5-1983

An Evaluation of Various Methods of Roasting Whole Turkeys From the Frozen State

Kim Merida-Klemmedson Teot
Utah State University

AN EVALUATION OF VARIOUS METHODS OF ROASTING WHOLE TURKEYS FROM THE FROZEN STATE

by

Kim Merida-Klemmedson Teot

A thesis submitted in partial fulfillment
of the requirements for the degree

of

MASTER OF SCIENCE

in

Nutrition and Food Science

Approved:

UTAH STATE UNIVERSITY
Logan, Utah
1983

ACKNOWLEDGEMENTS

I would like to thank Daren Cornforth for his full support which made it possible for me to complete the requirements of my master's. I would also like to thank Charlotte Brennand for her willingness to help me when it was absolutely necessary (2:00 a.m.).

Thanks is also extended to Calvin Leman for his technical advisement in the production of this thesis, and Don Sisson for his guidance regarding the statistical analysis of this thesis.

Most of all I would like to thank my husband Eric whose moral and physical support gave me the strength to complete this thesis.

Kim M.K. Teot

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

An Evaluation of Various Methods of
Roasting Whole Turkeys From the Frozen State

BY

Kim Merida-Klemmedson Teot, Master of Science

Utah State University, 1983

Major Professor: Dr. Daren P. Cornforth
Department: Nutrition and Food Science

Methods of roasting frozen turkeys were evaluated to determine the optimum final internal temperature (71,77, or 82°C), the best low oven temperature method (foil tent vs roasting bag at 93,107, 121, and 135°C), and the best overall method (foil tent-121°C, foil tent-163°C, roasting bag-163°C, foil wrap-232°C). The lower the final internal temperature the juicier and more tender the bird however, the 77°C final internal temperature is recommended because at the 71°C internal temperature, the thigh joint was unacceptably pink. Among the low oven temperature methods, birds roasted at 121°C received the highest average sensory scores. Birds roasted by the 163°C oven with a foil tent covering method received acceptable sensory scores, favorable comments from the panelists, and inoculated

birds roasted by this method were sterile. Therefore this method was chosen as the best overall method for roasting whole unstuffed frozen turkeys. The low oven temperature method produced also produced an acceptable turkey from a sensory standpoint, but the thigh joint was judged to be "uncooked" and therefore unacceptable. The roasting bag method was judged low for both appearance and palatablity attributes. Survival of Salmonella typhimurium was also highest on birds roasted in a bag. The high oven temperature method was given low palatability scores, and survival of Salmonella typhimurium was also observed on birds roasted by this method.

(84 pages)

INTRODUCTION

Traditionally, whole turkeys have been consumed in the United States on Christmas and Thanksgiving. This seasonal demand for turkeys creates a market glut for the product in the fall and winter but little or no demand during the spring and summer seasons. One reason consumers may not prepare whole turkeys at other times of the year is because of the inconvenience of thawing the turkey, stuffing it, and then roasting it. The thawing of the bird is probably the most inconvenient part since it requires a large amount of refrigerator or counter space for several hours.

REVIEW OF LITERATURE

End-point Temperature and It's Effect on Microbial Safety And Palatability Attributes.

It has generally been accepted that to adequately roast stuffed turkeys an end-point temperature of 85°C (185°F) should be reached in the breast. Hoke and Kleve (1966) reported that an inner thigh end-point temperature of 85°C (185°F) in stuffed turkeys was usually sufficient temperature to assure destruction of food poisoning organisms. Hoke and Kleve (1966) also pointed out that an end-point temperature of 85°C (185°F) yielded a turkey of acceptable eating quality. Hoke et al. (1965) found that 40% of the turkeys roasted to an end-point temperature of 85°C (185°F) in the breast had stuffing temperatures of 73.8°C (165°F) or below. However the stuffings that were below 73.8°C (165°F) had a post-oven temperature rise of 10°F letting all but one of the stuffings reach a safe temperature.

Goodwin et al. (1962) evaluated end-point temperatures of 55,60,66,71,77,72,88,and 94°C for shear test values and found that as end-point temperature increased so did the shear, value up to 71°C. At 77°C the shear value declined rapidly then gradually rose with end-point temperature. No sensory tests were performed for any of the end-point temperatures.

Alexander et al. (1951) concluded that no one end-point temperature was best for roasting turkeys, but did find that a range of 80-95°C (176-203°F) produced a satisfactorily cooked turkey. In the study by Hoke et al. (1967) the authors concluded that the optimum end-point temperature for turkey roasts was between 73.8 and 79.4°C (165 and 185°F) for dark meat (thigh). Although these studies did not recommend a specific end-point temperature they did suggest that around 80°C (175°F) produced a palatably acceptable turkey whereas the brest meat of birds roasted to a low end point temperature (71-82°C(160-180^{F})) were judged unsatisfactory.

Esselen et al. (1956) concluded that for a large stuffed bird, because of it's slower rate of heat penetration and longer cooking time, an end-point temperature of 68.3°C (155°F) was adequate to ensure safety from food poisoning organisms. When smaller birds (under 12 lbs.) were studied, Esselen et al. (1956) found that a higher temperature (73.8°C) was needed, to ensure safety.

Bramblett and Fugate (1967) were concerned with end-point temperature and its effect on palatability, and investigated end-point temperatures of 72.8°C (163°F) and 82.3°C (180°F) and oven temperatures of 93.3°C (200°F), 162.8°C (325°F), and 232.2°C (450°F). Although the birds roasted to an end-point temperature of 72.8°C (163°F) (in a 200°F oven) received the highest score for tenderness, adhesion and residue these birds were considered the least desirable of the turkeys cooked. These turkeys received low scores for appearance, mealiness (most mealy), flavor , and juiciness. The

birds roasted to an end-point temperature of 82.2°C (180°F) (in a 325°F oven) received intermediate scores, but were considered to produce the most desirable turkey. Cornforth et al. (1982) found that some turkeys roasted to 71.1°C appeared "uncooked", and were pink in color at the thigh joint.

Hoke et al. (1968) investigated the end-point temperatures of 73.8°C (165°F), 79.4°C (175°F), and 85°C (185°F) for frozen stored turkeys that were thawed, and then roasted at 162.8°C (325°F). They concluded that optimum doneness was reached at an end-point temperature of 79.4°C (175°F).

At the end-point temperature of 90°C (194°F) Goetz et al. (1960) found that the breast meat was nearer the general concept of done than at 85°C (185°F). They also found that the flavor and tenderness was not affected by end-point temperature (85, 90, or 95°C in the thigh), but that juiciness scores were significantly higher for the 85°C end-point temperature, as measured in either breast or thighs.

These articles maintained that an end-point temperature of 73.8°C (165°F) or above in the breast produced a palatable turkey. Although a range of temperatures from 55 to 95°C (131 to 201.2°F) was investigated, consumer acceptability of these end-point temperatures was not evaluated.

Covering and It's Effect on Palatability

When roasting a turkey, a covering of some sort is usually put over (foil tent) or around (roasting bag or foil wrap) the bird to prevent excess browning and also to avoid excess moisture loss. Some investigators (Deethardt et al. 1971) however found that turkey breasts roasted in an open pan were significantly juicier, more tender, and had a higher flavor score than those turkeys roasted in a foil wrap.

Baity et al. (1969) investigated the evaporation loss and cooking time associated with a tight-wrap foil, loose-wrap foil, and an open pan. They found that both cooking time and evaporation decreased when a tight-wrap foil covering was used in a low oven temperature oven ($93^{o}C$).

Stephens (1977) conducted a survey in which he asked consumers to roast frozen turkeys in a roasting bag, and then to answer a questionnaire regarding their opinions of this method. In the three years of study, the majority rated the turkeys roasted this way as very juicy, tender, with good flavor and texture as compared (by recollection) to the consumer's previous method of roasting turkeys.

Cooking Method and It's Effect on Palatability

To eliminate the inconvenience of thawing a whole turkey prior to roasting, several investigators suggested that the turkey be roasted directly from the frozen state. Fulton et al. (1967) investigated the possibility of roasting turkeys from both the thawed and frozen states, and concluded that roasting of frozen turkeys produced an acceptable bird. In this investigation cooking time was reduced up to 63% by cutting the turkeys in half, quarter, or pieces, without a reduction in palatability scores. Fulton and Davis (1974) compared chickens and turkeys roasted from the frozen versus thawed state and found no significant difference in palatability.

When Ibbetson et al. (1968) braised or pressured cooked turkey halves from the frozen and thawed states they found that there was no significant difference in flavor or juiciness scores either light or dark meat based on the initial state (frozen or thawed) of the bird. The dark meat of defrosted birds was considered to be more tender than that of the frozen birds ($p=.01$). The braised halves were given higher juiciness scores than those that were pressure cooked, with tenderness and flavor of dark meat not significantly different. They concluded that braising turkeys from the frozen state produced an acceptable turkey.

When frozen quarters were either roasted or braised in a 162.8°C (325°F) gas oven to an end-point temperature of 86°C, Travnicek and Hooper (1968) found no significant difference in palatabilty scores. Both the braised and roasted birds were acceptable, but the braised halves had less cooking and volatile losses, less moisture loss, and required less cooking time than the roasted birds. Different oven temperatures (148°C, 163°C, and 177°C) did not significantly change the ratings for tenderness or juiciness for either the light or dark meat of whole turkeys (Goetz and Stacy, 1960).

Cornforth et al. (1982) evaluated six different methods of roasting frozen birds to a lower than normal internal temperature of 71°C. They concluded that birds roasted in a 93.3°C oven were of highest eating quality. However, many birds, especially those roasted in a microwave oven, received low appearance scores and had thighs which appeared undercooked.

Bacterial Contamination of Raw, Cooked and Frozen Product

Hagber et al. (1973) investigated 3 commercial turkey processing plants and found that in all plants some turkeys were contaminated in the meat and the skin with C. perfringens and Salmonella. In all three plants the number of organisms increased with increased handling, ie. deboning.

Lillard (1971) investigated three poultry processing plants for the occurence of Clostridium perfringens. Samples were taken from the processing area and from the birds before and after cooking. Most of the C. perfringens (31-77%) were found on the feathers, feet, caecum, vent area, and neck skin. The most interesting finding of the study was that when using enrichment techniques to isolate the C. perfringens no organisms were found on the uncooked product, but 2.6% of the cooked samples, which had been battered and fried were positive for C. perfringens. Further studies of the ingredients in the batter indicated that the flour itself was the main source of C. perfringens.

S. typhimurium was found to be the major contaminant of poultry processing plants by Patterson (1969). He discovered that although S. typhimurium was the major Salmonella species found, it did not occur in great numbers nor did it occur in a great number of places in the plant. Eviscerated turkeys did not show any signs of Salmonella, while swabs from the sewer were 67% positive for S. typhimurium. The cooling water for the turkeys did not show any signs of Salmonella and only low levels (less than 5/100g as measured by MPN) of S. typhimurium were detected on the cooked, boned-out poultry meat.

The freezing of poultry and its effects on the growth of food poisoning organisms has been investigated by several authors. Olson et al. (1981) concluded that, in a five-cycle freezing and thawing process of chicken wings inoculated with S. typhimurium, the process

was effective in reducing the numbers of this bacteria. Sorrels et al. (1970) found that 88% of Salmonella gallinarum was destroyed after storage of 1 day at -20°C, and of those that survived 42% exhibited metabolic injury. Salmonella species were found to survive frozen storage of 1 month at -29C in very small numbers (less than 1 organsim per sq. cm.) (Kraft et al. 1963). Reddy et al. (1978) showed that mesophiles and psychrotrophs were significantly reduced in numbers after spin chilling (submerging of the turkey in 0°C water with agitation), but there was no significant decrease in number of organisms from freezing procedures after the spin chilling. The coliform count was not significantly reduced by either spin chilling or freezing procedures. Reddy et al. (1978) did recommend that good sanitary practices and the implementation of spin chilling and freezing procedures would reduce the occurence of potentially pathogenic organisms such as Salmonella and C. perfringens.

Recontamination was the hypothesized reason for the appearance of C. perfringens on cooked turkey carcasses in a school lunch program study done by Bryan and McKinley (1974). They concluded that by rapidly chilling both turkey carcasses and broth the outbreak of potential pathogenic organisms could be reduced. The method for rapid chilling that they recommended was to cut up the whole turkeys or rolls into pieces and put them in a shallow pan to allow maximum surface area exposure to the refrigerator temperature.

The Effect of Cooking and Processing on Microbial Load of Turkeys

In 1954, Esselen and Levine looked at the viability of aerobic and anaerobic bacteria in frozen stuffed poultry stored at $0^{o}F$, or thawed and held at room temperature. They also investigated whether or not the stuffing itself provided an environment which promoted the growth of anaerobes. They found that during thawing and holding at room temperature there was a marked increase of aerobic and anaerobic bacteria in the stuffing after 20 hours. They also found that the stuffing provided a very good environment for the growth of aerobic and anaerobic bacteria, and frozen storage of the birds at $0^{o}F$ for one year did not affect the microbiological quality of the stuffing. The authors concluded that frozen stuffed poultry should be adequately refrigerated and not contaminated before, during or after cooking to prevent growth of the putrefactive bacteria.

In previously thawed turkey rolls that had been inoculated with Salmonella typhimurium, Wilkinson et al. (1964) found that an end-point temperature of $71.1^{o}C$ was sufficient to kill the low levels of pathogenic bacteria found after processing. In fact, none of the S. typhimurium survived an end-point temperature of $65.6^{o}C$ ($150^{o}F$) or more, but Streptococcus faecalis did survive that temperature. Therefore Wilkinson concluded that an end-point temperature of $71.1^{o}C$ ($160^{o}F$) provided a margin of safety.

Bryan et al. (1968) found that 27% of commercially pre-cooked turkey rolls contained Salmonella but no Salmonella was found on cooked rolls. When loads of more than one million Salmonella (per sq. cm. or gram) were inoculated into the rolls and cooked to an end-point temperature of 66°C and 71°C no detectable (>.3 cells/gram) Salmonella were observed. Zottola and Busta (1971) also investigated the presence of Salmonella in processed turkey rolls, but found that only 8.6% samples of the raw samples were contaminated. The processing end-point temperature of 74°C was sufficient to destroy the Salmonella.

Cornforth et al. (1982) concluded that an end-point of 71.1°C (with a post-cooking rise in temperature as high as 75°C) was sufficient to destroy S. typhimurium and C. perfringens on previously inoculated turkeys, although the inoculation level was rather low (2.7×10^{-3}/gr. in the giblets).

Bacteriological Procedures for Isolation of Salmonella and Clostridium perfringens.

For the detection of Salmonella in foods it is generally accepted that an enrichment technique is superior to direct plating (Fagerberg and Avens 1976). Smyser et al. (1963) as cited in Fagerberg and Avens (1976) found selenite cystine to be useful in the detection of S. typhimurium in artifically contaminated poultry products. Sveum and Kraft (1981) also found that an enrichment broth

such as selenite- cystine (SC) helped in the recovery of Salmonella on frozen turkey roasts. Sveum and Kraft (1981) observed that a combined tetrathionate broth was superior to an SC broth, but not significantly.

After enrichment, a plating agar that is able to give maximum numbers of Salmonella is needed to produce a valid most probable number (MPN) count. Fagerberg and Avens (1976) concluded that a xylose lysine desoxycholate (XLD) agar was superior to Salmonella-Shigella (SS) and MacConkey agars (MAC) because XLD yielded more Salmonella and less false-positives than either SS or MAC. In a clinical study performed by Rollender et al. (1969) they found that for direct plating the XLD agar was clearly superior to the MAC agar in that the XLD agar produced 38% more isolates of Salmonella than the MAC agar.

For the detection of C. perfringens, Adams and Mead (1980) found that tryptose-sulphite-cycloserine agar without egg yolk (TSC) gave satisfacory results. They did recommend that further confirmation of the 'presumptive' C. perfringens be done in order to insure a positive identification of C. perfringens.

