SENSORY AND NUTRITIONAL QUALITY OF BONELESS TURKEY ROLLS AS AFFECTED BY THERMAL PROCESSING CONDITIONS FOR FOODSERVICE USAGE

205

by

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TABLE OF CONTENTS

INTRODUCTION

The foodservice industry; an expanding enterprise composed of commercial, institutional, and military establishments; serves a wide sector of the population. Those consumers contribute to the growth and success of foodservice systems, therefore, foods of optimal sensory and nutritional quality must be prepared.

Various methods of food preparation and service practiced in foodservice establishments impair desirable quality attributes. Bengtsson and Dagersbog (1978) noted that hot-holding beef slices for more than two hours greatly reduced sensory quality. Hill et al. (1977) found flavor deteriorated in creamed potatoes after just 15 minutes of hot-holding. Inadequate design of equipment, causing uneven temperature distribution during reheating or hot-holding, also has affected sensory attributes (Milson and Kirk, 1980).

This study was designed to determine the effects of foodservice preparation and distribution procedures on the sensory quality and thiamin content of boneless turkey rolls. This information could be used by foodservice personnel and consumers to ascertain conditions which produce optimal quality of boneless turkey rolls. Specific objectives of the study were to determine:

1) effects of chilling, with reheating, versus no chilling on the aroma, juiciness, texture, flavor, and thiamin content of boneless turkey rolls;

2) effects of oven roasting temperature; 105°, 135°, and 165°C; on sensory attributes and nutrient content.

3) effects of 0, 60, and 120 minute hot-holding on sensory quality and thiamin content of boneless turkey rolls.

REVIEW OF LITERATURE

Factors influencing sensory qualities of turkey

Recent advances in food technology have increased the variety of turkey products, e.g., turkey frankfurters, turkey hams, and boneless turkey rolls, available for consumer and institutional use. Such alternatives are both nutritious and efficient in utilizing available food sources (Denton and Gardner, 1981). Sensory analysis is an important factor in determining consumer satisfaction and the ultimate success of these new products. Research has shown that various methods of preparation have influenced sensory quality of turkey and turkey products.

Oven and internal temperatures. Oven roasting and internal temperatures influence sensory qualities, particularly juiciness and tenderness, of turkey products. When studying the effect of roasting whole turkey hens at 300°, 325°, or 350°F (149°, 163°, 177°C) to 90°C internal temperature, Goertz and Stacy (1960) found no significant difference in palatability scores for tenderness and juiciness of light meat. Average sensory scores for initial tenderness, based on judges' first impressions of tenderness of samples, tended to be higher for those birds roasted at 350°F (177°C) and average juiciness scores tended to be higher when roasted at 300°F (149°C) than at the other two roasting temperatures studied.

Goodwin et al. (1962) studied the effects of end-point temperature on turkey meat tenderness, and although no significant differences were found, end-point temperature seemed to influence moistness of the product. Based on visual observations, turkeys cooked to 88° or 94°C appeared drier and tended to crumble more than samples obtained from birds cooked to 55°, 60°, 66°, 71°, 77°, or 82°C. When investigating the effect of oven and/or internal temperatures on the quality of boneless turkey rolls, Marquess et al. (1963) found no differences in aroma, tenderness, or juiciness for turkey rolls cooked at three temperatures to two internal temperatures. Light meat turkey rolls were dry roasted at 250°, 300°, or 350°F (121°, 149°, 177°C) to 176° or 185°F (80°, 85°C) for analysis in this study. Although no significant differences were found, average sensory tenderness scores tended to be highest (8.2) when roasting to 185°F (85°C) at 250°F (121°C) than for the other treatment combinations. Numerical scores of 0-10 were used for evaluation, with the highest score of 10 indicating maximum tenderness. Those trends oppose the trends noted by Goertz and Stacy (1960). Boneless turkey rolls also were used by Hoke et al. (1967) to study sensory qualities affected by oven and internal temperatures. Light meat roasts were cooked to internal temperatures of 161°, 178°, 195°, and 212°F (72°, 81°, 91°, 100°C) in ovens set at 325° and 400°F (163°, 204°C). Tenderness increased ($p<0.05$) from slightly tough (5.6) to tender (7.8) with increased internal end-point temperatures. Oven cooking temperatures did not contribute to the changes in light meat tenderness scores. Quality characteristics of juiciness and doneness of light meat samples were influenced ($p<0.05$) by both oven and internal temperatures. Turkeys roasted at 325°F (163°C) were significantly less done at an internal temperature of 161°F (72°C) than at 178°F (81°C). Doneness was evaluated on a 9-point scale with a score of 5 indicating optimal doneness, values of 5 to 9, increasing overdoneness, and values of 5 to 1, increasing underdoneness. Juiciness was higher ($p<0.05$) when roasting to 161°F (72°C) at 325°F (163°C) than when roasting to an internal temperature of 212°F (100°C) at 400°F (204°C).

Initial state of cooking: fresh versus frozen. Fulton et al. (1967) studied eating qualities of whole turkeys and turkey pieces roasted to 185°F (85°C) at 325°F (163°C) from frozen and thawed states. In relation to initial state of cooking, palatability scores showed no significant differences ($p<0.05$). Generally, light meat of whole turkeys roasted from the frozen state tended to be more tender and less juicy than those birds roasted from the thawed state. Mean mealiness scores were equal for thawed and frozen whole turkeys. Tenderness and juiciness were evaluated on a 9-point scale with 9 indicating optimum tenderness and juiciness. Mealiness was rated as "yes" or "no," with "yes" being assigned the value of 1 and "no" the value of 0. Mealiness and tenderness scores for light meat from turkey pieces were higher, but not significantly, when roasted frozen rather than thawed. Juiciness scores were the same for birds cooked from either initial state. Hoke et al. (1968) investigated differences in eating quality between fresh-unfrozen turkeys and those stored frozen at -5°F (-21°C) up to ten months. All roasts were cooked at 325°F (163°C) to internal thigh temperatures of 165°F (74°C), 175°F (79°C), or 185°F (85°C). Light meat sample scores for doneness, with 5 indicating optimal doneness on a 9-point scale, increased significantly ($p<0.01$) with increasing end-point temperatures and with increasing frozen storage time ($p<0.05$). Intensity scores for flavor of light meat tended to increase with longer cooking times and frozen storage. Those increases were not significant, however. Dark meat samples from frozen, stored turkeys were more tender ($p<0.05$) and mealy ($p<0.05$) compared to fresh birds. In contrast, Ibbetson et al. (1968) discovered that tenderness of dark meat was higher ($p<0.01$) for fresh birds compared with frozen birds. These turkey halves were braised at 163° and 176°C and pressure cooked at 15 pounds/square inch. Juiciness and flavor of dark and light meat were not affected by initial state of cooking, but by cooking method. Fulton and Davis (1974) also noted few significant differences, at the 5 percent level, in palatability due to the initial state of the turkey. Light meat of tom turkey halves was more tender ($p<0.05$) and juicy when the initial state of the bird was frozen. Palatability was evaluated on a 9-point scale with 9 the most tender or juicy.

Method of preparation: dry versus moist heat. Researchers have not found significant differences in turkey palatability when comparing roasting (dry heat) to braising (moist heat). Bowers et al. (1965) braised and roasted turkey rolls at 162.8°C and found no significant differences in palatability for light and dark meat between the two methods. A study by Travnicek and Hooper (1968) noted sensory scores for flavor intensity, flavor desirability, tenderness, and juiciness of light meat were similar for braising and roasting. Judging was done on a 7-point scale with 7 the highest possible score. These authors also used a constant temperature, 325°F (163°C) for both roasting and braising, but used turkey quarters.

Other researchers have compared roasting to braising at various oven and internal temperatures. Hoke et al. (1967) roasted boneless turkey rolls at 250°, 325°, and 400°F (121°, 163°, 204°C) while braising was done in ovens set at 250°, 300°, 350°, and 400°F (121°, 149°, 177°, 204°C). Internal temperatures of 165°, 175°, 185°, and 195°F (74°, 79°, 85°, 91°C) were used for both methods of cooking.

Tenderness scores for roasted and braised light meat were not affected when internal temperatures increased. Mealiness of light meat increased ($p<0.05$) with both roasting and braising; although, significant increases during roasting resulted with increasing oven temperatures while significant increases during braising occurred as internal temperatures increased. Tenderness and mealiness were evaluated on a 9-point scale with 9 denoting the highest and 1 the lowest intensity of each quality.

In the study by Fulton and Davis (1974), turkey pieces were heated to a constant internal temperature, 85°C, by roasting at 163°C and braising at 205°C. The light meat from roasted tom turkey halves was more tender and juicier ($p<0.01$), with a fuller flavor ($p<0.05$), based on the 9-point scale, than the braised halves. However, tom turkey thighs were significantly more juicy ($p<0.05$) when braised than roasted.

Method of preparation: type of oven heating. In the past, consumers were limited to using conventional and convection oven heating. Microwave ovens have become increasingly popular in both institutions and homes, primarily because they reduce cooking time and energy consumption. Cipra et al. (1971) reported that meat cooked by microwave heating tended to be less acceptable than that cooked in conventional gas or electric ovens.

McNeil and Penfield (1983) studied the palatability of boneless turkey roasts cooked by different methods of oven heating: conventional gas, convection, and microwave. An oven roasting temperature of 163°C was used for the conventional and convection ovens, while the microwave oven was set at the medium power level (990-1188 watts). All roasts were heated from the thawed state to an internal temperature of 77°C. Sensory characteristics including doneness, appearance, juiciness, flavor, and tenderness were evaluated on 15-cm unstructured scales with 1 the lowest score and 15 the highest score.

