COMPARISON OF TWO INTERNAL TEMPERATURES IN THE BREAST AND IN THE THIGH MUSCLES AS AN INDICATION OF DONENESS IN ROASTED TURKEY HALVES

by

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INTRODUCTION

The need for a standardized procedure for roasting turkey has been recognized by research workers. To make it possible for various research laboratories to supplement their results with one another the establishment of a standard method is desirable.

One of the major problems encountered in the cooking of turkey has been the lack of a satisfactory guide for determining doneness. Birds have been cooked for a specific number of minutes per pound or to certain internal temperatures in the thigh, breast or stuffing. Workers, too, have depended on such indications of doneness as the feel of the flesh when touched with the fingers, the tenderness of the meat when speared with a fork or the ease of manipulating the joints. A combination of several of the above mentioned methods also has been used in some laboratories.

A comparison of certain internal temperatures of the pectoralis major and thigh muscles with other physical signs of doneness in roasted turkey should provide beneficial data in the development of a standard method of roasting turkey. It was the purpose of this study to investigate the degree of doneness of roasted defrosted turkey halves cooked to the internal temperatures of 85° and 90° C. in the pectoralis major and in the thigh muscles.

REVIEW OF LITERATURE

Composition of Poultry Muscle

The major constituents of poultry muscle listed by Lowe (1955) are proteins, fat and water. Pigments, inorganic and organic salts, nitrogenous and non-nitrogenous extractives, carbohydrates, enzymes and vitamins are present in smaller amounts.

Proteins in Muscle. The proteins of skeletal muscle are classed as structural or extracellular and protoplasmic or intracellular. The extracellular proteins are mainly collagen and elastin. Lowe (1955) listed the names that have been given to the intracellular proteins as globulin X, myogen, myoalbumin, tropomyosin and myosin. According to Szent-Gyorgyi (1951), myosin is now considered to be made up of actin and myosin which on contraction are combined to form actomyosin.

The properties of proteins are closely related to their structure. All proteins are made up of amino acids that are linked together to form polypeptide chains. These chains form the backbone of the protein molecule and are bound together by cross linkages composed mainly of hydrogen bonds and salt bridges.

Effect of Heat on Protoplasmic Proteins. Heat coagulation of the protoplasmic proteins was considered by Bull (1949) to consist of three steps. The first is denaturation, an intramolecular rearrangement; the second involves flocculation of the denatured protein. The third step is the formation of an

insoluble coagulum brought about by polymerization of the denatured protein molecule. Two types of linkages broken by denaturation are the salt linkages and hydrogen bonds.

Some of the factors that affect the coagulation temperature of a protein as given by Lowe (1955) are the pH, the amount of water present and the salts present and their concentration. Bull (1949) reported that the temperature at which coagulation occurs also was dependent upon the length of exposure of the protein to a given temperature. He found that few proteins would stand temperatures above 60° C. for any length of time without undergoing considerable denaturation. Levy and Benaglia (1950) stated that the rate of denaturation of ricin in solution was a simultaneous function of temperature and pH and that salt concentration was a significant variable in protein denaturation. However, Pence et al. (1953) working with gluten found that variations of salt concentration had no effect on the rate of denaturation by heat, but that the amount of moisture was a significant factor. These workers reported that the rates of denaturation at both 80° and 90° C. were negligible at a low moisture content, but rose rapidly at intermediate moisture values.

The coagulation of proteins is an endothermic process. Lowe (1955) stated that when meat was cooked at low oven temperatures, the interior temperature was often stationary for several minutes at 75° to 85° C. The absorption of heat during this period probably indicated considerable coagulation of the intracellular proteins at this temperature range. The extent of coagulation of the proteins in turn influenced the degree of

doneness of the meat.

Effect of Heat on Structural Proteins. Structural proteins also undergo changes when exposed to heat. Lowe (1948) stated that some collagen was converted to gelatin when heated in the presence of water, but that the change was not rapid at the pH of muscle. Winegarden et al. (1952) found that the softening of connective tissue was greater as both time and temperature of heating were increased. Elastin was softened by heating similarly to collagen, but to a lesser extent, according to Lowe (1955).

Fat in Muscle. The fat content of turkey muscle was reported by Holcomb and Maw (1934) to be inversely proportional to the moisture content. They found that the average percentage of fat was 14 and of moisture was 65. It had been pointed out that different muscles of turkey vary in the amount and distribution of fat. Harshaw et al. (1943) found that the leg of Broad Breasted Bronze turkeys contained two to three times more fat than the breast muscle. Goertz et al. (1955) described differences in the distribution of fat in the gluteus primus and in the pectoralis major muscles. The fat of the gluteus primus occurred in small groups of cells, well distributed throughout the entire muscle. Large clusters of fat cells, concentrated in a few areas, were characteristic of the fat distribution in the pectoralis major. The amount and distribution of fat may affect the rate of cooking turkey. Thille and coworkers (1932) found with beef roasts that exterior fat increased the rate of heat penetration but interior fat tended to retard it.