OBJECTIVES

Past work has shown that roasting frozen turkeys is feasible, but more specific methods are needed to ensure consumers an acceptable product. Therefore the purpose of this study is to develop one or two specific roasting methods that will consistently and conveniently produce an acceptable frozen roasted turkey under home conditions.

MATERIALS AND METHODS

Experimental Design

To develop the optimum method for roasting frozen turkeys, the study was divided into four parts. The object of Part I was to determine the optimum end-point temperature to which the frozen turkey should be roasted. Nine sets of six turkeys were each roasted on separate days using all possible combinations of end-point temperature, roasting method, and weight of bird. Review of literature showed the end-point temperatures of 70-85°C produced an acceptable bird therefore end-point temperatures chosen were 71.1, 76.6, or 82.2°C. The methods were as follows: 1) 163°C oven, foil tent, thawed bird; 2) 93°C oven, foil tent, frozen bird; 3) 232°C oven, foil wrap, frozen bird. These methods were chosen to provide a control method (1), a low oven temperature method (2), and a high oven temperature method (3) to give a range of cooking methods. The weight of the bird was either ca 4.5 kg. or ca 9.1 kg. (Appendix B).

Since some previous work recommended roasting at low oven temperatures, the objective of Part II was to determine the optimum low oven temperature (93.1, 107.2, 121.1, or 135°C), and the best covering for the turkey (foil tent or roasting bag). The optimum end-point temperature determined in Part I was used in Part II. Six sets of four turkeys were roasted from the frozen state to an

end-point temperature of 76°C, varying the covering (foil tent and roasting bag) and oven temperature (93.3°C (200°F), 107.2C (225°F), 121.1°C (250°F), 135°C (275°F) (Appendix B).

The objective of Part IIIa was to determine the overall optimum roasting method, comparing the optimum low temperature roasting method as determined in Part II with other common roasting procedures. Again all birds were roasted to the optimum end-point temperature determined in Part I. Eight sets of six turkeys each were roasted from the frozen state using a combination of four methods: 1) 121.1°C (250°F) oven with a foil tent; 2) 162.7°C (325°F) oven with a foil tent; 3) 163°C (325°F) oven in a roasting bag; 4) 232.2C (450°F) oven with a foil wrap, and four weights: 1) 3.6-5.5 kg.; 2) 5.51-7.3 kg.; 3) 7.4-9.1 kg.; 4) 9.11-10.9 kg. at an end-point temperature of 76°C (Appendix B). In all parts the combinations were tested in triplicate.

Included in Part III was a survey of the panel judges asking them which method they would realistically use at home. The purpose of Part IIIb was to determine which of the roasting methods evaluated in Part IIIa would most likely be used when all factors (including roasting time) were considered. Means were calculated for individual panelists' sensory evaluation data from Part IIIa. Since there was some variation between scores due to weight of the bird each panelist was asked the normal weight of turkeys prepared in his/her home. The panelists were told: 1) how the turkeys had been roasted; 2) how much time each method required for a turkey of weight normally used

by that panelist; 3) the panelist's own average scores for that weight category (Appendix A). Panelists were then asked to rank the roasting methods in the order they would use them at home, if they were going to roast a frozen turkey. They were also asked the question "What determined your choice?"

Significance of ranking score was based on the tables in "Expanded Tables for Significance of Ranking Data" (Kahan et al. 1973).

Based on their responses they were each given a frozen turkey to roast and evaluate at home using their first or second choice of roasting method from Part IIIb.

Each panelist was instructed on how to cook the turkey according to the assigned method (foil tent at 121°C, foil tent at 163°C, roasting bag at 163°C, or foil wrap at 232C). All turkeys weighed between 4.3 kg. to 5.7 kg. When each panelist received his/her turkey, he/she was loaned an accurate meat thermometer, or had his/her own thermometers calibrated for accuracy at 76°C. Each panelist also received: 1) instructions on how to roast the turkey (Appendix A); 2) ballots to be used by family and guests to evaluate the turkey (Appendix A); 3) two sealed envelopes with questions for the cook (Appendix A). Envelope 1 contained a single question which asked for the cook's general reaction to the cooking method. Envelope 2 contained a ballot similar to the ones used in the previous taste panels. The cook was also asked questions about the

method, ease of use, problems, and whether or not he/she would use this method again. Each guest was asked to evaluate the turkey on general appearance, flavor, juiciness, and to give an overall rating, using a 7-point hedonic scale. The ballots were tallied and statistically analyzed using analysis of variance. Comments were compiled and reviewed for trends or repetitive comments.

In Part IV, birds were inoculated with food poisioning microorganisms (Salmonella typhimurium and Clostridium perfringens) and roasted according to the four methods described in Part III. The roasted birds were then analyzed to determine the relative effectiveness of these methods in the destruction of these food pathogens.

Storage and Holding

One hundred forty-two unbasted frozen turkeys were obtained from a local turkey processing plant and stored at -27°C (-17F). To approximate the conditions of a home freezer, all but 16 of the turkeys were held at -17.7°C (0°F) for five days prior to roasting. For Part I, 16 turkeys were thawed in a 4.4°C (40°F) refrigerator for the four days prior to roasting.

Roasting the Turkeys

A foil tent was used with the low oven temperatures in Part I (93.3,107.2, 121.1, and 135°C) and with the 162.7°C oven in Part II, for both the frozen and thawed turkeys. The foil tent was made by draping a piece of aluminum foil over the bird and down to the roasting pan. A loose foil wrap was used with the birds roasted in a 232.2C oven. Aluminum foil was placed under and around the bird and folded over on itself. Commercially available roasting bags (Reynolds) were used in Parts II and III.

Each bird was weighed prior to cooking. Insulated thermocouples were inserted midway into the thickest area of the breast and thigh, first by using a hammer and nail to create a hole. Each bird was placed in an aluminum roasting pan, breast up and covered with either a foil tent, foil wrap, or a roasting bag, depending on which cooking method was used. The turkeys were then placed in the oven and the initial time was recorded. During the roasting period, temperature of the breast and the thigh was constantly monitered by a Leeds-Northrop thermocouple recorder. To enhance browning, the foil tent or wrap was removed about 1 hour before the low oven temperature roasted birds were removed from the oven. The birds roasted in the 163°C and 232°C ovens were browned 30 and 15 minutes, respectively. Since preliminary testing had shown that the 93.3°C(200°F) and 107.2(225) oven roasted birds did not brown, even when the foil was removed, the oven temperature was increased to 204.4°C (400°F) for

the last 30 minutes of roasting.

When the end-point temperatures were reached, the turkeys were removed from the oven and the final roasting time recorded. Cooked bird and drippings were individually weighed 15 minutes after removal from the oven.

Sensory Evaluation

The roasted birds were then displayed for observation by 28 judges who had experience roasting turkeys at home. Prior to viewing, each bird was assigned a random number to serve as a coded reference for the judges when making their visual observation. Each bird had a slice of breast meat exposed by making a small cut into the thickest part of the breast parallel to the breastbone. The judges visually rated the turkeys on degree of browning, uniformity of browning, general outside appearance, and general inside appearance, using a seven-point scale (7=brownest, most uniform, best outside appearance, and best inside appearance Appendix A).

Two x 3 cm portions of both breast and thigh meats were served to each judge, in partitioned booths under white light and where rinse water was available. Portions were coded with new random numbers and served while still warm. The order in which samples were served was rotated between judges to avoid any positional bias. Each judge evaluated these portions based on a seven-point scale (7=best

flavor, juiciest, most tender, and best overall) for flavor, juiciness, tenderness, and overall acceptability (Appendix A). The evaluation of the breast and thigh meat was rated as a combined score in Parts I and II, but in Part III, at the panelist's request, light and dark meat was evaluated separately.

Statistics

Analysis of variance for Parts I-III were obtained by using a Statistical Package for Social Sciences (SPSS) (Nie et al. 1975), on a Burroughs 3600 computer.

Microbial Assays

The test cultures of Salmonella typhimurium and Clostridium perfringens were obtained from the Utah State University microbiology laboratory, transferred to fresh growth media and incubated at 37°C for 24 hours before inoculation onto the birds. The stock cultures were then suspended in 2 liters of distilled water in a large plastic bag. The pooled giblets, the pooled necks, and the eight individual thawed birds were separately inoculated by immersing in the inoculation solution for 60 seconds, with agitation. Giblets were resealed in a plastic bag and the necks were replaced in their former positions in each turkey, and the birds were re-frozen in a blast freezer at -27°C (-17°F).

Twenty five grams of the neck and giblets were taken from the pooled samples immediately after inoculation and from each bird after roasting. Skin samples were taken immediately after inoculation, after frozen storage for 72 hours, and again after roasting, using a 1.77 sq. cm. coring knife to obtain samples.

Samples were analyzed for total aerobic plate count by first taking the skin, neck, and giblet samples and placing them into 225 ml of 1% sterile peptone water and blending them at 2,000 rpm for 1 minute. The homogenate was then serially diluted, and plated out to obtain duplicate plates with dilution factors of 10^{-1} to 10^{-4}. Plate count agar (Appendix C) was poured overlayed, the plates were allowed to solidify, and placed in a 35°C incubator for 48 +/- 2 hours (Messer 1978). The plates were then removed from incubator and a plate count determined.

Clostridium perfringens was enumerated as described by (Harmon and Duncan 1978). The previously prepared sample homogenate was serially diluted to 10^{-2}, 10^{-3}, and 10^{-4} and transferred to obtain duplicate plates with factors of 10^{-1}-10^{-5}, on previously poured tryptose-sulfite-cycloserine (TSC) plates containing egg yolk emulsion (Appendix C). The samples were spread with a sterile glass rod. After the inoculum was absorbed (5 min.), an overlay of the TSC agar without egg yolk emulsion (10 ml.) was poured on the plates. When the agar had solidified the plates were placed in an upright position in an anaerobic jar and after anaerobic conditions were

obtained the plates were incubated at 35°C for 24 hours. After 24 hours plates were checked and counted for typical black colonies. Ten typical colonies from the TSC plates were then placed in fluid thioglycollate broth (Appendix C) and then examined by gram stain to confirm the presence of Clostridium perfringens.

Salmonella typhimurium was enumerated using the most probable number (MPN) procedure (FDA, 1978). One ml of sample from the previously prepared serial dilutions of homogenate was transferred into 10 ml tubes of selenite cystine (SC) (Appendix C) enrichment broth to promote the growth of injured cells. These tubes were then incubated for 24 hours at 35°C. After incubation a loopful of the SC broth from each tube was plated on xylose-lysine-deoxycholte (XLD) broth (Appendix C) to obtain a MPN. These plates were incubated at 35°C for 24 hours after which they were observed for positive growth which was indicated by the appearance of colonies that changed the XLD agar from pink to yellow. A sample of two or more yellow colonies was then inoculated into triple sugar iron tubes (Appendix C) to confirm the presence of Salmonella species by the appearance of a red slant (alkaline production) and a yellow butt (acid production) and the appearance of hydrogen sulfide (blackening of agar).

RESULTS AND DISCUSSION

Part I: Determination of Optimum End-point Temperature

The purpose of Part I was to evaluate the effects of end-point temperature (71, 76, and 82°C), weight (4.5 and 9.1 kg.), and cooking method 1) foil tent (thawed bird) in a 163°C oven; 2) foil tent (frozen bird) in a 93°C oven and 3) roasting bag (frozen bird) in a 232°C oven on palatability and appearance attributes of cooked turkeys. The end-point temperature that produced birds with highest overall ratings was used in Parts II, III, and IV.

The analysis of variance of the main effects of end-point temperature, weight, and cooking method, and their interactions on sensory attributes are summarized in Table 1 with the means of the main effects presented in Table 2.

Table 1: Summary of Analysis of Variance for Main Effects and Interactions of Final Temperature, Method, and Weight on Sensory Attributes of Roasted Birds (Part I).

Appearance Attributes

Source	df	Browning MS	Uniformity MS	Outside Appearance MS	Inside Appearance MS
FINAL T.	2	**93.3	*6.0	**12.1	**12.6
METHOD	2	**216.1	**32.7	**18.4	**19.6
WEIGHT	1	**197.5	**16.7	**25.5	**42.5
FTxM[1,2]	4	**21.8	*6.4	**10.5	*3.9
FTxW[1,3]	2	**8.0	*5.9	**22.1	*7.0
MxW	2	NS0.6	**13.1	**13.5	**10.4
MxFTxW	4	**39.5	**14.3	**16.0	**11.8
SETS	8	**28.3	**9.50	**10.0	**19.3
MSE	1336	1.28	1.96	1.76	1.50

Palatability Attributes

Source	df	Flavor MS	Juiciness MS	Tenderness MS	Overall Quality MS
FINAL T.	2	NS0.2	**120.7	NS1.8	**7.8
METHOD	2	**29.2	**17.7	**64.3	**24.0
WEIGHT	1	NS0.1	**24.3	NS0.3	NS1.2
FTxM	4	NS3.8	**12.5	NS3.0	*3.5
FTxW	2	*8.5	*5.4	NS0.4	NS3.3
MxW	2	NS0.5	NS0.3	NS0.9	NS0.02
MxFTxW	4	NS2.6	**8.8	NS3.4	NS2.5
SET	8	NS3.9	*9.6	NS2.6	**4.1
MSE	1336	1.86	1.51	1.44	1.37

[1]-Weight of birds (4.5 or 9.1 kg.)
[2]-Final temperature of the breast (71,76, or 82°C).
[3]-Method 1-93°C oven, foil tent, frozen bird
2-163°C oven, foil tent, thawed bird
3-232°C oven, foil wrap, frozen bird
*=Significant at 5% level
**=Significant at 1% level
NS=Not Significant

Table 2: Summary of Means of Sensory Attributes of Roasted Turkeys by Final Temperature, Method, and Weight (Part I).

	Appearance Attributes			
	Browning	Uniformity	Outside Appearance	Inside Appearance
Method				
163°C(thawed)	3.35c[2]	3.70b	3.59b	4.24a
93°C (frozen)	4.34b	4.06a	3.90a	4.28a
232°C(frozen)	4.70a	3.53b	3.52b	3.90b
LSD=	.16**	.18**	.17**	.16**
Final Temperature				
71°C	3.79c	3.71b	3.52b	4.18a
76°C	3.94b	3.90a	3.85a	4.28a
82°C	4.66a	3.69b	3.63b	3.95b
[1]LSD=	.19**	.19**	.18**	.17**
Weight				
4.5 kg.	3.75b	3.65b	3.53b	3.96b
9.1 kg.	4.51a	3.87a	3.80a	4.31a
LSD=	.13**	.15**	.14**	.13**

	Palatability Attributes			
	Flavor	Juiciness	Tenderness	Overall Quality
Method				
163°C(thawed)	4.48a	4.16a	4.70	4.49a
93°C (frozen)	4.46a	3.88b	5.04a	4.42a
232°C(frozen)	4.04b	3.76b	4.29c	4.06b
LSD=	.18**	.16**	.16**	.15**
Final Temperature				
71°C	4.32	4.36a	4.74	4.44a
76°C	4.33	4.09b	4.62	4.34a
81°C	4.35	3.36c	4.67	4.18b
[1]LSD=	NS	.17**	NS	.16**
Weight				
4.5 kg.	4.32	4.07a	4.66	4.35
9.1 kg.	4.34	3.80b	4.69	4.29
LSD=	NS	.13**	NS	NS

* differences among means exceeding this value are significant at p=.05.

** differences among means exceeding this value are significant at p=.01.

NS no significant difference

[1]LSD was computed with unequal number of observations, but since the computed values were similar the higher LSD is listed.

[2]means with in the same group with the same letter are not significantly different.

Table 1 shows that all three main effects were significantly different for appearance attributes. The interaction of final temperature and weight for browning and uniformity of browning was not significant. All other interactions for appearance attributes were significant. Both main effects and interactions were signifiant for juiciness with the exception of the interaction of method and weight (Table 1). The remainder of palatability attributes were usually not significantly different. Goetz et al. (1960) also found that flavor and tenderness scores were not significantly different as affected by end-point temperature.