Significant differences ($p<0.05$) were noted only for tenderness. Mean scores showed that microwave samples, with a score of 7.8, were less tender than samples heated in the conventional (10.5) and convection (9.8) ovens. Frozen turkeys cooked in a non-rotary microwave oven proved to be significantly less tender ($p<0.05$) than those roasted with a foil tent in a 93.3°C oven. Microwave roasted birds also received substantially lower scores ($p<0.05$) for color uniformity than the other birds. Other roasting treatments included foil tent, 93.3°C oven; foil wrap, 93.3°C oven; foil tent, 162.8°C oven; roasting bag, 176.7°C oven; and foil wrap, 204.4°C oven. Sensory attributes were judged on a 7-point scale with 7 the highest score for each attribute in question (Cornforth et al., 1982).

Reheating and hot-holding influences on food quality

Reheating and/or hot-holding of foods, a common practice of foodservice establishments, may have detrimental effects on the nutritive and sensory quality of the product. Nutrient retention is decreased with extensive exposure to heat. Undesirable sensory attributes such as dryness, burned colors, off-flavors, and aromas, caused by lipid oxidation from inappropriate reheating and/or holding techniques, may be diminished (Bengtsson, 1979). Researchers have suggested that sensory quality losses can be reduced by control of cooking, reheating, holding temperature, and time between preparation and service (Bengtsson and Dagersbog, 1978).

Various foods such as potatoes, cod, and hamburgers were subjected to hot-holding and evaluated for palatability in a study by Karlstrom and Jonsson (1977). Samples were kept warm in covered aluminum pans in a convection oven at a given temperature for different periods of time prior to sensory analysis: potatoes were held at 60°, 75°, or 90°C for one, two, three, or four hours; cod fillets were held at 180°C for one, two, three, or four hours; hamburgers were held at 75°C for three hours. Quality characteristics of odor, flavor, texture, and appearance were evaluated on a 9-point quality scale with a score of 9 indicating optimal quality.

Average quality scores for flavor for potatoes decreased ($p<0.05$) with increasing holding temperatures. Differences ($p<0.05$) in flavor also were found with hot-holding of the cod fillets; flavor quality significantly decreased with increased holding time. Flavor and juiciness of hamburgers deteriorated ($p<0.001$) with warm holding. Both holding time and temperature were significant factors in altering sensory qualities of various foods, and certain quality characteristics are affected differently depending upon the type of food.

Sensory quality of turkey. Precooking and reheating turkey in conventional gas and microwave ovens have been shown to affect sensory attributes, particularly flavor and aroma. Cipra and co-workers (1971) examined turkey breast halves roasted in a rotary gas oven at 163°C or a microwave oven to a constant internal end-point temperature of 85°C. After six weeks of frozen storage (-17.5°C), the cooked turkey breasts were reheated to 70°C by the same methods used to precook the meat. Sensory evaluation, using a 6-point scale with 6 indicating the greatest intensity of the quality attribute, was done on the pectoralis major muscle. Flavor intensity was greater ($p<0.05$) in meat precooked and reheated in the microwave oven, while stale flavor was more intense ($p<0.01$) in meat precooked and reheated in the gas oven. These authors speculated that longer exposure to heat in the gas oven resulted in greater lipid deterioration in the meat causing the stale flavor.

Conventional and microwave reheating methods also were studied by Cipra and Bowers (1971). Boneless turkey roasts were precooked using a rotary gas oven set at 177°C to an end-point temperature of 76°C. Roasts were reheated from the frozen state, -17°C, to an end-point temperature of 55°C in a microwave or the gas oven (177°C). Sensory evaluations were scored on a 0 to 4 intensity scale (0=absent; 4=strong).

Stale aroma was more intense ($p<0.01$) from light meat samples reheated in the gas oven than from light meat reheated by the microwave oven, while meaty-brothy aroma was more intense ($p<0.01$) for light meat reheated by the microwave than by the gas oven. The meaty-brothy flavor of light meat also was more intense ($p<0.05$) when reheated in the microwave than in the gas oven.

Effect of reheating methods on quality characteristics of turkey breasts was the subject of another study by Cipra and Bowers (1970). Precooked turkey breasts, braised in a gas oven (177°C) to an end-point temperature of 85°C, held at 6°C for 24 hours, then reheated in the gas oven (205°C) to 60°C, were compared to fresh turkey breasts braised according to the same procedures. Sensory evaluation, made on pectoralis major muscles, on intensities of selected flavor and aroma components were scored 0 (absent) to 3 (strong).

Intensity scores for meaty-brothy aroma and flavor were higher ($p<0.01$) for freshly braised meat than for braised-reheated meat. Stale flavors and aroma were greater ($p<0.01$) in meat that had been precooked and reheated. Aroma rancidity, described by panelists as being similar to old oil and fat, was more intense ($p<0.01$) in meat braised and reheated than for meat freshly cooked.

Factors influencing instrumental measures of turkey meat tenderness

Tenderness is an important attribute contributing to consumer acceptability of turkey meat. This quality characteristic is measured by both sensory and instrumental methods. The Kramer Shear Press, Warner-Bratzler Shear, and Instron Universal Testing Machine have been used.

Oven and internal temperatures. Studies by Goodwin et al. (1962) and Hoke et al. (1968) revealed that shear values decrease (tenderness increases) with increasing internal temperatures up to an optimum, after which they remain constant or increase. Goodwin and co-workers (1962) found differences in shear values ($p<0.05$) among meat cores, which had been cooked to an end-point temperature of 55°C and cores cooked to 77°, 82°, 88°, or 94°C. Hoke et al. (1968) noted lower shear values (lb/g) ($p<0.05$) for light meat cooked to an end-point temperature of 175°F (79°C) compared to 165° or 185°F (74° or 85°C).

Cornforth et al. (1982) studied the effects of oven temperatures and roasting method on shear values of turkey samples from birds roasted from the frozen state. They found Warner-Bratzler shear values to be significantly lower ($p<0.05$) when birds were heated in a low temperature oven, 93.3°C. They noted that cooking at a high oven temperature, 204.4°C, in a roasting bag at 176.7°C, or in a microwave oven, caused internal temperatures to increase beyond the desired end-point temperature of 71°C, which may have contributed to the toughness of these samples. Internal end-point temperatures of birds roasted at 204.4°C, 176.7°C, or in a microwave oven were 75.6°, 74.0°, and 75.7°C, respectively.

Initial state of cooking: fresh versus frozen. Evidence has shown that the initial state of cooking often does not significantly affect shear values of turkey samples. Fulton et al. (1967), Ibbetson et al. (1968), and Fulton and Davis (1974) found no significant differences in tenderness of light meat samples according to shear value, when cooking from the fresh or frozen state. However, when evaluating dark meat, Ibbetson and co-workers (1968) discovered shear values to be higher ($p<0.001$) when turkey roasts were cooked from the frozen state. Shear values were based on kg/1.3 cm. Although no significance was evident, Fulton and Davis (1974) noted dark meat tended to be more tender when cooked from the thawed than from the frozen state. Significant differences between initial states of cooking influencing shear values of light meat samples were found by Hoke and co-workers (1968). They noted an increase ($p<0.05$) in the force (lb/g) to shear samples from turkeys cooked frozen than fresh.

Method of preparation: dry versus moist heat. Researchers who compared roasting to braising in relation to sensory attributes of turkey meat also investigated instrumental changes in tenderness influenced by cooking method. Generally, cooking method did not result in significant differences in shear values. Travnicek and Hooper (1968) noted Warner-Bratzler shear values (lbs/1 inch core) were lower for roasting than braising, although differences were not significant. Both methods of cooking were done at 325°F (163°C) to 80°C. Light meat samples studied by Hoke et al. (1967) were roasted at 250°, 325°, or 400°F (121°, 163°, or 204°C) or braised at 250°, 300°, 350°, or 400°F (121°, 149°, 177°, or

204°C) to internal temperatures of 165°, 175°, 185°, or 195°F (74°, 79°, 85°, or 91°C). Although no significant differences were found, slightly higher (8.9 lb/g) mean shear values were found from roasted meat than from braised meat (8.6 lb/g).

Significant differences in shear values resulting from roasting method, however, were found by Fulton and Davis (1974). Dark meat samples from tom turkey thighs had higher mean shear force values (lb/g) ($p<0.05$) when braising at 205°C than roasting at 163°C.

Method of preparation: type of oven heating. Few researchers have measured shear values of turkey meat when studying the effect of oven heating on turkey quality. Cornforth et al. (1982) found Warner-Bratzler shear values for turkey roast were lower ($p<0.05$) for turkey roasts cooked in a 93.3°C oven than for birds cooked by other methods studied; 176.7°C oven in a roasting bag, 204.4°C oven wrapped in foil, or in a non-rotary microwave oven. The turkeys cooked in the 93.3°C oven also were wrapped in foil or covered with a foil tent. Shear values were 4.8, 5.7, 7.5, 7.4, and 7.5 poinds for a 1.6 cm diameter core.

