEE
KNOXVILLE 37916
COLLEGE OF HOME ECONOMICS

DEPARTMENT OF FOOD SCIENCE, NUTRITION
AND FOOD SYSTEMS ADMINISTRATION

FOOD SCIENCE (615) 974-5445
NUTRITION (615) 974-3491
FOOD SYSTEMS
ADMINISTRATION (615) 974-5445

I am conducting an experiment on the effect of cooking temperatures on the overall acceptability of meat by consumers for my thesis work in Food Science. In order to complete this research, I seek your cooperation in serving on a consumer panel.

The consumer panel will consist of a group of men and women from the staff, faculty, and graduate students of the College of Home Economics. Your name was one of those drawn randomly from this group of individuals.

If you decide to serve, you will be given several samples of roast beef to taste and evaluate for color, flavor, juiciness, tenderness, and texture. The meat has been treated in no way that will be harmful to you. You will also be asked to complete a questionnaire regarding your meat cookery and consumption practices.

The tasting session will be held on and will last approximately thirty minutes. You will be able to come at any time between 11:30 A.M. and 12:15 P.M. The questionnaire will be sent to you before the tasting session to answer at your convenience. You will turn in the questionnaire when you come to the tasting session.

If you are able and willing to participate in this consumer panel, please sign the enclosed Consent Form. Also include the date, your home and office telephone numbers, and a witness's signature (friend or spouse) on the Consent Form. If you are unable to participate, please indicate in the space provided on the enclosure. I will appreciate your letting me know if you will or will not be able to participate.

Please return the enclosed form by in the self-addressed envelope through campus mail. If you have any questions, contact me at 974-3491 or Dr. Marjorie P. Penfield at 974-5445.

We appreciate your consideration and cooperation.

Sincerely,

Norma P. Ball
Graduate Student, FSNFSA

APPENDIX B

CONSENT FORM

I, the undersigned, _____,
by my signature agree to participate in this project and understand that all results will be treated anonymously.

By my signature, I indicate that the research has been explained in sufficient detail and that any question that I may have about the project will be answered.

Signed: _____

Date: _____

Phone numbers (office): _____
(home): _____

Witness: _____

Will not be able to participate in this project.

Signed: _____

APPENDIX C

TABLE 17

MEAN SQUARES FROM ANALYSIS OF VARIANCE OF SELECTED VARIABLES OF SEMIMEMBRANOSUS ROASTS HEATED AT THREE RATES

Source of Variation	Degrees of Freedom	Mean Squares[a]		
		Expressible Liquid Index	Percent Total Cooking Loss	Dominant Wave Length
Between	2	0.0049	28.7523	1.0833
Within	9	0.0102	26.5876	6.0833

[a]All nonsignificant ($P < 0.001$).

APPENDIX D

TABLE 18

MEAN SQUARES FROM ANALYSIS OF VARIANCE OF QUALITY ATTRIBUTES OF ROAST BEEF AS RANKED BY THE CONSUMER PANEL

Source of Variation	Degrees of Freedom	Mean Squares
Between	3	40.5198***
Within	156	0.5198

***P < 0.001.

VITA

Norma Pauline Ball was born in Richmond, Virginia, on October 4, 1951. She attended elementary school in Kenbridge, Virginia. In 1970, she graduated from Kenston Forest School in Blackstone, Virginia.

She attended Mary Baldwin College in Staunton, Virginia from 1970 to 1972, and Longwood College from 1972 to 1974, where she received the Bachelor of Science degree in Home Economics. In September 1974, she began graduate study at the University of tennessee.

She is a member of Omicron Nu and the Institute of Food Technologists.

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