Table 2 shows the means and LSD values of sensory attributes as summarized for main effects of method, final temperature and weight. The birds roasted to an end-point temperature of 71°C were rated significantly higher for juiciness and overall quality (Table 2, Fig. 2) than birds roasted to the higher temperatures. The birds roasted to 76°C had the highest rating for unifromity of browning and general outside and inside appearance (Table 2, Fig. 1). As expected the birds roasted to the highest internal temperature (82°C) were rated highest for degree of browning (Table 2, Fig. 1). Flavor and tenderness scores were not significantly affected by temperature. In summary birds roasted to an internal temperature of 76°C were rated highest in all appearance attributes except degree of browning (Fig. 1).

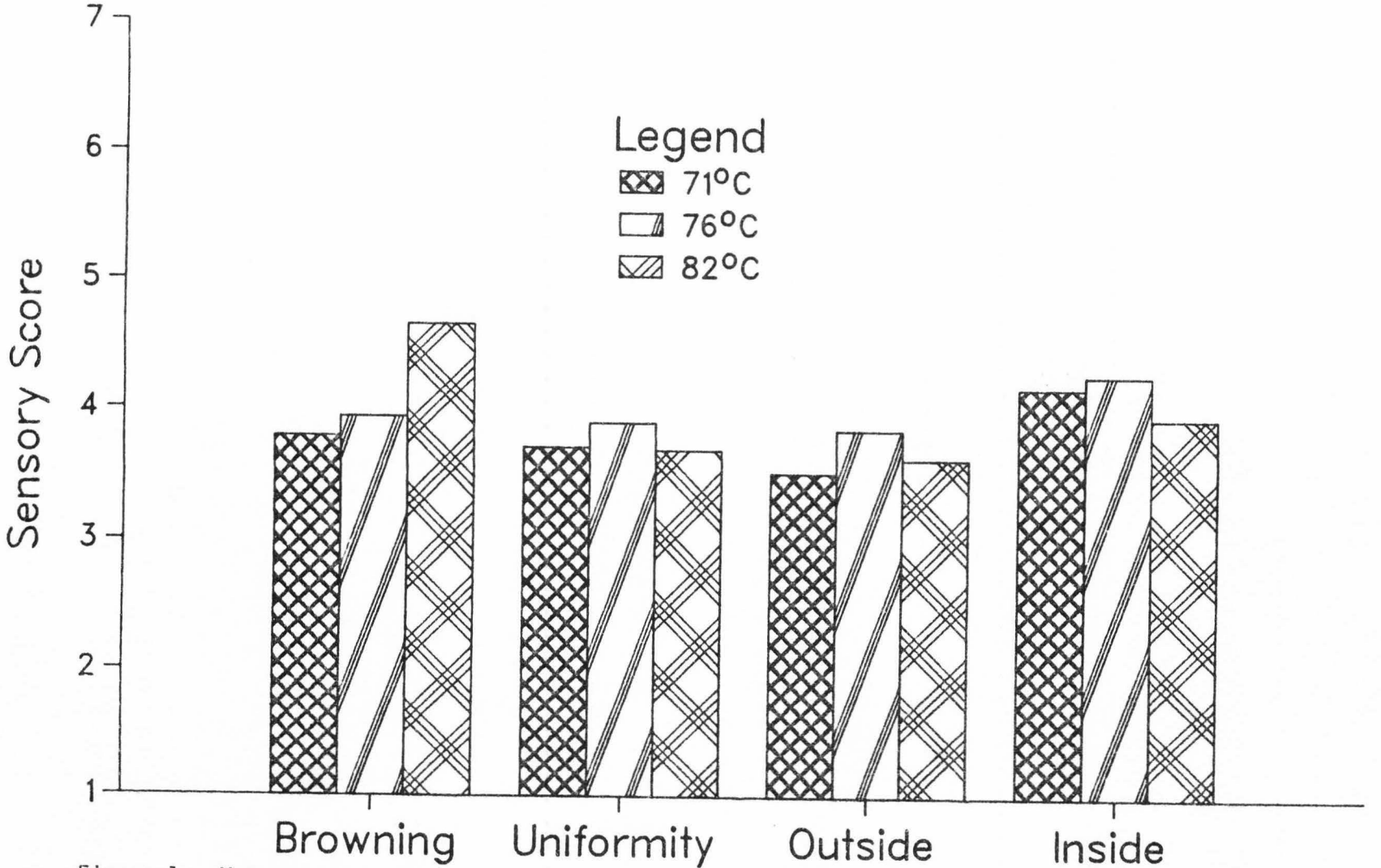

Figure 1: Mean appearance scores of roasted turkeys as affected by final temperature (Part I).

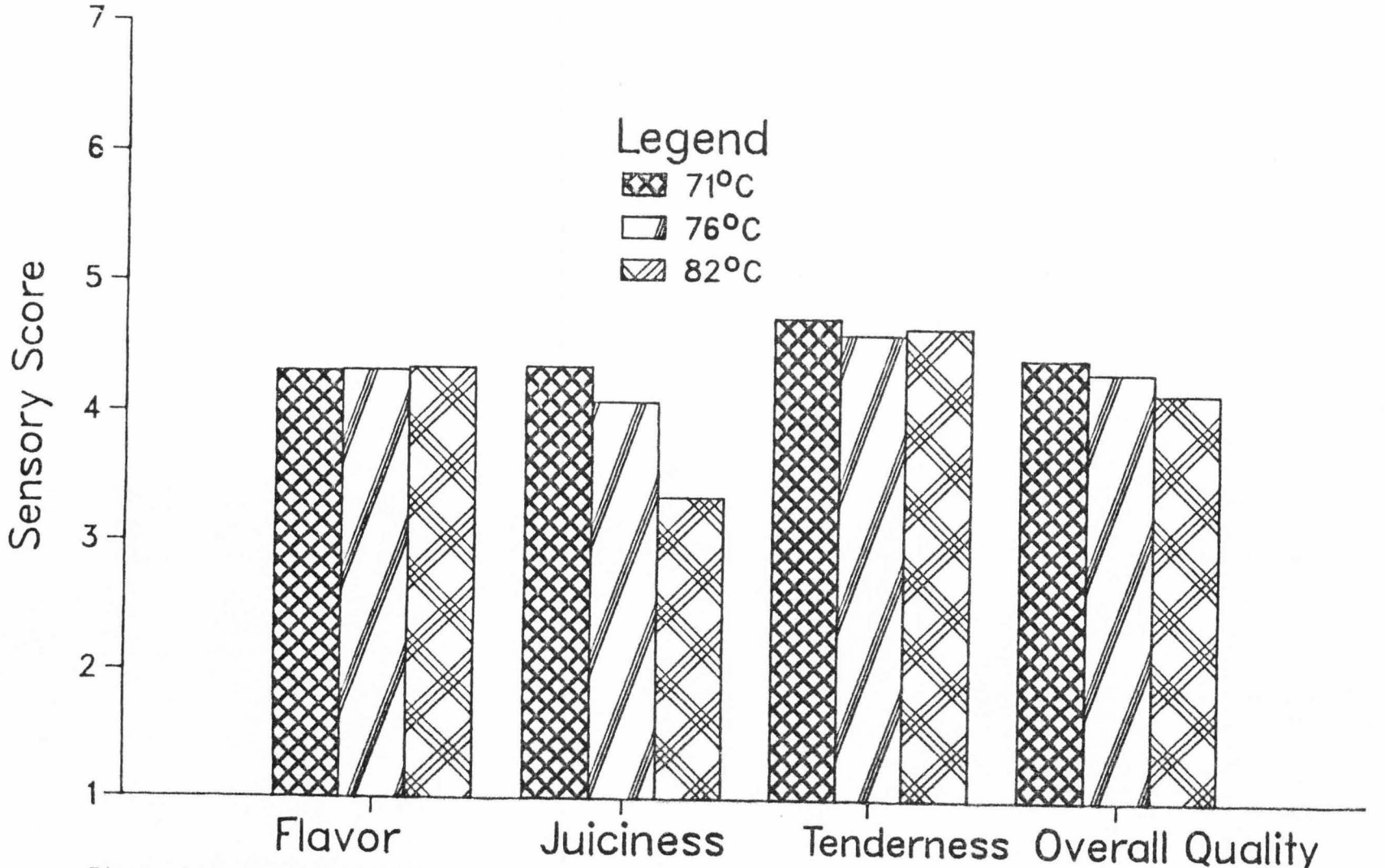

Figure 2: Mean palatability scores of roasted turkeys as affected by final temperature (Part I).

Both oven temperature and final weight affected sensory ratings of the roasted turkeys. Foil wrapped birds roasted in a 232°C oven were typically more browner, less uniform in color, and received lower outside and inside appearance scores, especially at the higher end-point temperatures. Among palatability attributes, only juiciness was significantly affected by end-point temperature. (Fig. 2). Frozen birds roasted in a 93°C oven were light and uniform in color, and higher in juiciness especially at the lower end-point temperatures. Usually heavier birds received higher scores for both outside and inside appearance. Heavier birds were in the oven longer, which increased browning and thus accounted for these higher ratings.

Summary of roasting time per pound as affected by final internal temperature is shown in Figure 3. For the lower oven temperature (93°C) the roasting time per pound increased directly with final internal temperature. For the higher oven temperatures (163 and 232°C), roasting time per pound was independent of final internal temperature. The birds roasted in a hotter oven required about 10.9 min. per kg. to reach the desired internal temperature regardless of the weight of the bird. However, birds roasted in a 93°C oven required roasting times as long as 42 hours for a 9.1 kilogram bird.

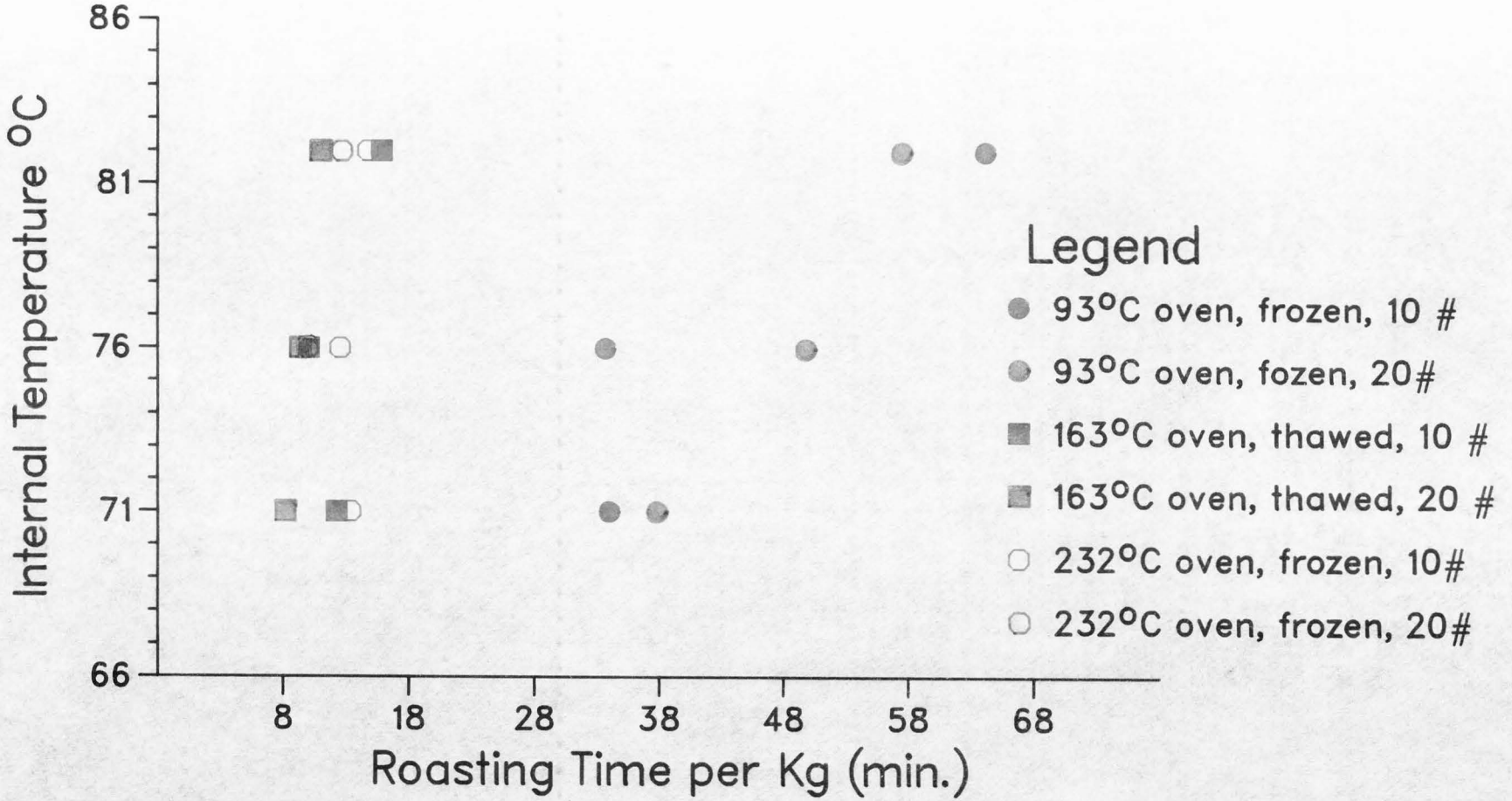

Figure 3: Roasting time /kg (min.) as affected by final oven temperature (Part I).

In conclusion, the 76°C end-point temperature was selected as the "best" temperature for several reasons. The birds roasted to an internal temperature of 71°C were found to be the most juicy and tender followed by the birds roasted to 76°C. The birds roasted to an internal temperature of 82°C were least juicy and tender. The birds roasted to 71°C however, were often red or bloody-appearing around the thigh joint. The birds roasted to 76°C received highest general appearance scores. A final internal temperature of 76°C was therefore used for all the turkeys roasted in Parts II and III.

Part II: Determination of Optimum Low Oven Temperature (93, 107, 121, 135°C) for Roasting Frozen Turkeys.

A summary of means and LSD values of sensory attributes of roasted turkeys is presented in Table 3. Uniformity of browning, flavor and overall quality did not vary significantly as a function of oven temperature (93, 107, 121, or 135°C) (Table 3). However, for tenderness, juiciness and inside appearance (Fig. 4), significant differences were observed, with the birds roasted in a 121°C oven consistently receiving high scores. The birds roasted in a 121°C oven did not receive high scores for outside appearance and they did not brown to the degree observed for the birds roasted by the other methods (Figure 5).

Table 3: Summary of Means and LSD Values of Sensory Attributes of Roasted Turkeys by Oven Temperature and Covering (Part II).

Variable	Browning	Uniformity	Outside Appearance	Inside Appearance
	Appearance Attributes			
Oven Temp.				
93°C	3.58c[2]	4.07	3.38c	4.11b
107°C	3.81b	3.84	3.67ab	4.35b
121°C	3.03d	3.84	3.61bc	4.72a
135°C	4.35a	3.92	3.97a	4.31b
LSD=[1]	.33**	NS	.31**	.28**
Covering				
Foil tent	4.55a	4.08a	4.07a	4.43
Roasting Bag	2.84b	3.78b	3.25b	4.32
LSD=	.20**	.21**	.21**	NS

Variable	Flavor	Juiciness	Tenderness	Overall Quality
	Palatability Attributes			
Oven Temp.				
93°C	4.45	3.82b	4.79a	4.40
107°C	4.37	4.17a	4.62a	4.36
121°C	4.40	4.28a	4.80a	4.46
135°C	4.33	4.09ab	4.35b	4.22
LSD=[1]	NS	.30**	.26**	NS
Covering				
Foil Tent	4.52a	4.41a	4.74a	4.54a
Roasting Bag	4.25b	3.78b	4.53b	4.17b
LSD=	.25**	.21**	.15*	.19**

* differences among means exceeding this value are significant at p=.05.

** differences among means exceeding this value are significant at p=.01.

NS no significant difference

[1] difference was computed with unequal number of observations, but since the values were similar the higher LSD is listed.

[2] means with in a group with the same letter are not significantly different.