McNeil and Penfield (1983) also noted increased tenderness (low shear values) with turkey roasts cooked in slow, low temperature, ovens. Shear values for 1.9 cm diameter cores obtained from roasts heated in a convection oven were lower ($p<0.05$) than for turkey samples heated in a microwave oven. Settings for the convection and microwave ovens were 163°C and medium (990-1188 watts), respectively. The height of the force-distance curve produced by the Instron (Model 1130) was measured as an indicator of shear force expressed in kilograms.

Relationship between sensory and instrumental measurements

Some researchers prefer instrumental texture evaluations to sensory methods because instruments tend to produce results quickly and are not labor intense (Bourne, 1983). Instrumental measurements have correlated successfully with sensory evaluations in some studies; in others they have not. Deficiencies in experimental procedures, improper use of instruments, inappropriate selection and use of samples, and use of the wrong test principle are known to result in low correlations (Bourne, 1983).

Very few researchers have investigated the relationship between instrumental and sensory texture of turkey meat. Texture evaluation of light meat boneless turkey rolls was performed subjectively and instrumentally by Marquess et al. (1963). Warner-Bratzler shear values did not agree with the judges' scoring of tenderness since correlations between average tenderness scores and average shear values were not significant ($r=-0.458$) and only moderately related. Travnicek and Hooper (1968) correlated instrumental values with tenderness scores for braised and roasted turkey breasts. Mean sensory tenderness scores and mean Warner-Bratzler shear values of 24 turkey breast quarters were correlated negatively ($r=-0.48$) for the braised and ($r=-0.42$) for the roasted turkey.

Prusa et al. (1982) also studied the relationship of sensory scores and Instron measurements of turkey meat. Panelists evaluated tenderness and mealiness of samples from pectoralis major muscles using a 21 cm structured, linear scale divided and labeled every 3 cm beginning 1.5 cm from the end. Instrumentally, samples from the pectoralis major muscle were compressed using a simulated molar attachment, and sheared, parallel to the fibers, with a Warner-Bratzler shear attachment mounted on an Instron (Model 1122).

Warner-Bratzler shear correlation coefficients for tenderness were related ($p<0.05$) to sensory measurements, n=60. Correlation coefficients for Warner-Bratzler measurements of areas under curves correlated negatively with sensory scores which positively correlated to peak height measurements. The authors expected negative correlation coefficients because as tenderness increases, Instron measurements should decrease.

Nutritional evaluation of thiamin in turkey

Since boneless turkey rolls have become popular in both homes and institutions, as mentioned earlier, nutritional quality must not be overlooked. Thiamin often is measured in food products because it serves as an indicator nutrient (Klein et al., 1984). Thiamin is heat sensitive; therefore, various thermal cooking treatments may alter nutrient retention (Ang et al., 1978).

Bowers and Fryer (1972) investigated thiamin content of turkey pectoralis major muscle roasted either in a rotary gas oven set at 177°C to an internal temperature of 80°C or in a microwave oven to an internal temperature of 68°C. Neither type of oven heating nor internal temperature significantly affected thiamin content. No significant differences in thiamin content of turkey breast were found when comparing infrared and convective heating (Unklesbay et al., 1983). Engler and Bowers (1975) compared moist heat "slow-cooking" using a Rival crockpot set at 200°F (93°C) to dry heat by conventional roasting at 350°F (177°C) and found that turkey breasts roasted conventionally retained more thiamin ($p<0.01$)

than meat cooked slowly. Thiamin (μg/g) content was influenced significantly on both wet-weight and moisture-and-fat-free basis.

MATERIALS AND METHODS

This study was conducted in the Department of Foods and Nutrition research and sensory analysis laboratories at Kansas State University. Experimental data were collected March-May and June-July, 1985.

Preparation of turkey rolls

Boneless turkey rolls and roasting procedures used in this study were standardized by the North Central-120 regional research team (Appendix, Tables A-1 and A-2). Turkeys, produced and procssed in October, 1984, were obtained from Norbest Turkey Growers Association, Moroni, Utah, in mid-January, 1985.

Storage. Turkey rolls were held in frozen storage at 0° to -10°C for the duration of the study. Time from when turkeys were received until the study was completed was three and one-half months. Three days prior to roasting, a turkey roll was randomly selected, pre-weighed for calculation of estimated roasting time, and thawed at 4°C.

Production-roasting. Twenty minutes before roasting, the turkey, drip pan, and roasting rack were weighed with a Toledo balance. Thermocouples were inserted in the roast, one in front positioned at the geometric center, two in the back on either side of the geometric center. One thermocouple was placed in the Farberware Convection turbo-oven (Model 460/5) to monitor the roasting temperature according to the treatment determined by the experimental design (Table 1). Oven roasting and internal meat temperatures were recorded every five minutes by the

Minitrend 205 microprocessor. All roasts were cooked uncovered. Time-temperature curves were prepared from these data (Appendix, Figures A-1, A-2, A-3). Mean heating times and endpoint temperatures for each treatment combination are shown in the Appendix, Table A-3.

Table 1-Experimental design for roasting boneless turkey rolls

	Treatment Combinations[a]	
Temperature (°C)	Chill	No Chill
105	1	2
135	3	4
165	5	6

[a]Slices for each treatment combination were held 0, 60, 120 minutes.

Heating was terminated when two of the three thermocouples reached the endpoint temperature of 80°C. The turkey roll then was removed from the oven and allowed to stand at room temperature 15 minutes prior to re-weighing and slicing. During this interval, the thermocouples remained in the roast to measure fluctuations in internal temperatures.

Upon completion of the designated standing time, the turkey roll was re-weighed for cooking loss calculations (Appendix, Table A-4), then sliced, using a conventional foodservice meat slicer, into 1 cm and 2 cm thick slices. Those slices containing the greatest amount of light meat were selected for samples. In order to obtain 800 g of light turkey meat for sensory and instrumental measurements, dark meat within the slice and the skin around the slice were removed.

Production-holding. Slices representing the 0 holding time variable were served within 30 minutes of roasting. To begin the 60 minute holding period, four 1 cm and two 2 cm thick slices of turkey were overlapped slightly in a covered disposable aluminum half size steamtable pan. Thermocouples were positioned in two randomly selected slices while a third thermocouple monitored the 100°C hot-holding oven temperature. The oven setting had to be adjusted so that the endpoint temperature of 66°C was maintained during the hour of holding.

When 60 minutes of holding were completed, two 1 cm thick slices and a 2 cm thick slice were removed for testing. The remaining slices were held at 100°C for an additional hour.

Production-reheating. Boneless turkey rolls requiring roasting, 24 hours chilling, reheating, and holding before testing, were cooked in the same manner as described earlier. At the completion of roasting and the 15 minute standing time, the whole roast was refrigerated at 4°C overnight.

Prior to reheating, the turkey was sliced so that 800 g of light meat were obtained. Slicing procedures and slice thicknesses were identical to those for freshly roasted turkeys. Reheating was done in the convection oven, set at 105°C, in covered disposable aluminum pans. When two of the six slices reached an internal temperature of 66°C, reheating ceased and the 60 minute holding time began. Holding procedures also remained constant.

Sensory analysis

Panelist selection and training. Twelve panelists from the Departments of Foods and Nutrition and Dietetics, Restaurant, and

Institutional Management were trained during a two-week period (three hours per week) for sensory analysis of turkey roll samples. From this pool of panel members, four panelists were selected and assigned randomly to sampling periods for each treatment and holding time.

Panelists were familiarized with the score card and terminology used in this study during training sessions. Panel members were served samples and trained to recognize characteristics of the extremes, or anchors, for each attribute to be evaluated. A sample score card is included in the Appendix, Figure A-4.

Preparation of samples. Two 1-cm thick slices of turkey roll from each holding period were analyzed by panelists. A 1.3 cm diameter corer was used to cut sample cores from one slice of meat for determining chew count. The remaining turkey slice was cored into 2.5 cm diameter samples for evaluating other sensory attributes of the turkey. Remaining portions of each slice were frozen in laminated polyester polyethylene Seal-a Meal™ bags for later chemical analysis.

Holding and serving of samples. Turkey cores were placed in 150 ml glass beakers covered with watch glasses. Each core size had its own holding beaker. Covered beakers were placed in a pan of hot water at approximately 62°C on a General Electric warming tray (Model 33WTZ) set on "HIGH." Glass custard cups, previously oven dried at 200°F (93°C) for two hours, and watch glasses were warmed in the drawer of the warming tray.

Panelists served themselves, at the designated hour of testing (Appendix, Table A-5), selecting two cores from each beaker. Reference samples for aroma, representing partially roasted and over roasted, were provided each evaluation period. Characteristic aroma was retained in samples by using covered glass brandy snifters at room temperature.

Procedures for preparing reference samples are included in the Appendix, Table A-6.

Instrumental evaluation of tenderness

Preparation of samples. Three 2 cm thick slices of turkey, representative of each holding period, were cooled at room temperature to an internal temperature of 20°C. These 2 cm thick slices were cored parallel to the fibers into 2 cm diameter samples producing four cores per slice for a total of 12 samples.

Measurement. Tests for turkey meat tenderness were made using the puncture probe (0.317 cm diameter) and the Warner-Bratzler shear attached to an Instron Universal Testing Machine (Model 1122). Two cores from each holding period were punctured to 50% compression, parallel to the muscle fibers, using a full scale load of 0.1 (1 kg). A full scale load of 0.2 (2 kg) was used with the shear to measure the force necessary to completely slice the remaining six samples. These cores were sheared parallel to the muscle fibers. Chart and crosshead speeds of 100 mm/min were used. Height of the force-distance curves for compression or shearing was measured as an indicator of sample tenderness.