Muscle Pigment. The color of muscle is attributed to the presence of myoglobin. Lowe (1955) stated that the amount of myoglobin present varied with the age of the animal, the breed and extent of exercise. A variation in the amount of myoglobin in the different muscles of the same animal was pointed out by Lawrie (1950) who found about 10 times as much myoglobin in the leg as in the breast muscle of poultry.

Myoglobin is unstable to heat, and as it decomposes the meat becomes gray or brown in color. Lowe (1955) reported that decomposition of myoglobin appeared at about 65° to 70° C., although this appeared to be influenced by the rate of heat penetration and other factors.

Factors Affecting Rate of Heat Penetration in Poultry

Many factors affect the rate of heat penetration in poultry. Alexander et al. (1951) suggested that information on the rate of heat penetration was important in a study of end-point temperature. The differences in rate of heat penetration in several muscles of one turkey were investigated by Iacono et al. (1956). By means of thermocouples, they determined the length of time required for the various muscles of one bird to reach 185° F. This temperature was reached in 197 minutes in the left rear breast, whereas 240 minutes were needed for the center of the right breast to reach this point. The temperature rise was slowest in the right breast and increasingly faster in the left thigh, right drumstick and left rear breast.

Initial Temperature of the Bird. Lowe (1955) stated that one of the factors which affects the length of cooking time of meat was its initial temperature. She reported meat having a temperature of 0° to 5° C. required a longer time to cook than meat having an initial temperature of 20° C. In a comparison of turkeys cooked from the defrosted and the frozen state Iacono et al. (1956) found that the time required to reach a specific temperature was about two-thirds as long for the defrosted as for the frozen birds.

Fresh Chilled vs. Defrosted Birds. The possibility that the rate of heat penetration differs in roasting chilled and frozen defrosted turkeys was suggested by Marsden and coworkers (1952). These workers roasted fresh Broad Breasted Bronze turkeys until the flesh was soft and the leg joint moved easily and found the cooking time to be 26.9 minutes per pound. In an earlier study in the same laboratory, defrosted birds cooked to the same subjective end point required only 23.6 minutes per pound. A partial denaturation of the protein or a change in the muscle structure during freezing might account for the shorter cooking time for the frozen birds. However, this is a problem that needs further investigation.

Oven Temperature. Wide variations were reported in the oven temperatures used for roasting turkeys. Cooking temperatures were related to end-point temperatures by Edgar (1953). She found that birds roasted in a 300° F. oven were considered done at a lower internal temperature than the birds cooked in a 400° F. oven. Very low oven temperatures were used by Alexander

et al. (1948) who roasted Broad Breasted Bronze males at 262° F. and females at 289° F. The temperature used by Klose and Pool (1954) was 300° F., whereas Cook et al. (1949) roasted turkeys at an average oven temperature of 334° F. and Iacono et al. cooked birds at 350° F. The United States Department of Agriculture (1954) and the Poultry and Egg National Board (1953) recommended an oven temperature of 325° F. for roasting turkeys.

Tests for Doneness in Poultry

A successfully roasted turkey, as described by Alexander et al. (1951) has tender, juicy flesh and is easily disjointed with the aid of the carver's knife. Internal temperature, time of cooking and various subjective observations were used to determine when the turkey is done.

Internal Temperature. Investigators have located thermometers in the breast muscle, the thigh muscles or the stuffing of a bird to determine the degree of doneness. Alexander et al. (1951) found that the leg (thigh) temperature of satisfactorily cooked birds varied from 90° to 94° C. (194° to 201° F.); whereas the breast muscles varied from 80° to 95° C. (176° to 203° F.) and the stuffing from 80° to 94° C. (176° to 201° F.). It was found by Edgar (1953) that turkeys roasted at 400° F. required an internal thigh temperature of 88° C. to be considered as well done as those cooked to 85° C. in a 300° F. oven. Lowe (1955) stated that when a high cooking temperature was used the rate of heating was rapid; hence, to coagulate the proteins of the muscle sufficiently, a higher internal temperature was needed than when

the birds were cooked slowly. Klose and Pool (1954) roasted whole turkeys to an internal temperature of 180° F. in the breast muscle. The front quarter of defrosted birds was cooked to an internal temperature of 180° F. and the rear quarter to 185° F. in a study by Klose et al. (1955). The degree of doneness of the birds was not reported in the last two studies.

When internal temperature of the stuffing was used for the end point of cooking, Lowe (1955) suggested that a temperature of 70° to 85° C. was required for a well done bird. She indicated that the optimum temperature would vary with the type of stuffing as a moist stuffing conducts heat more rapidly than a dry stuffing. However, Castellani et al. (1953) found little difference in the rate of heat penetration in the two types of stuffing.