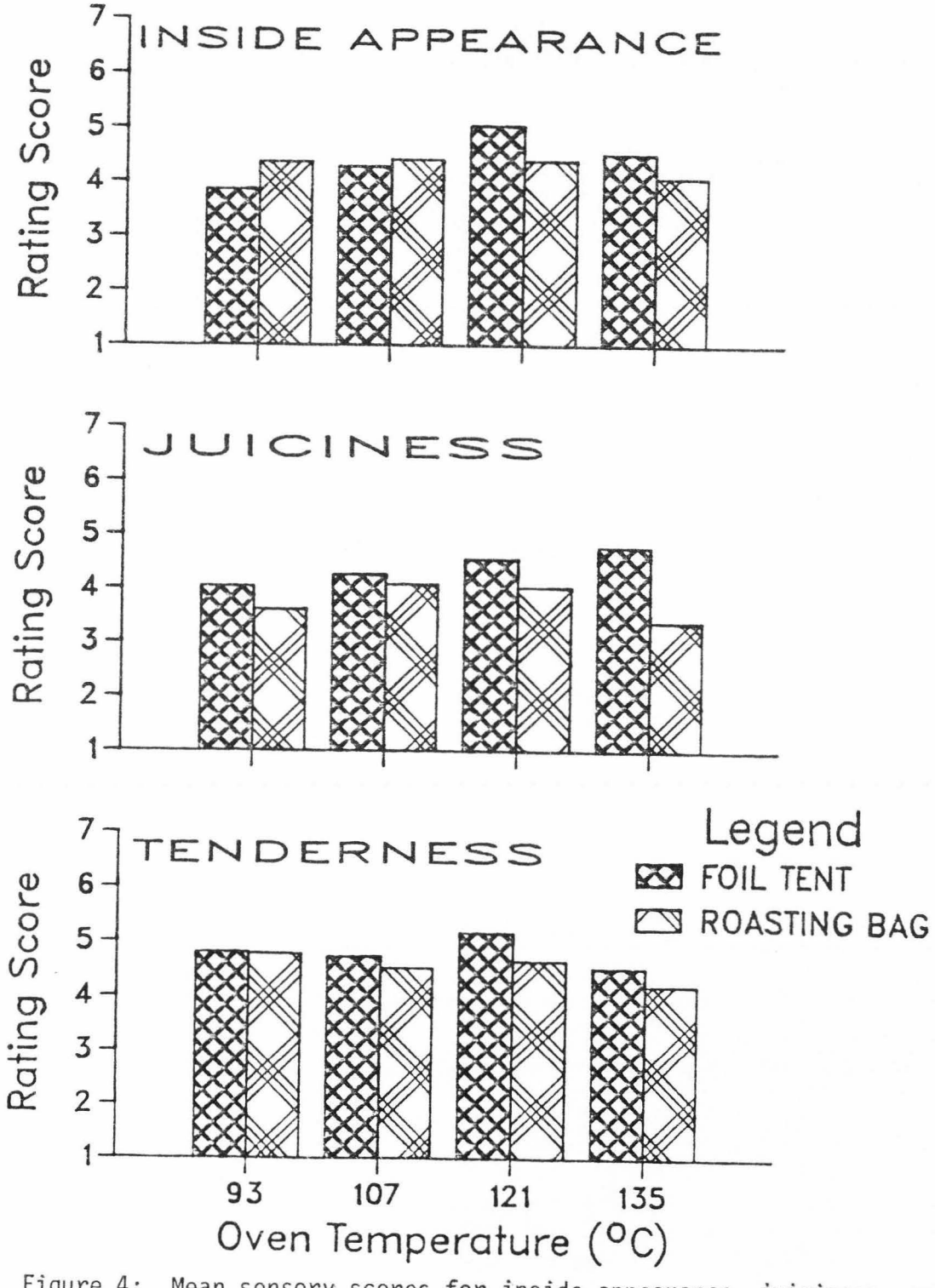

Figure 4: Mean sensory scores for inside appearance, juiciness, and tenderness of roasted turkeys as affected by oven temperature (Part II).

The birds roasted at the lower temperatures of 93 and 107°C required an increased oven temperature at the end of roasting (204°C for 30 minutes) in order to brown. This was not necessary for birds roasted at the higher temperature ovens. As a result of the browning treatment given birds roasted in the low temperature ovens those birds actually received higher scores than birds roasted in the higher oven temperatures.

The turkeys covered with a foil tent received significantly higher sensory scores for all attributes except inside appearance, when compared to birds roasted in a bag (Table 3). Roasting bags were therefore not used for low temperature roasting of birds in part III.

Summary of roasting time per pound for Part II is presented in Figure 6. As the oven temperature increased, roasting time per pound decreased. Mean roasting time per pound was 42 +/- 5 % lower for birds covered with a roasting bag, rather than a foil tent.

The 121°C oven was chosen as the preferred low oven temperature, because birds roasted at this temperature were rated higher in more sensory attributes than birds roasted in any of the other three low temperature ovens. In conclusion a 121°C oven with a foil tent was chosen as the optimum low oven temperature roasting method. This method was then included in further studies in Parts III and IV.

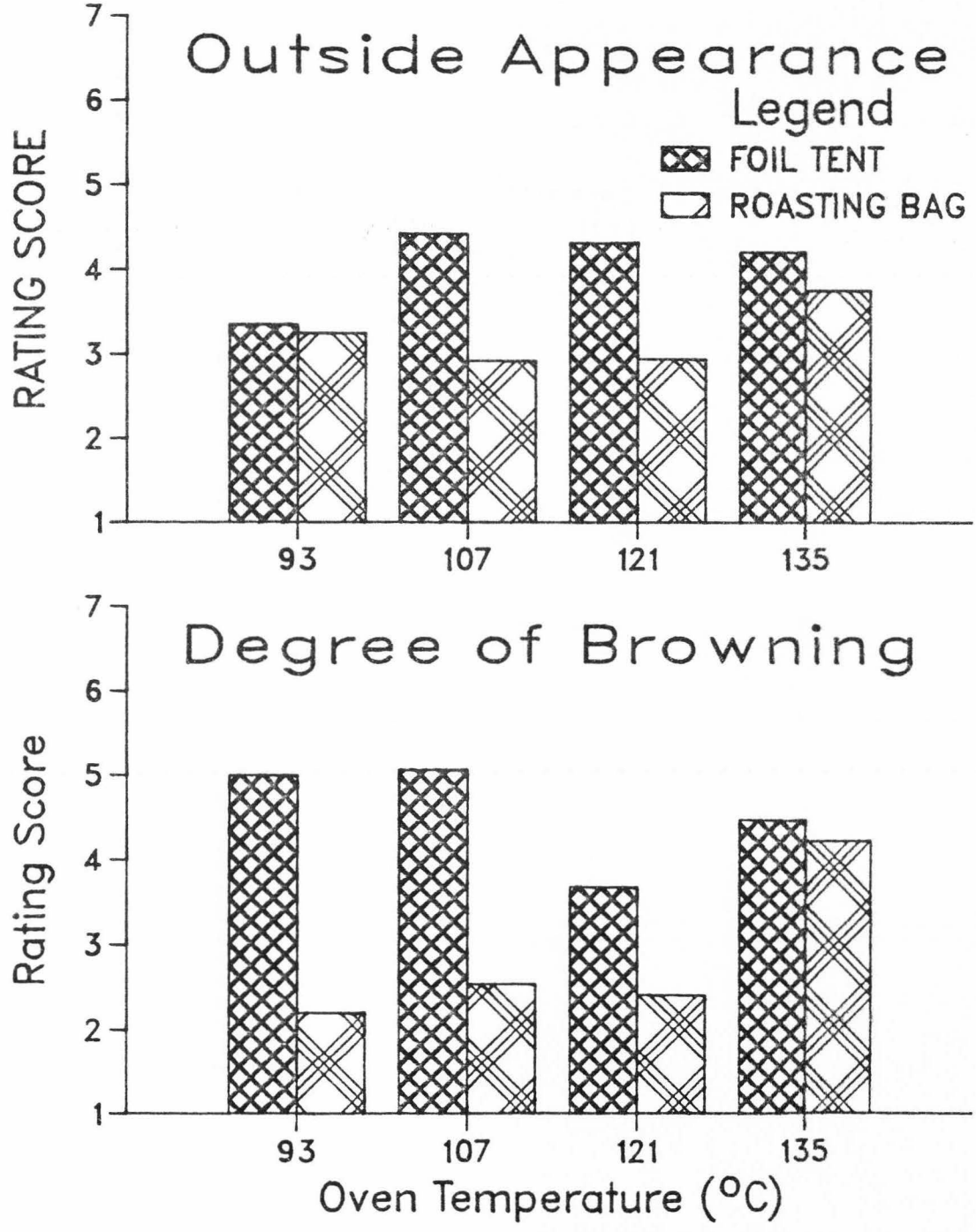

Figure 5: Mean sensory scores for degree of browning and outside appearance of roasted turkeys as affected by oven temperature (Part II).

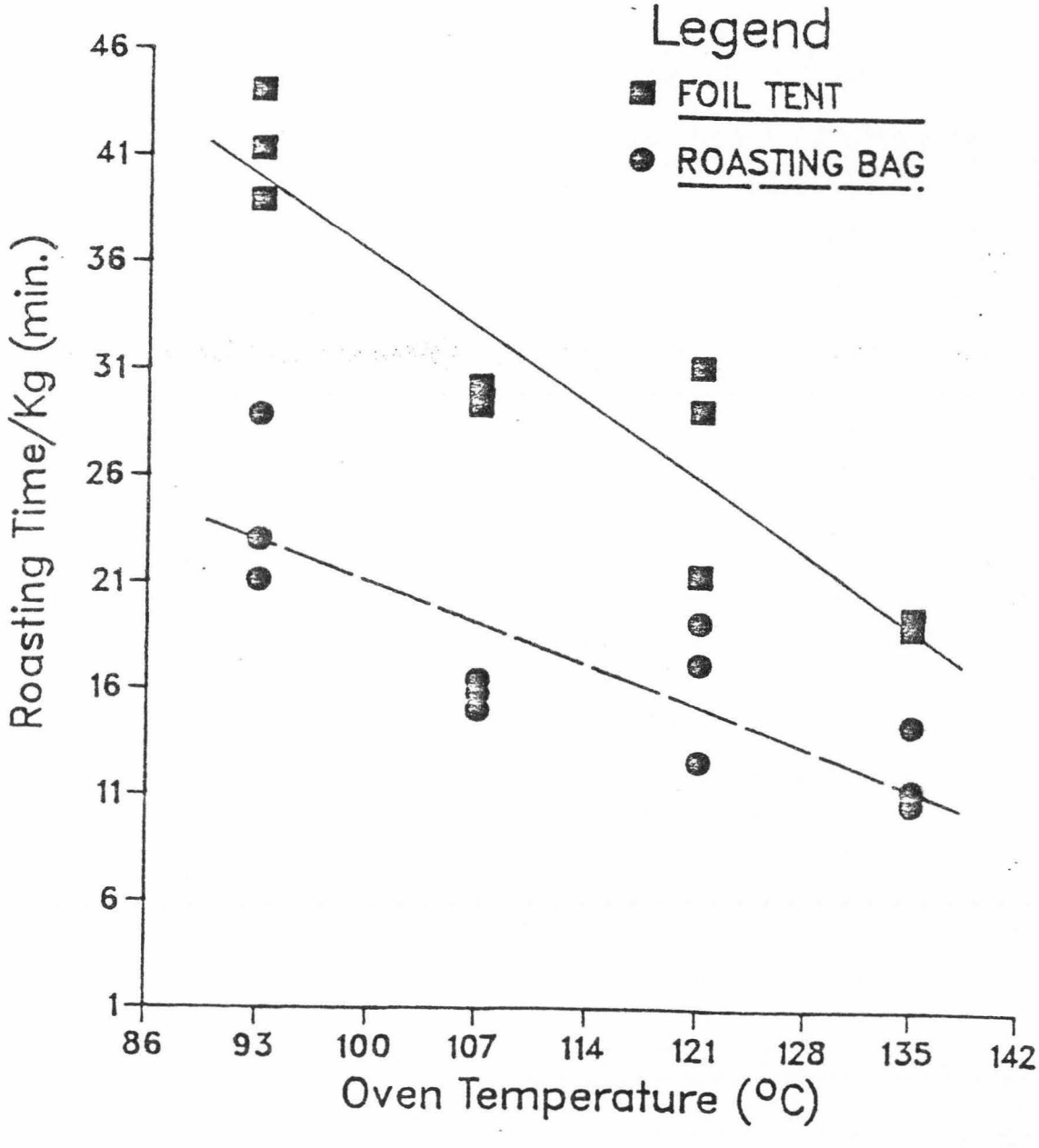

Figure 6: Roasting time/kg (min.) as affected by oven temperature (Part II).

Part IIIA: Determination of Best Method for Roasting a Turkey from the Frozen State.

The four methods compared in this trial were:

1) 121°C oven with a foil tent covering (the low oven temperature method, as determined in Part 2).
2) 163°C oven with a foil tent.
3) 163°C oven with a roasting bag (roasting bag method).
4) 232°C oven with a foil wrap (high temperature method).

All birds were roasted to an internal temperaure of 76°C as determined in Part I.

The turkeys prepared in a low temperature oven were rated highest for the following attributes: 1) flavor of light meat; 2) juiciness of dark meat; 3) tenderness of both light and dark meat; 4) overall quality of both light and dark meat (Table 4). Birds roasted in the high temperature oven were rated significantly higher for degree of browning (Table 4). Birds roasted in the 163°C oven with a foil tent were rated significantly higher for outside appearance, and highest for juiciness of the light meat (Table 4). Flavor of the dark meat was not significantly affected by roasting method (Table 4).

Table 4: Summary of Means of Sensory Attributes of Roasted Turkeys as Affected by Roasting Method (Part IIIA).

Appearance Attributes

Method	Browning	Uniformity	Outside Appearance	Inside Appearance
Low Oven	3.67d[2]	4.00a	3.88b	4.20a
163°C oven	3.92c	3.99a	4.07a	4.36a
Roasting bag	4.33b	3.68b	3.61c	3.96b
High Oven	5.52a	4.07a	3.82b	3.99b
LSD=	.18**	.21**	.20**	.19**
Weight (kg.)				
3.6-5.5	3.73c	3.71b	3.54b	4.12ab
5.51-7.3	4.19b	4.05a	3.73b	4.23a
7.31-9.1	4.74a	4.05a	4.06a	4.25a
9.11-10.9	4.84a	3.94a	4.06a	3.88b
LSD=	.20**	.21**	.20**	.19**

Palatability Attributes

Method	Flavor D/L	Juiciness D/L	Tenderness D/L	Overall Quality D/L[1]
Low Oven	4.77 /4.44a[3]	4.52a/3.58b	4.86a/4.75a	4.64a/4.38a
163°C oven	4.56 /4.34ab	4.37a/3.97a	4.42b/4.61a	4.31b/4.26a
Roasting bag	4.56 /4.28ab	4.40a/3.79a	4.46b/4.37b	4.35b/4.13b
High Oven	4.60 /4.13b	4.20b/3.55b	4.36b/4.17b	4.30b/3.97b
LSD[2]=	NS / .18*	.17**/.20**	.20**/.19**	.19**/.19**
Weight (kg.)				
3.6-5.5	4.47b/4.36	4.43 /4.07a	4.25b/4.40b	4.30b/4.25
5.51-7.3	4.50b/4.26	4.25 /3.79b	4.29b/4.43b	4.11b/4.19
7.31-9.1	4.79a/4.27	4.40 /3.56bc	4.77a/4.65a	4.53a/4.19
9.11-10.9	4.75a/4.29	4.41 /3.45c	4.82a/4.43b	4.60a/4.10
LSD[2]=	.10**/ NS	NS /.10**	.10**/.16**	.19**/ NS

[1] D/L Dark meat mean/Light meat mean

[2] LSD was computed with unequal number of observations, but since the values were similar the higher LSD is listed.

[3] means within a group with the same letter are not significantly different.

NS no significant difference.