Determination of thiamin content

Thiamin was analyzed using 10 g ground light turkey meat by the thiochrome method (Freed, 1966). The 75 ml of 0.1 N hydrochloric acid were added to the sample. Samples were immediately blended with a Brinkmann high speed homogenizer (Serial number 1003), autoclaved, incubated overnight, diluted, and filtered. The filtrate was collected and frozen at 0°C for analysis at a later date.

Frozen samples were thawed at 4°C in a household refrigerator for 24 hours as needed. Filtrates were purified by addition of activated Bio-Rex 70 and acid potassium chloride to columns prior to conversion to thiochrome. Fluorescence was measured with a Coleman Photofluorometer (Model T6434). Two duplicate readings were averaged for each sample, and thiamin content (mcg/g) during hot-holding of boneless turkey rolls was calculated on a moisture-free, fat-free basis.

Determination of fat content

Fat analysis was done using 5 g ground light turkey meat using methods of Folch et al. (1957) as modified by Chen et al. (1981), substituting methylene chloride for chloroform. Methodology is given in the Appendix, Table A-7. Duplicate readings were averaged for each sample, and percentage of fat was calculated.

Determination of moisture content

Moisture content was analyzed with 1 g ground light turkey meat using AOAC method 14.003 (1984). Turkey sample was added to pre-weighed aluminum pans, dried overnight in the Thermotainer drying oven (Model PW-1) at 150°C, cooled 30 minutes in dessicator, and re-weighed the next day. Duplicate readings were averaged for each sample, and percentage of moisture was calculated.

Experimental design and analysis

A split plot design is shown in Table 1 for two of the three variables, chilling and roasting temperature. Each of those treatment combinations was held for 0, 60 or 120 min for the third variable. Each replication was completed in a two week period, three days per week, with one sampling per day. Treatment combinations were randomized for each replication. Data were analyzed by analysis of variance (ANOVA) and least square means were determined when significant differences were present.

RESULTS

Sensory analysis

The ANOVA for sensory data is shown in Table 2. Treatment, roasting temperature and/or overnight chilling, significantly influenced juiciness scores of the turkey. Length of hot-holding caused significant differences in aroma, juiciness, and chew count.

Results obtained using ANOVA for physical and chemical measurements of turkey samples (Table 3) and cooking loss calculations are given (Appendix, Table A-8). No differences in instrumental texture evaluations were found for any of the variables studied. ANOVA was used for evaluating significance of treatment on thiamin content on a moisture-free, fat-free basis (Tables 4 and 5). Treatment methods caused significant differences for thiamin content and for percentage moisture and fat. Although not significant, total drip loss was less for roasts cooked at 105°C than for those roasts cooked at 135° or 165°C (Appendix, Table A-9). Length of holding time was a significant factor influencing the percentage of moisture retained. Samples held for 120 minutes contained less thiamin, moisture-free, fat-free basis, ($p \leq 0.05$) than those samples held for 0 and 60 minutes (Appendix, Table A-10). Means for sensory, physical, and chemical data for all treatments and holding times are given in the Appendix, Tables A-11 and A-12.

Table 2-Mean squares and F values[a] from analysis of variance of sensory attributes for boneless turkey rolls

Source of variation	df	Sensory attributes					
		Aroma	Juiciness	Texture	Chew count	Flavor	Off notes
Treatment (C and T)[b]	5	0.15 (2.11)	0.03* (4.02)	0.24 (1.61)	0.46 (1.01)	0.72 (0.58)	0.61 (0.74)
Replication	2	0.51 (0.73)	0.12 (2.69)	0.06 (3.72)	0.97 (0.03)	0.26 (1.56)	0.77 (0.27)
Treatment × replication	10	0.09 (1.93)	0.32 (1.23)	0.71 (0.70)	0.05 (2.26)	0.03 (2.53)	0.14 (1.70)
Holding time[c]	2	0.001* (9.27)	0.0001* (22.39)	0.63 (0.48)	0.0002* (12.08)	0.27 (1.37)	0.10 (2.60)
Treatment × holding time	10	0.20 (1.50)	0.18 (1.54)	0.40 (1.10)	0.07 (2.05)	0.99 (0.24)	0.79 (0.60)

[a] F values in parentheses.
[b] C=Chilling, T=Roasting temperature (105°C, 135°C, 165°C).
[c] 0, 60, 120 minutes.
*Significant at the 5% level.

Table 3–Mean squares and F values[a] from analysis of variance of physical and chemical measurements for boneless turkey rolls

Source of variation	df	Instron force		Chemical analysis		
		Probe (kg)	Shear (kg)	Thiamin (mcg/g)	Moisture (%)	Fat (%)
Treatment (C and T)[b]	5	0.44 (1.05)	0.38 (1.18)	0.0075* (7.30)	0.0483* (3.37)	0.0277* (4.09)
Replication	2	0.85 (0.17)	0.37 (1.11)	0.50 (0.76)	0.55 (0.63)	0.01 (8.55)
Treatment × replication	10	0.25 (1.38)	0.65 (0.77)	0.07 (2.22)	0.02 (2.73)	0.30 (1.28)
Holding time[c]	2	0.67 (0.41)	0.26 (1.41)	0.61 (0.51)	0.0001* (70.86)	0.63 (0.47)
Treatment × holding time	10	0.27 (1.34)	0.56 (0.89)	0.36 (1.18)	0.76 (0.65)	0.33 (1.21)

[a] F-values in parentheses.
[b] C=Chilling, T=Roasting temperature (105°C, 135°C, 165°C).
[c] 0, 60, 120 minutes.
*Significant at the 5% level.

Table 4-Mean squares and F-values[a] from analysis of variance of thiamin content for boneless turkey rolls based on moisture-free, fat-free basis

		Thiamin content (mg/100 g)	
Source of variation	df	Moisture-free	Moisture-free, fat-free
Treatment (C and T)[b]	5	0.002* (10.77)	0.003* (9.50)
Replication	2	0.128 (2.28)	0.818 (0.20)
Treatment × replication	8	0.167 (1.67)	0.170 (1.66)
Holding time[c]	2	0.004* (7.39)	0.006* (6.57)
Treatment × holding time	10	0.656 (0.77)	0.589 (0.85)

[a]F-values in parentheses.
[b]C=Chilling; T=Roasting temperature (105°, 135°, 165°C).
[c]0, 60, 120 minutes.
*Significant at the 5% level.

Table 5-Least square means[a] of thiamin content for boneless turkey rolls based on moisture-free, fat-free basis

	Thiamin content[b] (mg/100 g)	
Treatment combination	Moisture-free	Moisture-free, fat-free
Chill		
105°C[c]	0.13^{bc}	0.15^{b}
135°C[c]	0.12^{bc}	0.15^{b}
165°C[c]	0.13^{bc}	0.17^{b}
No Chill		
105°C[c]	0.19^{a}	0.24^{a}
135°C[c]	0.14^{b}	0.17^{b}
165°C[c]	0.11^{c}	0.14^{b}

[a]Means in a column sharing a common superscript are not significantly different ($p \leq 0.05$).
[b]3 observations/mean.
[c]Oven temperature used.

Effect of treatments on sensory and physical measurements

Sensory studies. Roasting temperatures and overnight chilling significantly influenced the juiciness of boneless turkey rolls (Table 6). Turkeys roasted at 105°C were juicier ($p \leq 0.05$) than those roasted at 135° and 165°C. All boneless turkey rolls roasted and served the same day were higher in juiciness than those roasted, chilled overnight, and reheated prior to sensory evaluation.

Turkey rolls roasted at 105°C without prior cooking and chilling were significantly higher in juiciness than those roasted at 135° or 165°C and chilled. Furthermore, roasting at 165°C, chilling overnight, and reheating produced turkey samples that were drier than any turkey samples which had not been chilled.

Physical data. Thiamin content (mcg/g) and moisture percentage were significantly higher (Table 7) when turkeys were roasted at 105°C and served the same day. Roasts cooked at each of the three oven temperatures and chilled overnight had lower moisture ($p \leq 0.05$) than those roasts prepared and served without chilling.

Percentages of fat contained in boneless turkey rolls subjected to chilling were significantly higher with increased roasting temperature. However, for those roasts not chilled, a higher ($p \leq 0.05$) fat content was obtained with roasting at 105°C compared to 135° and 165°C.

Effect of duration of holding period

Sensory attributes of aroma, chew count, and juiciness as well as percentage moisture, were affected ($p \leq 0.05$) by the length of holding. As shown in Figure 1, chew count (the number or chews to masticate the

Table 6-Least square means[a] of sensory properties for boneless turkey rolls

Treatment combination	Sensory attributes[b]					
	Aroma	Juiciness	Texture	Chew count	Flavor	Off notes
Chill						
105°C[c]	8.29[a]	7.08[abc]	9.43[a]	14.18[a]	8.40[a]	1.12[a]
135°C[c]	9.46[a]	6.38[bc]	9.09[a]	12.52[a]	8.21[a]	0.87[a]
165°C[c]	9.90[a]	5.63[c]	8.29[a]	14.56[a]	9.53[a]	0.69[a]
No Chill						
105°C[c]	9.52[a]	9.07[a]	8.64[a]	13.70[a]	8.52[a]	0.58[a]
135°C[c]	9.16[a]	8.29[ab]	7.93[a]	13.24[a]	8.69[a]	0.28[a]
165°C[c]	8.62[a]	8.39[ab]	8.24[a]	13.21[a]	9.61[a]	0.50[a]

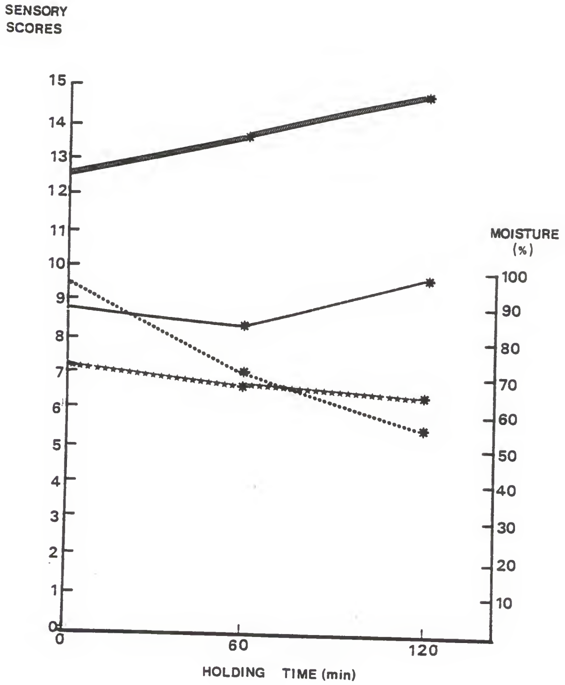
[a]Means in a column sharing a common superscript are not significantly different ($p \leq 0.05$); Data were pooled for holding times, 9 observations/mean.
[b]Intensity scale 0-15; 0=least, 15=most intense.
[c]Oven temperature used.

Table 7-Least square means[a] of physical and chemical analysis for boneless turkey rolls

Treatment combination	Instron measurements[b] Probe (kg)	Shear (kg)	Chemical analysis[c] Thiamin (mcg/g)	Moisture (%)	Fat (%)
Chill					
105°C[d]	0.56[a]	1.36[a]	0.40[b]	68.63[abc]	3.93[c]
135°C[d]	0.55[a]	1.19[a]	0.39[b]	67.66[c]	5.76[ab]
165°C[d]	0.62[a]	1.64[a]	0.42[b]	67.94[bc]	6.36[a]
No Chill					
105°C[d]	0.72[a]	1.36[a]	0.56[a]	70.31[a]	5.57[ab]
135°C[d]	0.67[a]	1.38[a]	0.43[b]	70.31[a]	4.24[bc]
165°C[d]	0.54[a]	1.32[a]	0.34[b]	69.84[ab]	4.24[bc]

[a] Means in a column sharing a common superscript are not significantly different ($p \leq 0.05$).
[b] Data were pooled for holding times; 9 observations/mean.
[c] 3 observations/mean.
[d] Oven temperature used.

Figure 1-Effect of hot-holding on quality attributes of boneless turkey rolls; aroma———— ; chew count▨▨▨; juiciness •••••• ; moisture★★★★ .



SENSORY
SCORES
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
MOISTURE
(%)
100
90
80
70
60
50
40
30
20
10
0
60
120
HOLDING TIME (min)

sample) progressively increased as samples were held for longer periods of time. Juiciness and moisture content were related in that both decreased significantly from one holding period to the next. Freshly prepared samples were juicier and higher in moisture ($p \leq 0.05$) when compared to samples held for two hours. Turkey slices held for 120 minutes had a stronger roasted aroma ($p \leq 0.05$) than those held for 0 and 60 minutes.

Means for all sensory and physical attributes as influenced by holding time at $p<0.05$ significance are shown in the Appendix, Tables A-13 and A-14.

DISCUSSION

The intensity of heat penetration, affected by oven roasting and internal temperatures, types of oven heating, precooking and reheating, and hot-holding, cause changes in quality attributes of turkey products as previously reported. In the present study, meat tenderness was influenced significantly by the length of the hot-holding period. Chew count, based on the number of chews to masticate the sample, progressively increased as samples were held for longer periods of time. This decrease in tenderness may have been caused by denaturation of the muscle proteins, actin and myosin, resulting from excessive heating (Charley, 1982). Textural changes result from this process since contractile proteins, such as actin and myosin, become somewhat tougher as heating progresses (Fennema, 1985). Another consequence of denaturation of muscle proteins is a decrease in water-holding capacity, an important factor related to decreased tenderness with continued hot-holding.

Moisture and juiciness decreased ($p<0.05$) from one holding period to the next. Moisture, held in the capillary spaces of raw tissue, is lost as evaporation or drip as the tissue shrinks with heating (Charley, 1982). Davey and Gilbert (1974) speculated that loss of juice may account for heat-induced toughening of meat. In the present study, moisture was lost as evaporation during the hot-holding periods rather than as drip since meat juices were minimal or absent.

Other researchers noted that turkey meat tenderness, based on sensory and instrumental measurements, decreased significantly as a result of high oven roasting temperatures. Mean sensory scores for boneless turkey roasts cooked in a microwave oven were less tender ($p<0.05$) than those samples heated in conventional and convection ovens set at 163°C (McNeil and Penfield, 1983). In the same study, shear values were lower ($p<0.05$), indicating increased tenderness for turkey samples cooked in the convection oven than for samples heated in the microwave oven. Cornforth and co-workers (1982) also found sensory scores for tenderness to be lower ($p<0.05$) for microwave heated samples while shear values were lower (increased tenderness) for samples cooked in a 93.3°C oven. These authors speculated that higher oven temperatures, as with microwave heating, may have caused internal temperatures to increase beyond the desired end-point temperature, thus, contributing to toughness of the meat. Tenderness has been found to increase with increasing internal temperature up to an optimum after which it decreases (Goodwin et al., 1962 and Hoke et al., 1968). In this study, no differences were noted for effect of roasting temperature on either chew count or texture. However, the scale used for texture may have confounded two characteristics; mealiness and stringiness. Further studies to evaluate those attributes on separate intensity scales would be desirable.

Oven roasting temperatures also proved to significantly influence juiciness of boneless turkey rolls in the present study, agreeing with the study by Hoke et al. (1967). Based on sensory measurements, roasts cooked to 105°C were more juicy ($p \leq 0.05$) than those cooked in ovens set at 135° and 165°C. Hoke and co-workers noted juiciness to be higher ($p<0.05$) when roasting at 325°F (163°C) as opposed to 400°F (204°C). Since moisture is lost with heating, greater heat intensity, such as high oven temperatures, would be expected to cause an increased loss of moisture, therefore, a less juicy product. Increased exposure to heat, such as with precooking and reheating, also resulted in a less juicy product. Those boneless turkey rolls subjected to precooking and reheating had significantly lower moisture than those roasts prepared and served without chilling. Further exposure to heat with hot-holding and its effect on moisture retention have been reported previously.

Along with moisture, fat is squeezed from storage areas as connective tissue shrinks upon exposure to heat (Charley, 1982). In this study, fat content was higher ($p \leq 0.05$) for roasts not chilled and roasted at 105°C (lower heat intensity) than those roasted at 135° or 165°C. However, no clear-cut pattern for fat content related to holding time or treatment was shown. Thus, variation in the compositional make-up of the turkey rolls more likely explains the differences in percentage fat contained in the samples.

Thiamin is heat sensitive and, therefore, altered by thermal cooking treatments (Ang et al., 1978). Engler and Bowers (1975) noted turkey breasts roasted at 350°F (177°C) retained more thiamin ($p<0.01$) than meat cooked slowly at 200°F (93°C). Since drip losses were greater for the "slow-cooked" than conventionally roasted turkey, the researchers speculated that more thiamin may have been transferred to the drippings. However, in the present study, thiamin content (mcg/g) was higher ($p \leq 0.05$) when turkeys were roasted at 105°C and served the same day. These roasts were not subjected to further heat exposure (reheating) which caused a decrease in nutrient losses. Drip losses were approximately equal for roasts cooked at 105°C and served the same day and those roasts cooked at 105°C, chilled, and reheated. Therefore, it is unlikely lower thiamin content, for roasts precooked, chilled, and reheated, was due to nutrient losses in the drippings.

Aroma was ($p \leq 0.01$) more stale and rancid in turkey meat that was precooked and reheated than meat freshly cooked (Cipra and Bowers, 1970). Lipids of cooked turkey are susceptible to oxidative rancidity which contributes to off-flavors and aromas (Wilson et al., 1976). In the present study, turkey slices held for 120 minutes had a significantly stronger roasted aroma than those held for 0 and 60 minutes. This aroma, however, was not characterized as stale or rancid.

Results obtained in this study support earlier recommendations given by Bengtsson and Dagersborg (1978). The most effective measure to maintain desirable quality in foodservice operations is to hold the time between preparation and serving to a practical minimum. Low cooking temperatures (105°C) are recommended when they can be scheduled reasonably.

CONCLUSIONS

Based on the results of this study, one can conclude:

1) Roasting at a low oven temperature, 105°C, without prior cooking and chilling, resulted in greater juiciness than roasting at 135° or 165°C with overnight chilling and reheating.

2) Thiamin content (mcg/g) and percentage moisture were high when turkey rolls were roasted at 105°C and served the same day.

3) Sensory data indicated with increasing holding time, 0 to 120 minutes, boneless turkey rolls became dry and tough ($p \leq 0.05$) with a strong roasted aroma.

REFERENCES

Ang, C.Y.W., Basillo, L.A., Cato, B.A., and Livingston, G.E. 1978. Riboflavin and thiamine retention in frozen beef-soy patties and frozen fried chicken heated by methods used in food service operations. J. Food Sci. 43: 1024.