When the sensory data was analyzed by weight, the heavier (7.3-10.0 kg.) turkeys were found to be significantly superior in six attributes: degree of browning, flavor of the dark meat, tenderness of the light and dark meat, and overall quality of the dark meat (Table 4). The lighter birds (3.6-7.2 kg.) were rated significantly higher in one attribute, juiciness of the light meat (Table 4). Flavor of the light meat, juiciness of the dark meat and overall quality of light meat were not significantly affected by weight (Table 4). Some significant interactions between weight and roasting method were observed. For instance degree of browning was highest for heavier birds and hotter ovens (Figure 7). Birds roasted in a 163°C oven with a foil tent received higher outside appearance scores as the weight of the bird (Figure 8). Birds roasted by this method also received higher scores for juiciness and overall quality of the light meat (Figure 9 and 10 respectively), although the differences were not large. All other interactions were not significant.

The effect of roasting method on roasting time is presented in Figure 11. As expected, increased oven temperature varied inversely with roasted time. However, birds roasted in a bag had the shortest roasting times, even though the oven was not the highest temperature used in this study. For all methods, heavier birds required less roasting time per pound than did lighter birds.

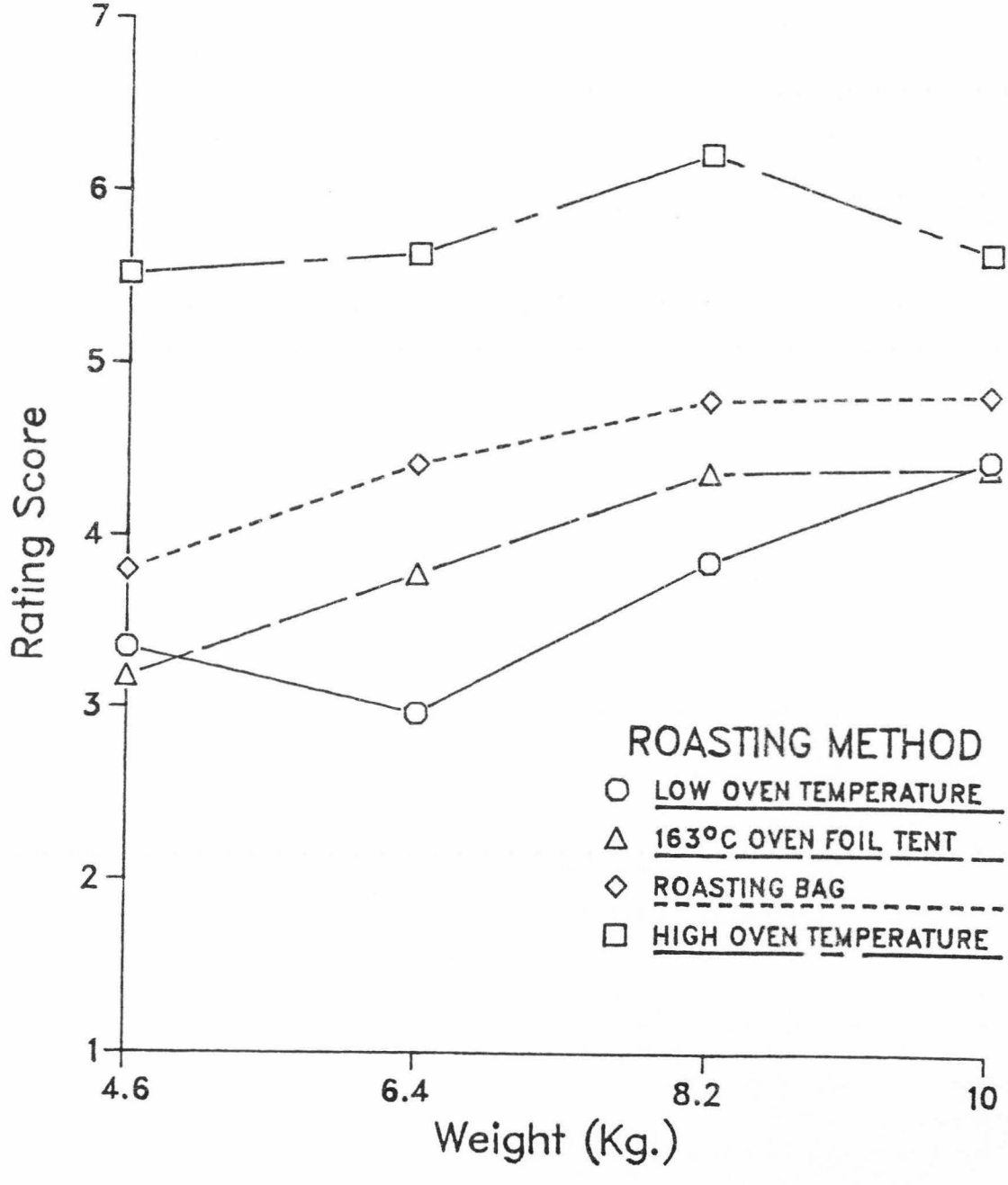

Figure 7; Mean sensory scores for degree of browning as affected by roasting method (Part IIIA).

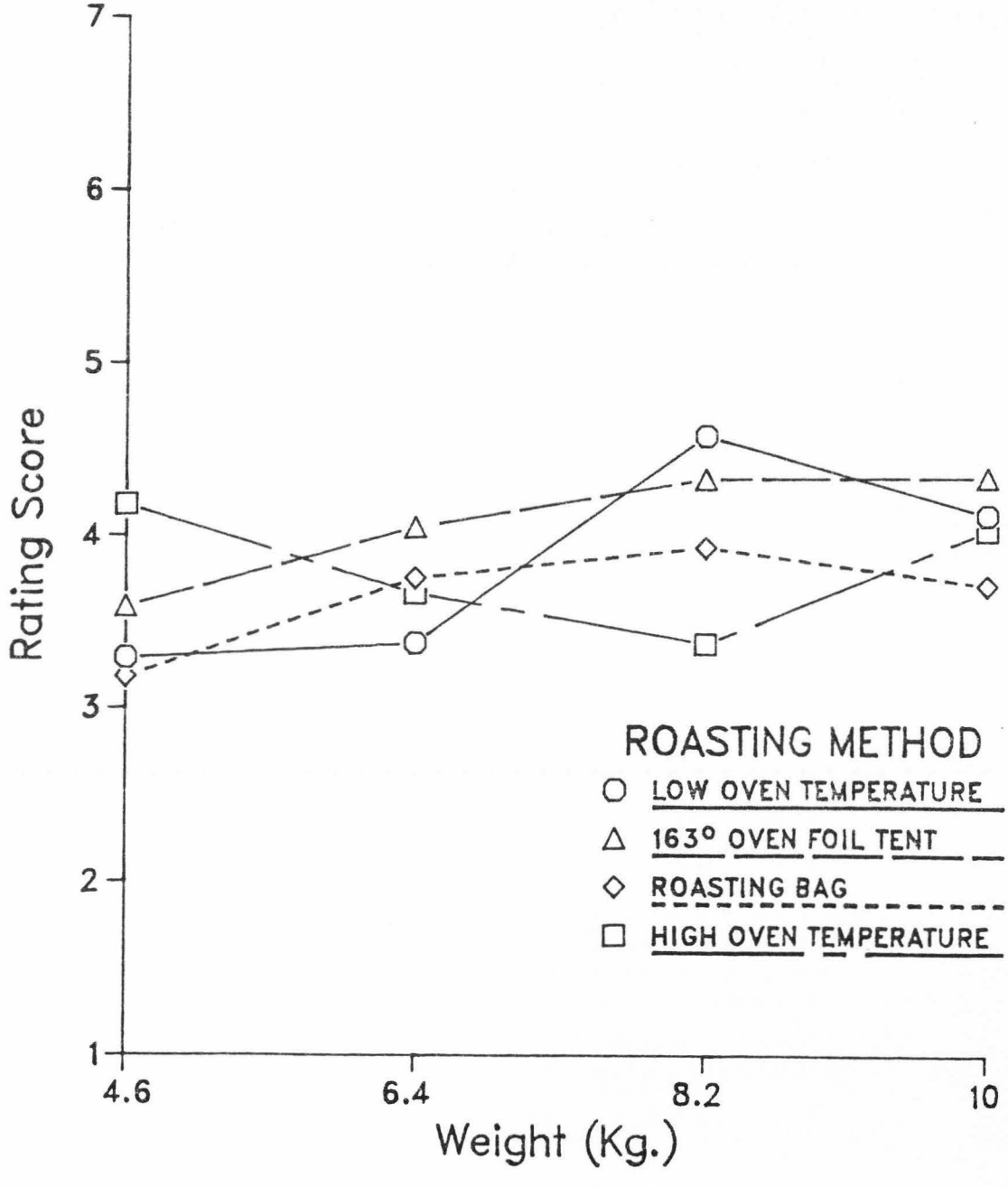

Figure 8: Mean sensory scores for outside appearance as affected by roasting method (Part IIIA).

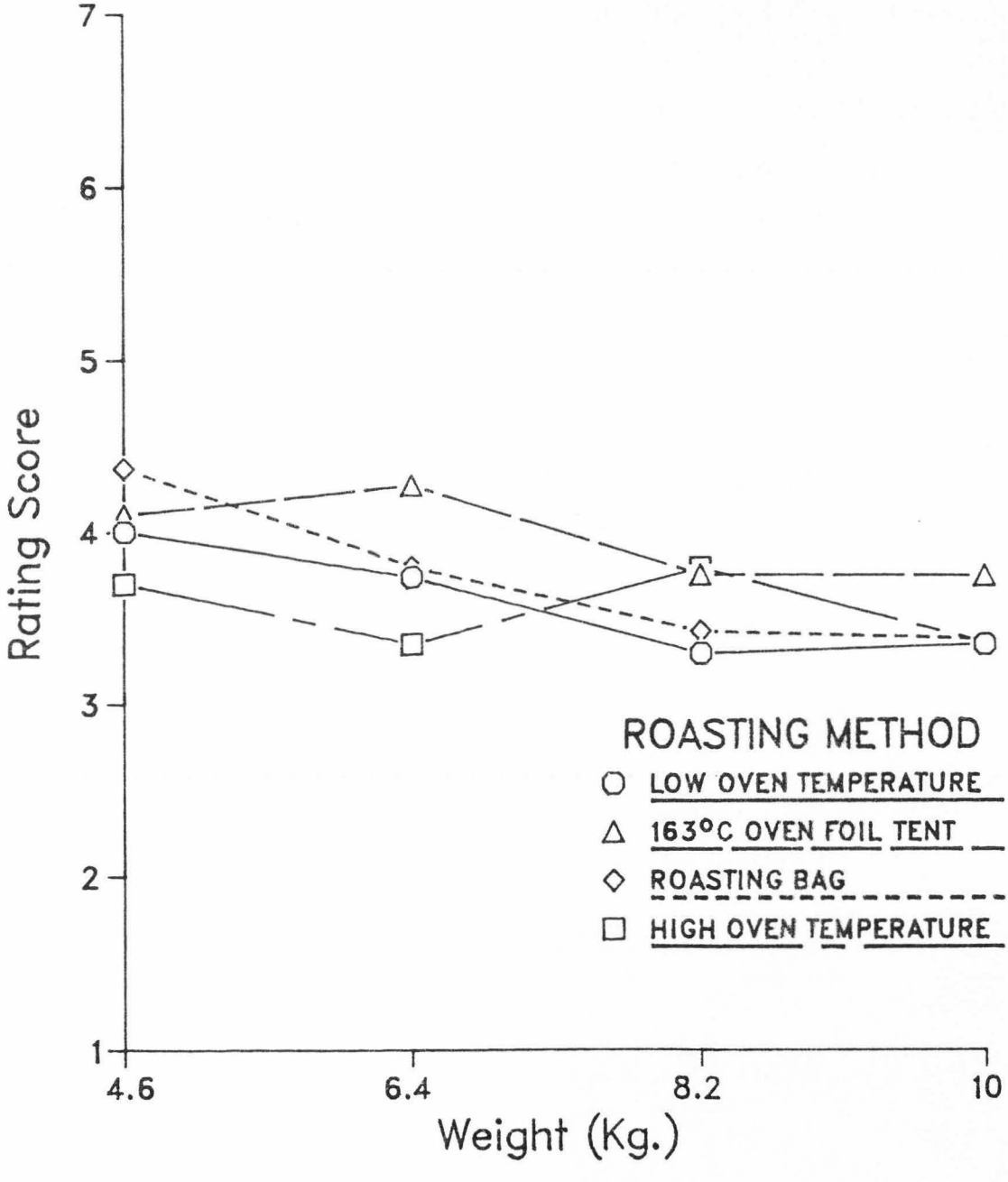

Figure 9: Mean sensory scores for juiciness of the light meat as affected by roasted method (Part IIIA).

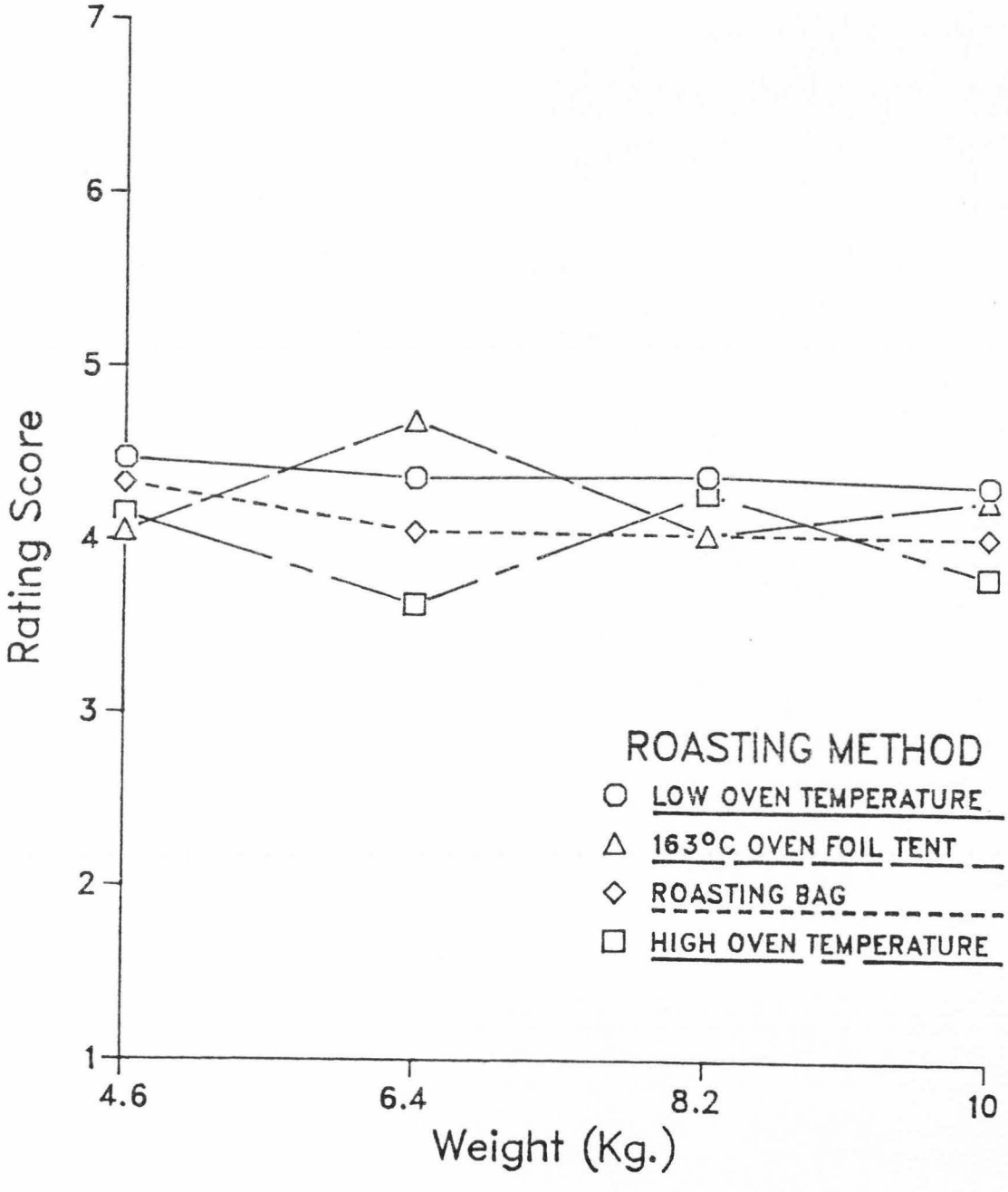

Figure 10: Mean sensory scores for overall of light meat as affected by roasting method (Part IIIA).