AOAC. 1984. "Official Methods of Analysis," 14th ed. Association of Official Analytical Chemists, Washington, DC.

Bengtsson, N. 1979. Catering equipment design and food quality. In "Advances in Catering Technology," G. Glew (Ed.), p. 121. Applied Science Publishers, Ltd., London.

Bengtsson, N. and Dagersbog, M. 1978. Fried meat and meat patties--the influence of preparation and processing on quality and yield. In "How Ready are Ready-to-serve Foods?," K. Paulus (Ed.), p. 158. S. Karger, New York.

Bourne, M.C. 1983. Correlating instrumental measurements with sensory evaluation of texture. In "Sensory Quality in Foods and Beverages: definition, measurement, and control," A.A. Williams and R.K. Atkin (Eds.), p. 155. E. Horwood Ltd., New York.

Bowers, J.A. and Fryer, B.A. 1972. Thiamin and riboflavin in cooked and frozen, reheated turkey. J. Amer. Diet. Assoc. 60: 399.

Bowers, J.A., Goertz, G.E., and Fry, J.L. 1965. Effect of cooking method and skewers on quality of turkey rolls. Poultry Sci. 44(3): 789.

Charley, H. 1982. "Food Science," 2nd ed., p. 403. John Wiley and Sons, New York.

Chen, I.S., Shen, C.-S.J., and Sheppard, A.J. 1981. Comparison of methylene chloride and chloroform for the extraction of fats from food products. J. Amer. Oil Chem. Soc. 58(5): 599.

Cipra, J.S. and Bowers, J.A. 1970. Precooked turkey. Flavor and certain chemical changes caused by refrigeration and reheating. Food Technol. 24: 85.

Cipra, J.S. and Bowers, J.A. 1971. Flavor of microwave- and conventionally-reheated turkey. Poultry Sci. 50(3): 703.

Cipra, J.S., Bowers, J.A., and Hooper, A.S. 1971. Precooking and reheating of turkey. J. Amer. Diet. Assoc. 58: 38.

Cornforth, D.P., Brennand, C.P., Brown, R.J., and Godfrey, D. 1982. Evaluation of various methods for roasting frozen turkeys. J. Food Sci. 47: 1108.

Davey, C.L. and Gilbert, K.V. 1974. Temperature-dependent cooking toughness in beef. J. Sci. Food Agric. 25: 931.

Denton, J.H. and Gardner, F.A. 1981. Effect of processing systems of selected microbiological attributes of turkey meat products. J. Food Sci. 47: 214.

Engler, P.P. and Bowers, J.A. 1975. Eating and thiamin retention of turkey breast muscle roasted and "slow-cooked" from frozen and thawed states. Home Econ. Research J. 4(1): 27.

Fennema, D.R. 1985. "Food Chemistry," 2nd ed., p. 773-774. Marcel Dekker, Inc., New York.

Folch, J., Lees, M., and Sloane-Stanley, G.H. 1957. A simple method for the isolation and purification of total lipids from animal tissues. J. Biol. Chem. 226: 497.

Freed, M. 1966. "Methods of Vitamin Assay," 3rd ed., p. 127. Interscience Publishers, New York.

Fulton, L. and Davis, C. 1974. Cooking chicken and turkey from the frozen and thawed states. J. Amer. Diet. Assoc. 64: 505.

Fulton, L.H., Hilpin, G.L., and Dawson, E.H. 1967. Palatability and yield of whole and cut-up turkeys roasted from frozen and thawed states. J. Home Econ. 59(9): 728.

Goertz, G.E. and Stacy, S. 1960. Roasting half and whole turkey hens. J. Amer. Diet. Assoc. 37: 458.

Goodwin, T.L., Bramblett, V.D., Vail, G.E., and Stadelman, W.J. 1962. Effects of end-point temperature and cooking rate on turkey meat tenderness. Food Technol. 16(12): 101.

Hill, M.A., Baron, M., Kent, J.S., and Glew, G. 1977. The effect of hot storage after reheating on the flavour and ascorbic acid retention of precooked frozen vegetables. In "Catering Equipment and Systems Design," G. Glew (Ed.), p. 331. Applied Science Publishers, Ltd., London.

Hoke, I.M., McGeary, B.K., and Kleve, M.K. 1967. Effect of internal and oven temperatures on eating quality of light and dark meat turkey roasts. Food Technol. 21(5): 89.

Hoke, I.M., McGeary, B.K., and Lakshmanan, F. 1968. Muscle protein composition and eating quality of fresh and frozen turkeys. J. Food Sci. 33: 566.

Ibbetson, C.J., Travnicek, D.M., Hooper, A.S., and Mitchell, J.D. 1968. Turkey halves braised or pressure cooked from the frozen or defrosted state. Poultry Sci. 47(6): 1940.

Karlstrom, B. and Jonsson, L. 1977. Quality changes during warm-holding of foods. In "Catering Equipment and Systems Design," G. Glew (Ed.), p. 315. Applied Science Publishers, Ltd., London.

Klein, B.P., Matthews, M.E., and Setser, C.S. 1984. Foodservice systems: time and temperature effects on food quality. North Central Regional Research Publication. Ill. Agr. Exp. Sta., Un. of Illinois, Champaign-Urbana, IL.

Marquess, C.G., Carlin, A.F., and Augustine, G.M. 1963. Factors affecting the quality of roasted turkey rolls. Food Technol. 110.

McNeil, M. and Penfield, M.P. 1983. Turkey quality as affected by ovens of varying energy costs. J. Food Sci. 48: 853.

Milson, A. and Kirk, D. 1980. "Principles of Design and Operation of Catering Equipment," p. 190. AVI Publishing Co., Inc., Westport, CT.

Prusa, K.J., Bowers, J.A., and Chambers, E. IV. 1982. Instron measurements and sensory scores for texture of poultry meat and frankfurters. J. Food Sci. 47(2): 653.

Travnicek, D. and Hooper, A.S. 1968. Effect of cooking method on the quality of turkey breast meat cooked from the frozen state. Poultry Sci. 47(4): 1281.

Unklesbay, N., Davis, M.E., and Krause, G. 1983. Nutrient retention in pork, turkey breast, and corned beef roasts after infrared and convective heat processing. J. Food Sci. 48: 865.

Wilson, B.R., Pearson, A.M., and Shorland, F.B. 1976. Effect of total lipids and phospholipids on warmed-over flavors in red and white muscle from several species as measured by thiobarbituric acid analysis. J. Agric. Food Chem. 24: 7.

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APPENDIX

Table A-1-Specifications of boneless turkey rolls

The menu item, turkey roll, selected for use in the study is limited to the following criteria established by the NC-120 Committee:

a. Product contains one or more critical nutrients; at least one product shall have substantial protein content.

b. Product is fairly uniform in product composition.

c. Product is appropriate to convective and microwave processing.

d. Product is used in large volume by the foodservice industry.

e. Product is of reasonable cost.

f. Product has defined supplier.

g. Product is widely accepted within the general population.

h. Product is of potential importance in the 21st century.

The turkey rolls shall be formulated in accordance with USDA specifications and furnished by Natick Research and Development Center.

a. The formula for the turkey roasts specified by the USDA is:

Ingredient	Percent of Total
Breast Meat (minimum)	47.0
Thigh Meat (maximum)	34.0
Skin (maximum)	12.5
Water	5.0
Salt (iodized)	1.0
Sodium Phosphates	0.5

Breast meat may replace thigh meat, and either breast meat or thigh meat may replace skin. The maximum percentage of thigh meat may be exceeded if thigh meat replaces skin and the minimum percentage of breast meat is obtained.

b. The finished product requirements for the turkey roasts are:

1. Nine to 17 inches in length.
2. Four to seven inches in diameter.
3. Eight pounds (minimum) to 12 pounds (maximum) weight.
4. Netted or string ties (most are netted).
5. A minimum of 75% of outer surface covered by skin.
6. Netted or tied roasts placed in a sealed moisture-proof casing.

Table A-2-Standardized roasting procedures of boneless turkey rolls

1. Turkey rolls will be shipped to arrive at universities in October 1984.

2. Turkey rolls will be stored frozen no longer than three months for any sensory studies or no longer than six months for all other studies.

3. Before cooking, turkey rolls will be tempered to 4°C for greater than 48 hrs but not greater than 72 hrs. Turkey will be cooked to an internal temperature of 80°C (176°F).

4. Temperatures will be recorded at least every five minutes with potentiometer thermocouples placed at the geometric center of the pan.

5. Unchilled variables will be roasted according to experimental design, sliced in 1 cm thick slices and served within 30 minutes after roasting for the 0 time variable.

6. Only light meat will be sampled for measurements.

7. The mass to be held in disposable half size steam table pans with lids is to be 800 g.

8. Turkey meat will be held at 66°C (151°F) at geometric center of pan (calibrated to arrive at that temperature within 60 minutes).

9. Chilled meat will be chilled at 4°C for 24 hrs before reheating at 105°C to 66°C (151°F).

10. A split plot statistical design will be used to analyze data from the nutritional and sensory qualities, microbiological and chemical safety and energy usage studies.

Figure A-1-Time-temperature curves for chilled roasts based on 15 minute intervals; treatment 1, mean endpoint temperature 80.0°C±1.00; treatment 3, mean endpoint temperature 80.0°C±1.00••••••••; treatment 5, mean endpoint temperature 79.3°C±0.47––––.

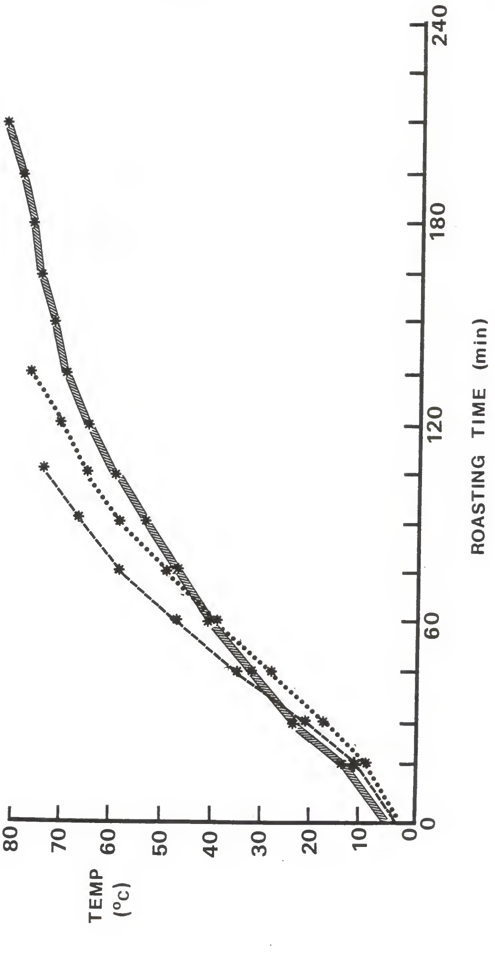
TEMP
(°C)
0
10
20
30
40
50
60
70
80
0
60
120
180
240
ROASTING TIME (min)

Figure A-2-Time-temperature curves for reheated roasts based on 15 minute intervals; treatment 1, mean endpoint temperature 67.5°C±0.41; treatment 3, mean endpoint temperature 66.7°C±0.47; treatment 5, mean endpoint temperature 67.0°C±0.82.

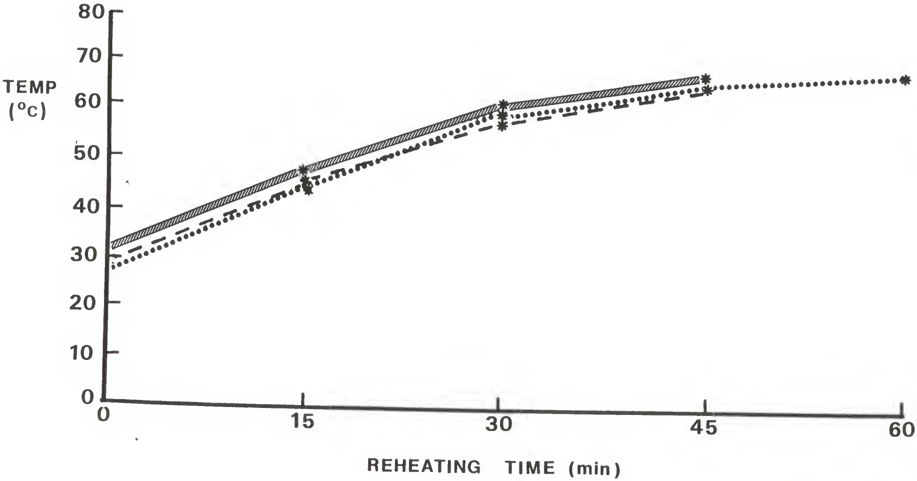
TEMP
(°c)
80
70
60
50
40
30
20
10
0
0
15
30
45
60
REHEATING TIME (min)

Figure A-3-Time-temperature curves for unchilled roasts based on 15 minute intervals; treatment 2, mean endpoint temperature 78.3°C±0.94■●■●■●; treatment 4, mean endpoint temperature 80.7°C±1.25★★★★ ; treatment 6, mean endpoint temperature 80.7°C±1.70 — — .

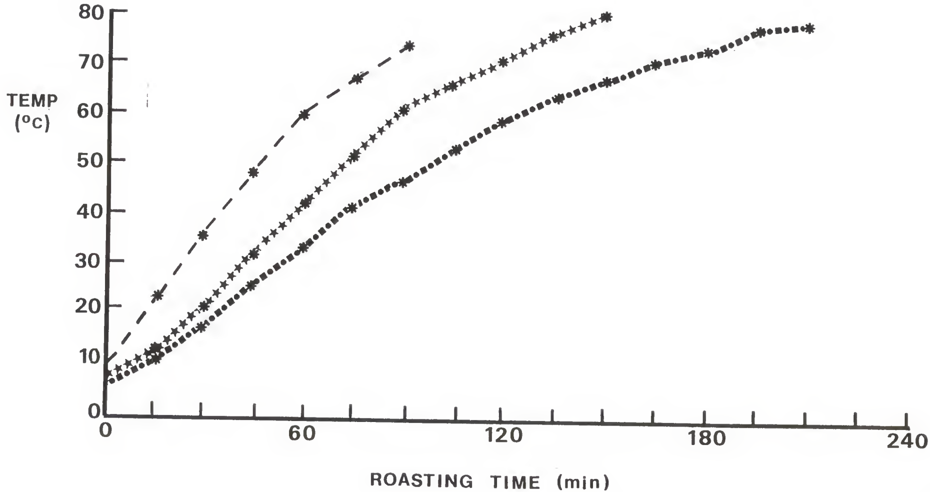
TEMP
(°C)
80
70
60
50
40
30
20
10
0
0
60
120
180
240
ROASTING TIME (min)

Table A-3-Mean heating times and endpoint temperatures for each treatment combination

	Treatment					
	Chill			No Chill		
	105°C	135°C	165°C	105°C	135°C	165°C
Min/kg						
Roasting	52.5±8.0	39.7±1.0	32.4±0.6	55.6±1.2	41.5±1.2	32.1±1.7
Reheating	99.2±4.7	94.2±4.7	98.0±13.0	—	—	—
Endpoint temperature (°C)						
Roasting	80.0±1.0	80.0±1.0	79.3±0.5	78.3±0.9	80.7±1.3	80.7±1.7
Reheating	67.5±0.4	66.7±0.5	67.0±0.8	—	—	—

Table A-4-Procedure for calculating cooking losses

A) Before cooking
   1. wt of drip pan and rack (g)
   2. wt of roast (g)
   3. wt of drip pan, rack, and roast (g)

B) After cooking
   1. wt of drip pan, rack, roast, and drip (g)
   2. wt of drip pan, rack, and drip (g)

C) Cooking losses
   1. due to evaporation (g) (A3-B1)
   2. due to drip (g) (B2-A1)
   3. total (g) (C1+C2)

D) Cooking losses as percent of weight of uncooked roast
   1. due to evaporation (%) (100×C1/A2)
   2. due to drip (%) (100×C1/A2)
   3. total (%) (D1+D2)

Figure A-4-Sample score card used for sensory evaluation of boneless turkey rolls.

INTENSITY RATINGS: TURKEY ROLLS
LIGHT MUSCLE

Name ______________________________

Date ______________________________

Place a vertical line across the horizontal line at the point representing your perception of the characteristic's intensity. Re-testing is permitted.

AROMA

Partially cooked ____ Roasted

JUICY MOUTHFEEL

Very dry ____ Very juicy

TEXTURE

Fibrous, stringy ____ Crumbly, mealy

Chew count _________

FLAVOR: MEATY, COOKED TURKEY

None ____ Intense

FLAVOR: OFF-NOTES

None ____ Strong, stale

Thank You!

Table A-5-Serving and testing schedule of sensory analysis of boneless turkey rolls

		Serving times for panelists		
Day	Treatment	0	60	120[a]
1	1	1:00pm	2:00pm	3:00pm
2	6	9:30am	10:30am	11:30am
3	4	1:00	2:00	3:00
4	4	1:00	2:00	3:00
5	3	9:30	10:30	11:30
6	5	1:00	2:00	3:00
7	5	1:00	2:00	3:00
8	1	9:30	10:30	11:30
9	6	1:00	2:00	3:00
10	3	1:00	2:00	3:00
11	2	9:30	10:30	11:30
12	2	1:00	2:00	3:00
13	4	1:00	2:00	3:00
14	2	9:30	10:30	11:30
15	5	1:00	2:00	3:00
16	3	1:00	2:00	3:00
17	6	9:30	10:30	11:30
18	1	1:00	2:00	3:00

[a]Hot-holding times in minutes.

Table A-6-Procedures for preparing reference samples for aroma[a]

Partially roasted	Over roasted
1. Place 2 × 2 cm sample of raw turkey in $4\frac{1}{2} \times 2\frac{1}{2} \times 1\frac{1}{2}$" loaf pan.	1. Place 2 × 2 cm sample of raw turkey in $4\frac{1}{2} \times 2\frac{1}{2} \times 1\frac{1}{2}$" loaf pan.
2. Add just enough water to cover bottom of pan.	2. Do not add water to pan.
3. Cover with aluminum foil.	3. Do not cover pan.
4. Roast[b] at 400°F for 2 minutes.	4. Roast at 400°F for 40 minutes.

[a]Partially roasted=slightly raw turkey aroma; Over roasted=intense cooked turkey aroma.

[b]Roasting was done in a Whirlpool electric range (Model RFE950P).