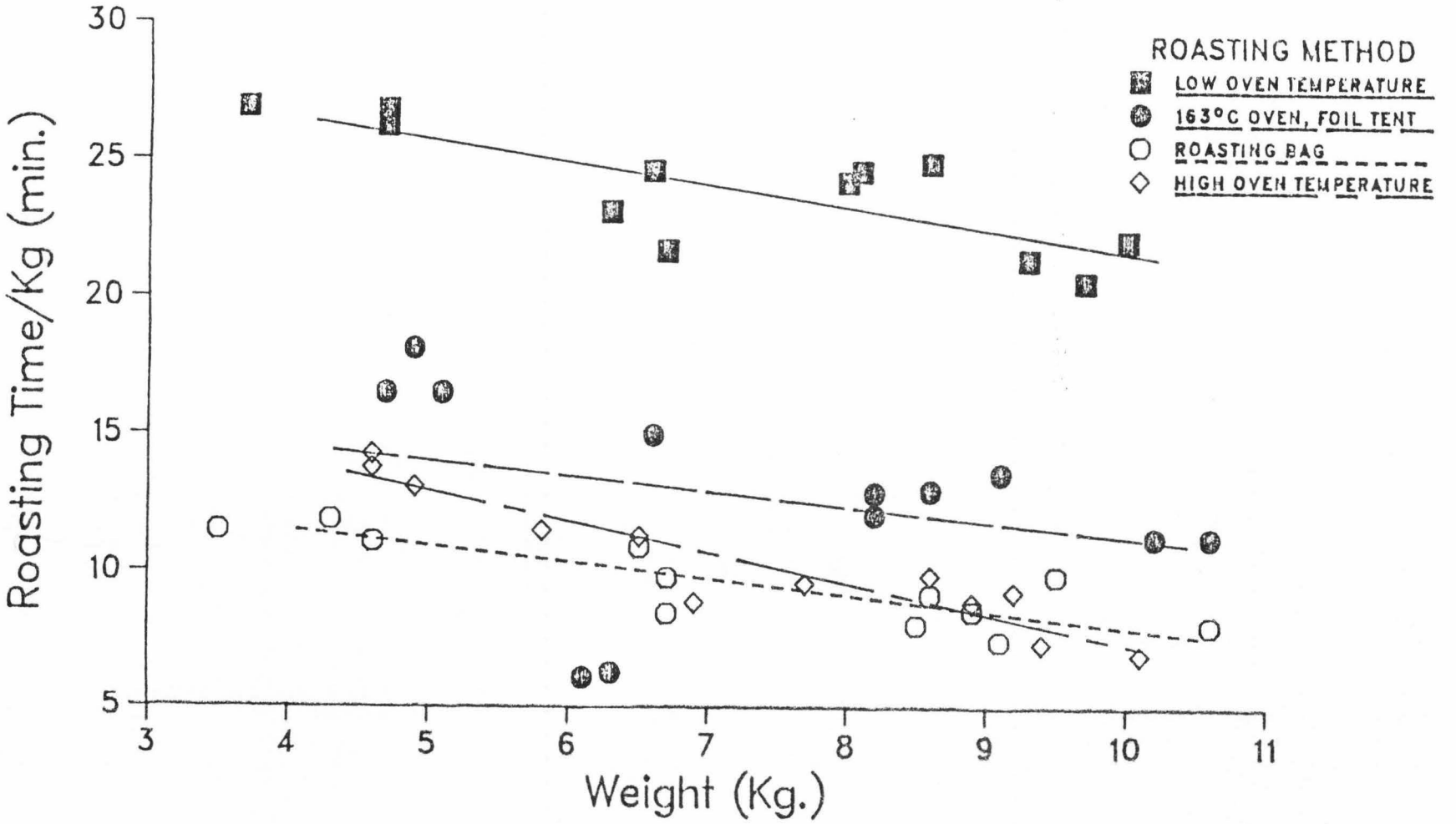

Figure 11: Summary of roasting time/kg (min.) as affected by roasted method (Part IIIA).

In conclusion, all methods were simple to use, and each method had its strong points. Birds roasted in the low temperature ovens (121°C) received higher sensory scores on most of the palatability characteristics, but did not brown well, especially for the lighter birds. Increasing the oven temperature for a short time at the end of roasting (232°C for 15 min.) alleviated this problem. The low oven temperature roasting method has the disadvantage of occupying the oven for a long time, making it unavailable to cook other foods. This method lends itself especially well to large turkeys which can be put on to roast the night before they are to be served.

Birds roasted in the 163°C oven covered with a foil tent were rated high on outside and inside appearance and juiciness of the light meat (Table 4). This method is very similar to the standard method of roasting thawed turkeys.

Surprisingly, roasting a frozen turkey at 163°C in a roasting bag resulted in higher browning scores than birds roasted at the same temperature with a foil tent, even though the foil was removed at the end of the roasting period. Turkeys cooked in a roasting bag were less uniform in color but required less roasting time. The high temperature roasting method resulted in a browner, more uniformly colored bird, but received lower palatability scores. This method did have short roasting time per pound, especially for the heavier birds.

In general none of the sensory scores were especially high. The highest mean appearance score was a 5.52 for degree of browning (for birds roasted in a high temperature oven), which corresponds to optimum browning on the seven point hedonic scale. However, the highest palatability score was 4.86 for tenderness of the dark meat of birds roasted in a low temperature oven, which corresponds to "moderately tender" on the scale.

Part IIIB: Panelist Evaluation of the Roasting Methods.

Each panelist completed a questionnaire (Appendix A) in which they were asked to rank the four roasting methods used in Part IIIa. The order of preference of roasting methods was as follows: 1) 163°C oven with a foil tent covering; 2) roasting bag method; 3) low oven temperature method; and 4) high oven temperature (Table 5).

Table 5: Distribution of Ranking of Roasting Methods (Part IIIb).

Roasting Method	Order of Choice 1st	2nd	3rd	4th
Low Oven	5*	5	11	7
163°C, foil tent[1]	13	6	5	4
Roasting bag	7	7	9	5
High Oven[2]	3	10	3	12

*For example, five judges out of 28 ranked the 163°C, foil tent roasting method first.
[1]Significantly superior method p=.05 (Kahan et al. 1973)
[2]Significantly inferior method p=.05 (Kahan et al. 1973)

The majority of the panelists based their choice on palatability factors such as tenderness, juiciness and flavor. Two of the panelists commented that they were especially interested in outside appearance and browning, while two other panelists commented that outside characteristics were not as important to them as was palatability. Comments on sensory attributes were frequently tied to other characteristics, i.e. "It is almost as juicy and took less time."

Next to specific sensory characteristics, the most commonly mentioned item was the time factor. Those that mentioned time chose the roasting bag method as first choice and, in most cases, the high temperature oven method was the second choice.

Others expressed a strong desire to continue cooking the turkey in their usual manner. For example: "I would use method III (163^{o}C oven with a foil tent covering) since that is the way I do it now." Another common comment was that they would want the bird stuffed. As was expected, there were differences of opinion. Two people wanted to cook the turkey until it was "really done", however, they did not agree on the best method of doing this. One person felt that high temperature cooking wastes energy while another worried about the electric bill with the low oven temperature method. Roasting bags were considered both more and less clean. Convenience was given as the reason for choosing the low oven temperature method, ("I like to put it in the oven late the night before so I can sleep and enjoy the holiday myself"), for the roasting bag ("convenience") and for

the high oven temperature method ("The roasting time would fit my schedule").

Part IIIC: Home Evaluation of the Four Roasting Methods used in Part IIIA.

Each panelists was asked to take home a turkey and roast it using his/her first or second choice of method from Part IIIB. Statistically, there was no significant difference among sensory attributes based on roasting method, in part due to the low number of observations of each variable.

When the home panel results (Part IIIc) were compared with the in house results (Part IIIa) for each panelist, it was found that the panelists significantly preferred the home-roasted bird to the those roasted by the same method in the lab. Out of 24 panelists, 18 rated the bird roasted in their own home higher than their average score for the same method in the lab (Part IIIa).

Panelist comments are summarized in Table 6. All methods were thought to be convenient and easy to prepare. The panelists liked the fact that the turkey did not take up refrigerator space prior to cooking. The major complaints about roasting frozen birds were that the birds could not be stuffed, and the giblets could not be removed prior to roasting.

Table 6: Summary of Panelist Comments on Sensory and Convenient Attributes of Birds Roasted at Home by One of Four Methods.

General Impressions of the Roasting Method[1]
(Envelope 1)

Low Oven Method

couldn't get at giblets-2*
can't stuff it-1
method was easy-4
not brown enough-2
skin nicely brown-1
thigh were a magenta color-1
red thigh joint-1
white meat was good-1
dark was bad-1
made home too hot-2
generally like-1

163°C Oven, Foil Tent

couldn't get at giblets-3
can't stuff-3
convenient-2
not brown enough-1
nonuniform browning-1
bloody thighs-1
skin was leather-like-1
roasting took too long-1
decreased amount of dripping-1
frozen-1

Roasting Bag Method

couldn't get at giblets-2
can't stuff-2
convenient-1
brown skin-1
nonuniform browning-1
juicy-1
meat done-1
good meat-1
dry meat-1

High Oven Method

couldn't get at giblets-2
can't stuff-2
convenient-4
brown enough-2
done meat-1
dry meat-2
tough meat-1
good tasting-5
lacks flavor-1
looks good-1
can't cook other things

*i.e., 2 of 7 panelists made this comment.
[1]each method was evaluated by 7 panelists.

Table 6 (continued): Specific Problems with Roasting Methods
(Envelope 2)

Low Oven Method

couldn't get at giblets-1*
couldn't stuff-1
red thighs-2
not brown enough-2
thigh was done-1
roasting took too long-4
easy to carve-1
no problems-6

163°C oven, foil tent

couldn't get at giblets-2
not brown enough-1
rubbery meat-2
too juicy-1
generally good-1
decreased amount of drippings-1
not easy to carve-2
looked raw-1
no problems-7

Roasting bag Method

couldn't get at giblets-2
meat stuck to bag-4
nonuniform browning-1
good meat-2
underdone meat-1
no problems-4

High Oven Method

can't stuff-1
aluminum foil stuck to meat-2
pink thighs-1
bad appearance-1
tough meat-2
dry meat-2
good meat-2
hard to slice-1

*ie, 1 of 7 panelists made this comment

Panelists commented that the low oven temperature method took too long, had "uncooked" thigh joints, and produced turkeys with insufficient browning. Panelists did think that this method produced a very juicy, easy to carve, tender turkey.

Panelists commented that roasting in a 163°C oven with a foil tent covering lacked browning and was not uniform. One person said that the thigh meat was bloody and uncooked. Most of the panelists using this method said the meat was tender and good.

The major complaint for the roasting bag method was that the skin stuck to the bag. Some panelists commented that turkeys roasted in a bag were non-uniform in color and too light. Yet one panelist commented that this method produced birds with juicy meat and an abundant amount of drippings for gravy.

The birds roasted by the high oven temperature method browned well. Some thought the meat was dry and tough, but the majority of the panelists thought the meat had good flavor. Also, with this method, the panelists complained of the skin being stuck to the foil.

When panelists were asked if they would roast another turkey using method assigned to them 15 replied "No" and 13 replied "Yes".

Part IV: Microbial Assays

The inoculation fluid contained high levels of both pathogens (Table 7). Significant numbers of pathogens adhered to all sample sites, with the giblets and neck retaining relatively more pathogens after inoculation than the skin (Table 7). Freezer storage of the birds for 72 hours had little effect upon the microbial load of the skin (Table 8). All microbial counts were of the same order of magnitude before and after freezing (Tables 7 and 8).

Table 7: Aerobic Plate Count, Salmonella typhimurium, and Clostridium perfringens Numbers on Turkey Parts After Inoculation (Part IV).

	Aerobic Plate Count	S. typhimurium	C. perfringens count	
Spore			Vegetative	
Inoculation Fluid[1]	5×10^7	>240	8×10^6	0
Skin[2]	237	8.5	7.0	0
Neck[3]	7.9×10^3	>240	16	0
Giblets[3]	5.4×10^3	>240	512	0

[1]-organsisms per ml
[2]-organisms per cm^2
[3]-organisms per gram

Table 8: Aerobic Plate count, Salmonella typhimurium, and Clostridum perfringens Numbers on Turkey Skin After Freezing (Part IV).

	Aerobic Plate Count	S. typhimurium	C. perfringens count	
			Plate	Spore
Skin sample from Bird 1	320*	8.68	56.6	0
Skin Sample from Bird 2	56	.08	18.0	0
Skin Sample pooled from all birds	727	3.88	31.78	0

* organisms per cm^2

There was no survival of Clostridum perfringens organisms after roasting, regardless of method (Table 9). Spores of Clostridium perfringens were expected to survive roasting. However, no spores were detected in the inoculation fluid (Table 7). This is not unusual, since sporulation does not readily occur in a rapidly growing microbial culture.

Salmonella typhimurium did survive in small numbers, on most birds. However, no Salmonella typhimurium were detected on samples from birds roasted in a 163°C oven with a foil tent covering (Table 10). It is probable that the combination of a long roasting time with a relatively high oven temperature resulted in the observed sterility of the birds roasted at 163°C. In fact, only the low oven temperature method required more roasting time per pound (Figure 11),

Table 9: *Clostridium perfringens* Numbers After Roasting by Various Methods.

Roasting Method	*C. Perfringens* count
Low Oven Temperature	
skin (organisms/cm^2)	NG
neck (organisms/gram)	NG
giblets (organisms/gram)	NG
163°C oven, foil tent	
skin	NG
neck	NG
giblets	NG
Roasting bag	
skin	NG
neck	NG
giblets	NG
High Oven Temperature	
skin	NG
neck	NG
giblets	NG

NG- no growth

Table 10: *Salmonella typhimurium* Load of Turkey Samples After Roasting by Various Methods

Roasting method	*S. typhimurium* (MPN)	C.I.
Low Oven Temperature		
skin (organism/cm^2)	.29	.05-0.9
neck (organism/gram)	.13	.30-3.7
giblets (organisms/gram)	.06	.10-2.0
163°C oven, foil tent		
skin	NG	
neck	NG	
giblets	NG	
Roasting bag		
skin	.31	.05-1.3
neck	2.68	1.0-1.5
giblets	1.07	.10-3.6
High Oven Temperature		
skin	.54	.05-2.0
neck	.09	.05-.90
giblets	.05	.05-.90

NG - no growth
C.I.-confidence interval (95%)

and only the high oven temperature method used a higher roasting temperature than the 163°C oven, foil tent method.

In several instances, samples had no growth on the aerobic plate count (Table 11), but did in fact contain viable Salmonella organisms. This is evidence that the Salmonella cells were injured during roasting, but were able to recover in the enrichment medium used in the isolation of Salmonella. Injured Salmonella cells present at the levels detected in these samples (less than three cells/gram of tissue, Table 10) would not present a health hazard, since Salmonella food poisoning requires the ingestion of 100,000-1,000,000 viable cells during the course of a meal. However, these data indicate that the low temperature oven method, the roasting bag method, and the high oven temperature method of roasting frozen turkeys did not completely sterilize the bird. Consequently, improper handling of the birds after roasting could permit repair and growth of Salmonella cells to a level sufficient to permit Salmonella food poisoning. Cornforth et al. (1982) found no growth of Salmonella on frozen turkeys roasted to 71°C. Two observations may explain these apparently conficting results. First, different roasting methods were evaluated in Cornforth et al. (1982), and more importantly, the inoculation level was approximatley twice as high for the birds used in this study. In the previous report (Cornforth et al. 1982) the aerobic plate count for the giblets was 2,720 cells per gram, compared to a value of 5,400 cells per gram in the present study.

Table 11: Aerobic Plate Count Numbers of Turkey Samples After Roasting by Various Methods.

Roasting Method	Aerobic Plate Count
Low Oven Temperature	
skin (organisms/cm^2)	NG
neck (organisms/gram)	420
giblets (organisms/gram)	113
163°C oven, foil tent	
skin	NG
neck	NG
giblets	NG
Roasting bag	
skin	NG
neck	NG
giblets	NG
High Oven Temperature	
skin	NG
neck	240
giblets	10

NG- no growth

It is unlikely that commercially prepared turkeys would be as contaminated as the inoculated birds used in this study. Thus, all of the methods tested would probably destroy normal levels of Salmonella and Clostriduium perfringens vegetative cells, producing a roasted turkey that could be safely eaten, assuming proper handling of the birds both before and after roasting. Of the methods tested, the foil tent, 163°C oven roasting method is most highly recommended from the standpoint of microbiological safety, since birds roasted by this method were sterile after roasting.

CONCLUSION

In part I (optimum end-point temperature) 76°C was chosen as the best end-point temperature because it received the highest appearance scores, and was both juicy and tender. Although the 71°C end-point temperature was rated higher on juiciness and tenderness it frequently produced a turkey with red or bloody-appearing thigh joints, which did not occur at the 76°C end-point temperature.

In part II the 121°C was chosen as the preferred low oven temperature, because birds roasted at this temperature were rated higher in more sensory attributes than birds roasted in any of the other three low oven temperatures. The roasting bag was rated significantly inferior in both appearance and palatability attributes at the low oven temperatures, but was acceptable at an oven temperature of 163°C (Part IIIa).

When roasting whole unstuffed turkeys from the frozen state it is recommended that the bird be roasted in a 163°C oven covered with a foil tent (Part IIIa). This roasting method produced a sterile turkey with acceptable sensory scores and favorable comments from the panelists. The low oven temperature method also produced an acceptable turkey from a sensory standpoint, but the thigh joint was judged to be "uncooked" and therefore unacceptable. The roasting bag method was judged low for both appearance and palatability attributes. Survival of Salmonella typhimurium was also highest on

birds roasted in a bag. The high oven temperature method was given low palatability scores, and survival of Salmonella typhimurium was also observed on birds roasted by this method. For these reasons the low oven temperature, roasting bag, and high oven temperature methods were not highly recommended as acceptable methods for roasting frozen turkeys.

To insure a good quality roasted turkey it is recommended that the consumer take the frozen turkey directly from the freezer, place it in a roasting pan breast up, and cover it with a foil tent. Place the bird into a cold oven, set the oven temperature to 163°C, and roast for 11-12 min./kg. To brown the bird, remove the foil tent 45 minutes before the breast temperature reaches a final temperature of 76°C.

Since only unstuffed birds were used in this study this roasting method cannot be recommended for stuffed birds.

REFERENCES CITED

Adams, B.W.; Mead, G.C.; Comparison of media and methods for Clostridium perfringens in poultry meat and further-processed products. J. Hyg. 84:151-58; 1980.

Alexander, L.M.; Schomeyer, G.E.; and Lamb, J.C. Turkey temperature as the end point in roasting. Poult. Sci. 30:520-24; 1951.

Baity, M.R.; Ellington, A.E.; Woodburn, M. Temperature effects in use of foil wrap in oven cooking. J. Home Econ. 61:174-76; 1969.

Bramblett, V.D.; and Fugate, K.W. Choice of cooking temperatures for stuffed turkeys, Part I: Palatibility factors. J. Home Econ. 59:180-85; 1967.

Bryan, F.L.; Ayres, J.C.; Kraft, A.A. Destruction of Salmonellae and indicator organisms during thermal processing of turkey rolls. Poult. Sci. 47:1966-78; 1968.

Bryan, F.L.; McKinely, T.W. Prevention of foodborne illness by time-temperature control of thawing, cooking, chilling, and reheating turkeys in school lunch kitchens. J. Milk Food Technol. 37(8):420-29; 1974.

Cornforth, D.P.; Brennand, C.P.; Brown, R.J.; Godfrey, D. Evaluation of various methods for roasting frozen turkeys. Food Sci. 47(4):1108-13; 1982.

Deethardt, D.; Burrill, L.M.; Schneider, K.; Carlson, C.W. Foil covered versus open-pan procedures for roasting turkey. J. Food Sci. 36:624-25; 1971.

Esselen, W.B.; Levine, A.S. Bacteriological investigations on frozen stuffed poultry. Food Technol. 17:245-49; 1954.

Esselen, W.B.; Levine, A.S.; Brushway, M.J. Adequate roasting procedures for frozen stuffed poultry. J. Am. Diet. Assoc. 32:1162-66; 1956.

Fagerberg, D.J.; and Avens, J.S. Enrichment and plating methodology for Salmonellae detection in food. A review. J. Milk Food Technol. 39:628-46; 1976.

Food and Drug Administration Bacteriological Analytical Manual. 5th edition. Association of official Analytical Chemists, Washington D.C; 1978.

Fulton, L.; Davis, C. Cooking chicken and turkey from the frozen and thawed states. J. Am. Diet. Assoc. 64:505-10; 1974.

Fulton, L.H.; Gilpin, G.L.; Dawson, E.H. Palatability and yield of whole and cut-up turkeys roasted from the frozen and thawed states. J. Home Econ. 59:728-31; 1967.

Goetz, G.E.; Cooley, K.; Ferguson, M.C.; Harrison, D.L. Doneness of frozen, defrosted turkey halves roasted to several end point temperatures. Food Technol. 14:135-38; 1960.

Goetz, G.F; .Stacy, S. Roasting half and whole turkey hens. Effect of varying oven temperatures. J. Am. Diet. Assoc. 37:458-61; 1960.

Goodwin, T.L.; Bramblett, V.D.; Vail, G.E.; Stadelman, A.J. Effects of end point temperature and cooking rate on turkey meat tenderness. Food Technol. 16(12):101-102; 1962.

Harmon, M.S; Duncan, C.L. Chapter 15. Clostridium perfringens. Enumeration, idenfication, and Entertoxin detection. In "FDA Bacteriological Analytical Manual", 5th ed. ed. Food and Drug Administration, Bureau of Foods, Division of Microbiology, Washington, D.C.; 1978.

Hagberg, M.M.; Busta, F.F.; Zottola, E.A.; Arnold, E.A. Incidence of potentially pathogenic microorganisms in further processed turkey products. J. Milk Technol. 36:625-35; 1973.

Hoke, I.M.; Gilpin, G.L.; and Dawson, E.H. Heat penetration quality, and yield of turkeys roasted to an internal breast temperature of 195°F. J. Home Econ. 57:188-91; 1965.

Hoke, I.M.; Kleve, M.K. Heat penetration, quality, and yield of turkeys roasted to different internal thigh temperatures. J. Home Econ. 58(5):381-84; 1966.

Hoke, I.M.; McGeary, B.K.; Kleve, M.K. Effect of internal and oven temperature on eating quality of light and dark meat turkey roasts. Food Technol. 21(5):89-93; 1967.

Hoke, I.M.; McGeary, H.K.; Lakshmanan, F. Muscle protein composition and eating quality of fresh and frozen turkeys. J. Food Sci. 33:566-71; 1968.

Ibbetson, C.J.; Travnicek, D.M.; Hooper, A.S.; Mitchell, J.D. Turkey halves braised or pressure cooked from the frozen or defrosted state. Poult. Sci. 47:1940-45; 1968.

Kahan, G.; Cooper, D.; Papavasiliou, A.; Kramer, A. Expanded Tables for determining significance of Differences for Ranked Data. Food Technol. 27(5):64-69; 1973.

Kraft, A.A.; Ayres, J.C.; Weiss, K.F.; Marion, W.W.; Balloun, S.L.; Forsyth, R.H. Effect of method of freezing on survival of microorganisms on turkey. Poult. Sci. Sci. 42:128-37; 1963.

Lillard, H.S. Occurance of Clostridium perfringens in broiler processing and further processing operations. J. Food Sci. 36:1008-10; 1971.

Messer, J.W. Chapter 4. Aerobic Plate Count. In "FDA Bacteriological Analytical Manual", 5th ed. Food and Drug Administration, Bureau of Foods, Division of Microbiology, Washington, D.C.; 1978.

Nie, N.H.; Hull, C.H.; Jenkins, J.G.; Steinbrenner, K.; Bent, D.H. Statistical package for the Social Sciences. Second Edition. McGraw-Hill Book Company, New York. 675 pp; 1975.

Olson, V.M.; Swaminathan, B.; and Stadelman, U.J. Reduction of numbers of Salmonellae typhimurium on poulty parts by repeated freeze-thaw treatments. J. Food Sci. 46:1323-26; 1981.

Patterson, J.T. Salmonellae in meat and poultry, poultry plant cooling waters and effluents, and Animal Feedingstuff J. Appl. bacteriol. 32:329-337; 1969.

Reddy, K.V.; Kraft, A.A.; Hasiak, R.W.; Marion, W.W.; Hotchkiss, D.K. Effect of spin chilling and freezing on bacteria on commercially processed turkeys. J. Food Sci. 43:334-36; 1978.

Rollender, W.; Beckford, O.; Belsky, R.D.; Kostroff, B. Comparison of xylose lysine desoxycholate agar and MacConkey agar for the isolation of Salmonellae and Shigella from clinical specimens. Am. J. Clin. Pathol. 51:285-87; 1969.

Smyser, C.F.; Bacharz, J; Van Roekel, H. Detection of Salmonellae typhimurium from artifically contaminated poultry feed and animal by-products. Avian Dis. 7:423-34; 1963.

Sorrels, K.M.; Speck, M.L.; Warren, J.A. Pathogenicity of Salmonellae gallenarum after metabolic injury freezing. Appl. Micorbiol. 19:39-43; 1970.

Stephens, J.F. Consumer acceptance of turkey cooked from the frozen state in roasting bags. Poult. Sci. 56:563-576; 1977.

Sveum, W.H; Kraft, A.A. Recovery of Salmonellae from foods using a combined enrichment technique. J. Food Sci. 46:94-99; 1981.

Travnicek, D; Hooper, A.S. Effect of cooking method on the quality of turkey breast meat from the frozen state. Poult. Sci. 47:1281-1283; 1968.

Wilkinson, R.J.; Mallmann, W.L.; Dawson, L.E.; Irmiter, T.F. 1964. Effective heat processing for the destruction pathogenic bacteria in turkey rolls. Poultry Sci. 44:131-36; 1964.

Zottola, E.A; Busta, F.F. Microbiological quality of further processed turkey product. J. Food Sci. 36:1001-04; 1971.

APPENDICES

Appendix A: Sensory Evaluation Ballots

Appearance Evaluation Ballot

Name:_____ Date:_____

Appearance Evaluation

Please evaluate the appearance of the whole turkey. Scales to use: (Note-any number between 1 and 7 can be used).

Degree of Browning	Uniformity of Browning	General Appearance (Outside & Inside meat)
7 extremely dark	7 extremely uniform	7 excellant
6	6	6 very good
5	5	5 good
4 medium brown	4 normal variation	4
3	3	3 fair
2	2	2 poor
1 very pale	1 non uniform	1 very poor

Bird Code Numbers

Degree of Browning	_____	_____	_____	_____	_____	_____
Uniformity of browning	_____	_____	_____	_____	_____	_____
General Outside appearance	_____	_____	_____	_____	_____	_____
General appearance of sliced meat	_____	_____	_____	_____	_____	_____

Tasting Evaluation Ballots

Name: Date:

Tasting Evaluation

Please score the samples in the order listed. The scores should represent how you evaluate the combined attributes of the white and dark meat. If you find a wide variation between the light and dark meat or notice anything special (good or bad) about the sample, please tell us about it under comments.

Bird Code Numbers

	_____	_____	_____	_____	_____	_____
Flavor	_____	_____	_____	_____	_____	_____
Juiciness	_____	_____	_____	_____	_____	_____
Tenderness	_____	_____	_____	_____	_____	_____
Overall	_____	_____	_____	_____	_____	_____

Comments:

Flavor	Juiciness
7 very flavorful	7 extremely juicy
6	6 very juicy
5 moderately flavorful	5 moderately juicy
4	4 slightly juicy
3 slightly flavorful	3 slightly dry
2	2 moderatley dry
1 flavorless	1 very dry

Tenderness	Overall Quality
7 extremely tender	7 extremely good
6 very tender	6 very good
5 moderately tender	5 moderately good
4 slightly tender	4 slightly good
3 slightly tough	3 slightly poor
2 moderately tough	2 moderately poor
1 very tough	1 very poor

Letter Sent to Sensory Panelists (Part IIIb)

Your participation during the frozen turkey study has been appreciated. The conscientious attendance and sample evaluation of taste panel judges provides us with data which cannot be obtained in any other way.

Many of you have expressed an interest in knowing more about the variables now that the study is completed.

There were three parts to the study. In the first part, we were working with final temperatures. Previous work during the summer had shown that birds roasted to 160°F were safe to eat, but were sometimes redder than desired. The temperatures you helped us test were 160, 170, and 180°F using both small (10 lbs.) and large (20 lbs.) turkeys. These birds were also prepared using three different methods to see if this would influence the appearance of the turkeys at their final temperature. The panel gave the 160°F final temperature the highest rating on most attributes, however, these frequently had bloody looking thigh joints so we are recommending 170°F.

The second part of the study dealt completely with low temperature roasting of turkeys. Birds were roasted in 200, 225, 250, and 275°F ovens until they reached 170°F internally. Two different methods (foil tent and roasting bag) were used. The preferred method based on the average panel score was the foil covered bird roasted in a 250°F oven. This variable was then included in Part 3.

Test 3 was to derive the final recommendations for cooking method and also cooking time information based on the weight of the turkey. Four methods were tested. In all cases, the frozen turkey (0°F) was placed in a non-preheated oven. Giblets were in a plastic bag in the craw and the neck was in the cavity of turkey purchased. Cooking methods were as follows.

COOKING METHODS

I. Low Temperature Roasting. Frozen turkey was placed in roasting pan, loosely covered with foil and roasted in a 250°F oven. The foil was removed for the last 1 hour for cooking.

II. Roasting Bag. Frozen turkey was first put in a large roasting bag, then in a roasting pan and roasted in a 325°F oven.

III. Foil Tent. Frozen turkey was handled as in #I, except roasted at 325°F.

IV. High Temperature. Frozen turkey was tightly wrapped in foil with space provided above the breast (to avoid having foil stick to skin), placed in a roasting pan and cooked in a 450°F oven. Foil was opened for the last 20 min.

PLEASE ANSWER THE QUESTIONS AT THE BOTTOM OF THIS PAGE AND SEND THIS BACK TO US.

We would appreciate your assistance on one more item. We now have data on time requirements and on the quality of the turkeys as rated by the sensory panel. What we would like to know-what is important to you when you choose a method for roasting tukeys. Examples are shown below, which tell how long was necessary to roast a frozen turkey weighing____pounds, plus the sensory scores which you gave that variable. During the course of the testing, you have sampled each combination of variables three times. The data shown is the average of your own rating scores. In case needed, a copy of the ballot is attached. What we would like for you to do is to rank the methods in the order which you think you would prefer to use them at home. If needed, information on cooking methods is on the preceding page.

Data for_____

Methods

	I Low T.	II Roasting bag.	III Foil tent	IV High T.
Time to cook a lb. bird				
Browning Score				
Uniformity				
General Appearance of Slice				
General Outside Appearance	D L	D L	D L	D L
Flavor				
Tenderness				
Juiciness				
Overall				

Given the above sets of your data, rank the methods in the order which you would probably use them at home.

First Choice _____
Second Choice_____
Third Choice _____
Fourth Choice_____
What determined you choice?

Roasting Instructions for Part IIIc-Home Roasting of Turkey.