Table A-7-Procedure for the determination of fat content[a]

1. Preparation of sample

    a. Grind meat sample
    b. Place 5 g ground sample in cultured tubes

2. Extraction of lipids

    a. Add 15 ml 2:1 methylene chloride methyl alcohol to sample
    b. Thoroughly blend (15 seconds) with high speed homogenizer
    c. Shake 5 minutes with standardized shaker
    d. Filter the homogenate

3. Washing of crude extract

    a. Add 4 ml 0.73% NaCl solution
    b. Shake 2 minutes
    c. Centrifuge 2 minutes
    d. Siphon aqueous (top) layer

4. Calculation of fat content

    a. Place methylene fat (bottom) layer in pre-weighed aluminum pans[b]
    b. Evaporate to dryness overnight
    c. Heat at 120°C in drying oven (Thermotainer, Model PW-1) 1 hour
    d. Cool in dessicator 30 minutes
    e. Re-weigh pans
    f. % fat=total weight (weight of pan after evaporation, drying, cooling)-weight of pre-weighed pan × 100

[a]Folch, Lees, and Sloane-Stanley (1957) as modified by Chen, Shen, and Sheppard (1981).
[b]Weigh pans were dried at 149°C 1½ hours, cooled in dessicator 30 minutes, and weighed.

Table A-8-Mean squares and F-values[a] from analysis of variance of cooking losses for boneless turkey rolls

Source of variation	df	Cooking losses					
		evap 1	drip 1	total 1	evap 2	drip 2	total 2
Treatment (C and T)[b]	5	0.16 (1.95)	0.10 (2.39)	0.22 (1.67)	0.39 (1.15)	0.66 (0.45)	0.38 (1.17)

[a]F-values in parenthesis, ($p \leq 0.05$).
[b]C=Chill, T=Roasting temperature.

Table A-9-Least square means[a] of cooking losses for boneless turkey rolls

Source of variation	Cooking losses			Reheating losses		
	evap	drip	total	evap	drip	total
Chill						
105°C	8.40	3.59	11.98	3.18	2.42	5.56
135°C	13.99	5.50	19.48	1.53	1.80	3.43
165°C	15.85	2.90	18.75	2.26	0.63	2.89
No Chill						
105°C	9.95	3.46	13.41	--	--	--
135°C	11.79	3.56	15.34	--	--	--
165°C	13.57	2.13	15.64	--	--	--

[a]No differences were found among means ($p \leq 0.05$); three observations per mean.

Table A-10–Least square means[a] of thiamin content for boneless turkey rolls on a moisture-free, fat-free basis

	Thiamin content (mg/100 g)	
Source of variation	Moisture-free	Moisture-free, fat-free
Holding times (min)		
0	0.15[a]	0.18[a]
60	0.14[a]	0.18[a]
120	0.13[b]	0.15[b]

[a]Means in a column sharing a common superscript are not significantly different ($p \leq 0.05$); Data were pooled for chill vs no chill and cooking temperatures; 18 observations/mean.

Table A-11-Least square means[a] of sensory data for each treatment combination

Treatment		Sensory attributes[b]					
		Aroma	Juiciness	Texture	Chew count	Flavor	Off notes
Temperature (°C)	Holding time (min)						
Chill							
105	0	8.7	8.1	8.1	13.1	9.3	0.8
	60	7.0	6.4	10.8	13.2	7.4	0.6
	120	9.2	6.8	9.4	16.2	8.5	2.0
135	0	9.5	7.5	9.9	12.6	8.5	0.9
	60	8.5	6.9	9.1	12.5	7.9	0.3
	120	10.3	4.7	8.3	12.5	8.2	1.4
165	0	9.7	6.9	9.6	12.0	10.2	0.9
	60	9.6	5.1	7.7	14.2	9.2	0.6
	120	10.4	4.8	7.5	17.4	9.2	0.6
No Chill							
105	0	8.3	12.8	8.2	11.8	9.2	0.4
	60	9.4	9.2	9.4	13.9	8.2	0.6
	120	10.9	5.3	8.3	15.4	8.1	0.8
135	0	8.8	11.0	8.0	12.3	8.9	0.3
	60	9.4	7.4	8.3	13.3	8.2	0.3
	120	9.3	6.4	7.5	14.2	9.0	0.3
165	0	8.4	10.9	7.6	14.0	9.4	0.2
	60	8.2	8.9	8.0	12.0	9.5	0.3
	120	9.2	5.4	9.2	13.7	10.0	1.0

[a] 3 observations/mean.
[b] Intensity scale 0-15; 0=least, 15=most intense.

Table A-12-Least square means[a] of physical and chemical data for each treatment combination

Treatment: Temperature (°C)	Holding time (min)	Instron force: Probe (kg)	Instron force: Shear (kg)	Chemical analysis: Thiamin (mcg/g)	Chemical analysis: Moisture (%)	Chemical analysis: Fat (%)
Chill						
105	0	0.5	1.4	0.4	70.8	4.1
	60	0.6	1.4	0.4	68.7	3.5
	120	0.6	1.3	0.4	66.4	4.2
135	0	0.7	1.1	0.4	70.5	5.9
	60	0.4	1.1	0.4	67.3	5.3
	120	0.5	1.3	0.4	65.1	6.1
165	0	0.7	1.3	0.5	69.7	5.8
	60	0.7	1.5	0.4	68.6	7.6
	120	0.5	2.2	0.4	65.6	5.7
No Chill						
105	0	0.6	1.3	0.5	72.7	5.5
	60	0.7	1.3	0.6	70.6	6.1
	120	0.9	1.5	0.6	67.7	5.2
135	0	0.6	1.2	0.4	73.3	3.6
	60	0.7	1.4	0.4	70.2	3.5
	120	0.7	1.6	0.4	67.5	5.7
165	0	0.5	1.1	0.4	71.3	4.5
	60	0.5	1.8	0.3	70.3	3.5
	120	0.6	1.1	0.4	67.9	4.7

[a]3 observations/mean.

Table A-13-Least square means[a] of sensory attributes for boneless turkey rolls

Source of variation	Sensory attributes[b]					
	Aroma	Juiciness	Texture	Chew count	Flavor	Off notes
Holding time (min)						
0	8.90[a]	9.54[a]	8.57[a]	12.62[b]	9.24[a]	0.57[a]
60	8.68[a]	7.31[b]	8.88[a]	13.18[b]	8.42[a]	0.42[a]
120	9.89[b]	5.57[c]	8.37[a]	14.91[a]	8.83[a]	1.01[a]

[a]Means in a column sharing a common superscript are not significantly different ($p \leq 0.05$); Data were pooled for cooking temperatures and chill vs no chill, 18 observations/mean.
[b]Intensity scale 0-15; 0=least, 15=most intense.

Table A-14-Least square means[a] of physical and chemical analysis for boneless turkey rolls

Source of variation	Instron force		Chemical analysis		
	Probe (kg)	Shear (kg)	Thiamin (mcg/g)	Moisture (%)	Fat (%)
Holding time (min)					
0	0.59^{a}	1.24^{a}	0.43^{a}	71.37^{a}	4.89^{a}
60	0.60^{a}	1.40^{a}	0.44^{a}	69.28^{b}	4.89^{a}
120	0.54^{a}	1.49^{a}	0.48^{a}	65.69^{c}	5.26^{a}

[a]Means in a column sharing a common superscript are not significantly different ($p \leq 0.05$); Data were pooled for chill vs no chill and cooking temperatures, 18 observations/mean.

SENSORY AND NUTRITIONAL QUALITY OF
BONELESS TURKEY ROLLS AS AFFECTED BY
THERMAL PROCESSING CONDITIONS FOR FOODSERVICE USAGE

by

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AN ABSTRACT OF A MASTER'S THESIS

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requirements for the degree

MASTER OF SCIENCE

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ABSTRACT

Effects of roasting methods and hot-holding on eating quality and thiamin content of boneless turkey rolls were investigated. Three oven temperatures; 105°, 135°, and 165°C; and two roasting procedures, chill versus no chill, were used to prepare and hold boneless turkey rolls for 0, 60, and 120 minutes. Treatment combinations of a split plot experimental design were randomized for each of three replications. A convection oven was used for roasting to 80°C, reheating to 66°C at 105°C, and hot-holding at 100°C.

Sensory characteristics, including aroma, tenderness, juiciness, flavor, and flavor off-notes, were evaluated by a four member trained panel using 15 cm unstructured line intensity scales. Chemical measurements; thiamin, fat, and moisture content; and physical evaluations of tenderness were determined using the Instron Universal Testing Machine.

Treatment, roasting temperature and overnight chilling significantly influenced juiciness scores of light meat turkey samples. Turkey rolls roasted at 105°C were juicier ($p \leq 0.05$) than those roasted at 135° and 165°C and chilled.

Sensory attributes of aroma, chew count, and juiciness, along with percentage moisture, were affected significantly by the length of the holding period. Chew counts of samples progressively increased as the meat was held for longer periods of time, whereas, juiciness and moisture content both decreased significantly from one holding period to the next. Turkey slices held for 120 minutes had stronger roasted aroma ($p \leq 0.05$) than those held for 0 and 60 minutes. Thiamin content (mcg/g) and percentage moisture were higher ($p \leq 0.05$) when turkey rolls were roasted

at 105°C and served the same day than for all other treatment combinations studied. Roasts cooked at each of the three oven temperatures, chilled overnight, and reheated were lower ($p \leq 0.05$) in moisture than those roasts prepared and served without chilling.