Thermometer calibration. Your thermometer will read_____when the temperature is 170°F.

INSTRUCTIONS

Do NOT thaw your turkey. Time tables are based on the turkey being around 0°F.

ROASTING METHOD

Place a large piece of foil under your frozen turkey. Bring the foil together above the bird and fold foil together for 2-3 turns (drug store wrap). Fold up ends likewise. Record the time. Place in oven and turn oven on to 450°F. It should take 27 to 33 minutes per pound for your turkey to roast, therefore your_____lb. turkey should take_____ to roast.

After the turkey has thawed (about half way through the time period), partially uncover the bird and place the thermometer in the center of the thickest portion of the breast. Recover and return to oven.

Remove the foil for the last 15 minutes of roasting.

When the bird reaches 170°F., remove from oven and record time.

QUESTIONNAIRES

1. Serve the turkey and rest of meal in your normal manner.

2. Give the 4 question ballot to all family members and/or guests (who are 10 years or older) to be filled out during the meal. (Note: Cook does not fill out the 4 question ballot.) PLEASE HAVE ALL FOLLOW PROPER PANEL PROCEDURE AND NOT DISCUSS THE TURKEY WHILE FILLING OUT THE FORMS.

3. As cook, please open Envelope 1 and answer the question.

4. Cook is then open Envelope 2 and complete the needed information.

5. Enjoy your dinner.

6. Return all ballots and information to Charlotte

Brennand, NFS Room #327 or (UMC 87).
Thermometer calibration. Your thermometer will read_____when the temperature is 170°F.

INSTRUCTIONS

Do NOT thaw your turkey. Time tables are based on the turkey being around 0°F.

ROASTING METHOD

Put a tablespoon of flour in the roasting bag and shake to coat the bag. Then place the frozen turkey in the bag and put the whole thing in a roasting pan with the turkey breast up. Record the time. Turn the oven on to 325°F. It should take 22 to 28 minutes per pound for your turkey to roast, therefore your_____lb. turkey should take_____to roast.

After the turkey has thawed (about half way through the time period), partially uncover the bird and place the thermometer in the center of the thickest portion of the breast. Recover and return to oven.

When the bird reaches 170°F., remove from oven and record time.

QUESTIONNAIRES

1. Serve the turkey and rest of meal in your normal manner.

2. Give the 4 question ballot to all family members and/or guests (who are 10 years or older) to be filled out during the meal. (Note: Cook does not fill out the 4 question ballot.) PLEASE HAVE ALL FOLLOW PROPER PANEL PROCEDURE AND NOT DISCUSS THE TURKEY WHILE FILLING OUT THE FORMS.

3. As cook, please open Envelope 1 and answer the question.

4. Cook is then open Envelope 2 and complete the needed information.

5. Enjoy your dinner.

6. Return all ballots and information to Charlotte Brennand, NFS Room #327 or (UMC 87).

Thermometer calibration. Your thermometer will read_____when the temperature is 170°F.

INSTRUCTIONS

Do NOT thaw your turkey. Time tables are based on the turkey being around 0°F.

ROASTING METHOD

Place the frozen bird in a roasting pan, breast up. Loosely cover the bird with aluminum foil. Record the time and place the turkey in the oven. Turn the oven on to 250°F. It should take 54 to 60 per pound for your turkey to roast, therefore your_____lb. turkey should take_____to roast.

After the turkey has thawed (about half way through the time period), partially uncover the bird and place the thermometer in the center of the thickest portion of the breast. Recover and return to oven.

Remove the foil for the last one hour of roasting.

When the bird reaches 170°F., remove from oven and record time.

QUESTIONNAIRES

1. Serve the turkey and rest of meal in your normal manner.

2. Give the 4 question ballot to all family members and/or guests (who are 10 years or older) to be filled out during the meal. (Note: Cook does not fill out the 4 question ballot.) PLEASE HAVE ALL FOLLOW PROPER PANEL PROCEDURE AND NOT DISCUSS THE TURKEY WHILE FILLING OUT THE FORMS.

3. As cook, please open Envelope 1 and answer the question.

4. Cook is then open Envelope 2 and complete the needed information.

5. Enjoy your dinner.

6. Return all ballots and information to Charlotte Brennand, NFS Room #327 or (UMC 87).

Thermometer calibration. Your thermometer will read_____when the temperature is 170°F.

INSTRUCTIONS

Do NOT thaw your turkey. Time tables are based on the turkey being around 0°F.

ROASTING METHOD

Place the frozen turkey in a roasting pan, breast up. Loosely cover with an aluminum foild tent. Record the time and place the turkey in the oven. Turn the oven on to 325°F. It should take 35 to 41 minutes per pound for your turkey to roast, therefore your_____lb. turkey should take_____to roast.

After the turkey has thawed (about half way through the time period), partially uncover the bird and place the thermometer in the center of the thickest portion of the breast. Recover and return to oven.

Remove the foil for the last 30 minutes of roasting.

When the bird reaches 170°F., remove from oven and record time.

QUESTIONNAIRES

1. Serve the turkey and rest of meal in your normal manner.

2. Give the 4 question ballot to all family members and/or guests (who are 10 years or older) to be filled out during the meal. (Note: Cook does not fill out the 4 question ballot.) PLEASE HAVE ALL FOLLOW PROPER PANEL PROCEDURE AND NOT DISCUSS THE TURKEY WHILE FILLING OUT THE FORMS.

3. As cook, please open Envelope 1 and answer the question.

4. Cook is then open Envelope 2 and complete the needed information.

5. Enjoy your dinner.

6. Return all ballots and information to Charlotte Brennand, NFS Room #327 or (UMC 87).

Four Question Ballot
(For Family and Guests)

Taster (Name)

Do not discuss the turkey with anyone before filling out this ballot. Please place a check mark by how you feel about the turkey on each of the following categories:

Appearance of roasted turkey

_____like extremely much
_____like very much
_____like moderately
_____like slightly
_____dislike slightly
_____dislike moderately
_____dislike very much

Flavor

_____like extremely
_____like very much
_____like moderately
_____like slightly
_____dislike slightly
_____dislike moderately
_____dislike very much

Juiciness

_____like extremely
_____like very much
_____like moderately
_____like slightly
_____dislike slightly
_____dislike moderately
_____dislike very much

Overall

_____like extremely
_____like very much
_____like moderately
_____like slightly
_____dislike slightly
_____dislike moderately
_____dislike very much

Comments:

Contents of Envelope One

Please give us your impressions concerning the turkey and method:

Open Envelope 2

Contents of Envelope Two

General Questions

How long did the turkey take to reach 170^{o}F?

Do you think your oven temperature is fairly accurate?

Did you have any problems with the roasting method itself? If so, what?

Comments by cook and/or carver on the turkey.

Do you plan to ever roast a turkey this way again.

Ballot to be evaluated by the cook

Name Date

Appearance Evaluation

Please evaluate the turkey based on the following scales: (Note: Any number between 1 and 7 can be used)

Degree of Browning	Uniformity of Browning	General Appearance (Outside & Inside meat)
7 extremely dark	7 extremely uniform	7 excellant
6	6	6 very good
5	5	5 good
4 medium brown	4 normal variation	4
3	3	3 fair
2	2	2 poor
1 very pale	1 non uniform	1 very poor

Please evaluate the dark and light turkey meat using the following scales:

Flavor	Juiciness
7 very flavorful	7 extremely juicy
6	6 very juicy
5 moderately flavorful	5 moderately juicy
4	4 slightly juicy
3 slightly flavorful	3 slightly dry
2	2 moderately dry
1 flavorless	1 very dry

Tenderness	Overall Quality
7 extremely tender	7 extremely good
6 very tender	6 very good
5 moderately tender	5 moderately good
4 slightly tender	4 slightly good
3 slightly tough	3 slightly poor
2 moderately tough	2 moderately poor
1 very tough	1 very poor

Appearance

Degree of Browning_____
Uniformity of Browning_____
General Appearance of Outside_____
General Appearance of Inside_____

Palatability

Flavor_____
Juiciness_____
Tenderness_____
Overall_____

Appendix B: Statistical Blocking

Statistical blocking for Part I.

Variables:

Roasting Method	Final Internal Temperature	Weight of Bird
A-325°F oven, tent, thawed	160°F	4.5 kgs.
B-200°F oven, tent, frozen	170°F	9.1 kgs.
C-450°F oven, wrap, frozen	180°F	

Set 1	Set 2	Set 3	Set 4
A-160-10	A-170-10	A-160-20	A-180-10
A-170-10	A-180-10	A-180-20	B-170-10
B-170-10	B-160-10	B-160-20	C-160-10
B-180-10	B-180-10	B-170-20	A-160-20
C-160-10	C-160-10	C-170-20	B-180-20
C-180-10	C-170-10	C-180-20	C-170-20

Set 5	Set 6	Set 7	Set 8	Set 9
A-170-20	A-160-10	A-160-20	A-160-10	A-170-20
A-180-20	A-180-10	A-170-20	A-170-10	A-180-20
B-160-20	B-160-10	B-170-20	B-160-10	B-160-20
B-180-20	B-170-10	B-180-20	B-180-10	B-170-20
C-160-20	C-170-10	C-160-20	C-170-10	C-160-20
C-170-20	C-180-10	C-180-20	C-180-10	C-180-20

Statistical blocking of variables to be tested in Part II.

Variables:

Oven Temperature	Roasting Method
200°F	Foil tent (F)
225°F	Roasting Bag (B)
250°F	
275°F	

Set 1	Set 2	Set 3	Set 4	Set 5	Set 6
F-200	F-225	F-200	F-250	F-200	F-225
F-250	F-275	F-225	F-275	F-275	F-250
B-225	B-200	B-250	B-200	B-250	B-200
B-275	B-250	B-275	B-225	B-250	B-275

Statisitcal blocking of variables to be tested in Part III

Method	Weight of Bird
Low temperature roasting (L)	a. 8.0 - 12.0 lbs.
Roasting bag, 325°F oven (B)	b. 12.1 - 16.0 lbs.
Foil tent, 325°F oven (C)	c. 16.1 - 20.0 lbs.
Foil wrap, 450°F oven (F)	d. 20.1 - 24.0 lbs.

Set 1	Set 2	Set 3	Set 4
L-a	L-b	L-c	L-d
B-b	B-c	B-d	B-a
C-c	C-d	C-a	C-b
F-d	F-a	F-b	F-c
L-c	C-a	L-b	B-c
B-d	F-b	C-d	F-a

Set 5	Set 6	Set 7	Set 8
L-d	L-c	L-b	L-a
B-c	B-b	B-a	B-d
C-b	C-a	C-c	C-d
F-a	F-d	F-c	F-b
L-a	B-a	C-b	B-b
F-c	L-d	F-d	C-c

Appendix C: Bacteriological Media and Procedures

Bacto Plate Count Agar

*Bacto-Tyrptone, pancreatic digest of casein USP	5.0 g
Bacto-yeast extract	2.5 g
Bacto-dextrose, glucose	1.0 g
Bacto-Agar	15.0 g

*Bacto-Tryptone, pancreatic digest casein USP, has been an APHA Standard Methods Peptone since 1923 and plate count agar peptone since 1939.

To rehydrate the medium, suspend 23.5 grams in 1000 ml. of cold distilled water. Heat to boiling to dissolve the medium completely. Sterilize in the autoclave for 15 min. at 15 psi (121°C).

Medium prepared as directed will have reaction of pH 7.0 at 25°C- the regcognized standard temperature for elecrometric and colorimetric determinations.

Tryptose-Sulfite-Cycloserine (TSC) Agar

Tryptose	15 g
Yeast extract	5 g
Soytone	5 g
Ferric ammonium citrate (NF Brown Pearls)	1 g
Sodium bisulfite (meta)	1 g
Agar	20 g
Distilled Water	900 ml.

Adjust pH 7.6 +/- 0.1, dispense 250 ml portions into 500 ml flasks, and sterilize for 15 min at 121°C. Before plating, add 20.0 ml of 0.5 % filter-sterilized solution of D-cycloserine to each 250 ml of sterile melted medium at 50°C. To make plates containing egg yolk, add 20 ml of 50 % egg yolk emulsion to 250 ml of sterile medium containing D-cycloserine. Dispense 15 ml portions into 100 x 15 mm sterile petri dishes. Cover the plates with a towel and allow to dry overnight at room temperature before use.

Phosphate buffer (pH8.0) for D-cycloserine solution

K_2HPO_4	8.7 g
KH_2PO_4	0.48 g
Distilled water	100.0 ml.

Dissolve the salts in the water. Check the pH and adjust, if necessary, to 8.0.

D-cycloserine solution. Dissolve 1 g of D-cycloserine without heating in 200 ml of 0.05 M phosphate buffer, pH 8.0, above, and sterilize with a 0.45 mcg membrane filter (Nutritional Biochemicals Corp., Cleveland, OH 44128; Serva Feinbiochemicia, Heidelberg, Germany; and Sigma Chemicals).

Egg yolk emulsion. Wash fresh eggs with a stiff brush and drain. Soak in 0.1% mercuric chloride solution for 1 hour. Pour off the mercuric chloride solution and replace with 70% ethyl alcohol. Soak for 30 min in the 70% ethyl alcohol. Aseptically remove the yolk and mix with an equal volume of sterile 0.85% NaCL solution. Store at 4°C.

Bacto
Fluid Thioglycollate medium

Bacto-casitone	15.0 g
Bacto-yeast extract	5.0 g
Bacto-dextrose	5.5 g
Sodium chloride	2.5 g
L-cystine, Difco	0.5 g
Sodium Thioglycollate	0.5 g
Bacto-Agar	0.75 g
Resazurin	0.001 g

Directions

To rehydrate, suspend 29.8 grams in 1 liter distilled or deionized water and heat to boiling to dissolve completely. Dispense as desired. Sterilize in autoclave for 15 min at 15 psi (121°C). If medium is not used the same day cool to 25°C and store upright at 2-8°C. When ready to use, loosen culture, boil for 3-5 min and cool to 45-50°C. Final pH 7.1 +/- .2 at 25°C.

Selenite Cystine Broth

Polypeptone	5 g
Lactose	4 g
Sodium phosphate	10 g
Sodium acid Selenite	4 g
L-cystine	0.1 g

Final pH 7.0 +/- .2

Suspend 23 grams of the dehydrated material in a liter of purified water. Heat with frequent agitation and boil for 1 min. Cool and use.

Alternatively, if the broth is not used on the day of preparation, dispense in tubes in 10 to 15 ml amounts after boiling. Heat in flowing steam for 15 min. Cool and store in the refrigerator. DO NOT AUTOCLAVE.

XLD Agar

Xylose	3.5 g
L-Lysine	5.0 g
Lactose	7.5 g
Sucrose	7.5 g
Sodium Chloride	5.0 g
Yeast extract	3.0 g
Phenol Red	0.08 g
Agar	13.5 g
Sodium Desoxycholate	2.5 g
Sodium Thiosulfate	6.8 g
Ferric Ammonium Citrate	0.5 g

Final pH 7.4 +/- .2

Suspend 55 grams of the dehydrated material in a liter of purified water. Mix. Heat with agitation just until the medium boils. DO NOT OVERHEAT. Discontinue heating and transfer to a water bath at about 50°C. Pour into plates as soon as it is cooled. Avoid over heating and consequent precipitation.

Triple Sugar Iron Agar

Bacto-Beef Exract	3 g
Bacto-Yeast Extract	3 g
Bacto-Peptone	15 g
Proteose-Peptone, Difco	5 g
Bacto-dextrose	1 g
Bacto-lacose	10 g
Saccharose, Difco	10 g
Ferrous Sulfate	0.2 g
Sodium Chloride	5 g
Sodium Thiosulfate	0.3 g
Bacto-Agar	12 g
Bacto-Phenol Red	0.024 g

To rehydrate the medium suspend 65 grams in 1000 ml cold distilled water and heat to boiling to dissolve the medium completely. Sterilize in autoclave for 15 min. at 15 pounds

pressure (121 ^{o}C). Allow the tubes to solidify in a slanting position in a manner which will give a generous butt.