Cooking Time. Cooking time, in minutes per pound, is sometimes recommended as a method of determining doneness in poultry. However, Lowe (1955) pointed out that a shorter time per pound is needed for a large than for a small bird. Recent publications of the Poultry and Egg National Board (1953) and the United States Department of Agriculture (1954) give total cooking time for birds in each weight range rather than minutes per pound.

Combined Cooking Time and Temperature. Combinations of cooking time and temperature also were used to determine when a turkey was done. Goertz (1952) cooked fresh turkey halves at 300° F. to an end point of 185° F. in the pectoralis major muscle or until they had remained in the oven 26 minutes per pound,

whichever was the shorter period. Cooking time rather than temperature was used for almost two-thirds of the birds. The pectoralis major muscle was done, but not well done. Lewis (1955) roasted defrosted turkey halves at 300° F. to an internal thigh temperature of 185° F. or until the birds had been in the oven 26 minutes per pound, whichever was the longer. Cooking time was used for about one-third, and internal temperature for the remainder of the birds cooked.

Subjective Observations. Turkeys were considered done by Swickard et al. (1953) when the joints moved easily and the flesh of the legs felt soft when gentle pressure was applied. Alexander et al. (1951) cooked turkeys until the breast and thigh speared tender with a fork and the joints had softened. These workers found that the results of spearing the muscle generally agreed with other organoleptic observations, although tenderness in one muscle did not necessarily indicate tenderness in other muscles of the same turkey. They considered subjective methods more accurate than temperature alone as a guide to accurate cooking of the turkeys roasted in their study.

MATERIALS AND METHODS

Twenty Broad Breasted Bronze turkey hens each weighing between 14 and 16 pounds were purchased from C. A. Swanson & Sons in Omaha, Nebraska. The birds were eviscerated immediately after killing, chilled and placed in Cry-o-vac bags. They were then frozen in a freezing tunnel at -45° to -50° F. and held at -10°

to -15° F. At the end of three months of storage they were shipped to Kansas State College.

The frozen turkeys were cut in half lengthwise, coded, wrapped in 0.0015 weight aluminum foil and stored at 0° F. in a commercial type locker operated by the Department of Animal Husbandry at Kansas State College. Each week eight turkey halves were transferred to a home freezer in the Food Research Laboratory where they were stored at -20° F. for two to five days. On the day previous to cooking, the turkey halves were removed from the freezer and thawed in the foil wrapping at room temperature (75° to 86° F.) for 21 hours.

The birds were cooked according to a split plot design (Table 1). Paired halves from two birds were roasted at each cooking period, and each half bird was removed from the oven at a different internal temperature. The thigh temperature was used as the end point of cooking in the right and left halves of one bird and the breast temperature in the two halves of the other bird.

The turkeys were roasted on a rotary hearth in a preheated gas oven maintained at 325° F. Each half bird was placed on a rack (cut side down) in an individual pan, and the cut side covered with aluminum foil to prevent drying. Thermometers were inserted in the mid-portion of both the pectoralis major and the thigh muscles of each half bird. The internal temperatures were noted every 20 minutes. The thermometers were read through the glass panel of the unopened oven door. The half birds were weighed before and after cooking and volatile, dripping and total

cooking losses were determined (Form I, Appendix).

Table 1. Internal temperature for removing turkey halves from the oven at each cooking period.

Cooking period	A		B	
	Right half	Left half	Right half	Left half
	°C.			
1	85 thigh	90 thigh	90 breast	85 breast
2	85 thigh	90 thigh	85 breast	90 breast
3	90 thigh	85 thigh	90 breast	85 breast
4	85 breast	90 breast	90 thigh	85 thigh
5	90 breast	85 breast	85 thigh	90 thigh
6	90 breast	85 breast	90 thigh	85 thigh
7	90 thigh	85 thigh	90 breast	85 breast
8	90 breast	85 breast	85 thigh	90 thigh
9	85 thigh	90 thigh	85 breast	90 breast
10	85 thigh	90 thigh	90 breast	85 breast

The turkeys were allowed to cool approximately two hours before carving and the ease of carving and appearance of the muscles were observed by the carver. The entire gluteus primus and semitendinosus muscles from the thigh and the mid-portion of the pectoralis major from the breast were sliced and each judge was given a piece from a similar location in the muscles at each cooking period. Light and dark meat from the pectoralis major and a composite of the gluteus primus and semitendinosus, respectively, were scored by a palatability committee of five members for flavor, tenderness and juiciness (Form II, Appendix). In addition, the meat juices that exuded when the birds were

carved were collected in small glass jars and checked by the judges for color and appearance as these factors were related to the degree of doneness. The juice and the dark and light meat were rated very undone, slightly underdone, done, slightly overdone and very overdone. The flavor, tenderness and juiciness of the meat were rated by a numerical score between seven and one, whereas the doneness evaluations were made by checking descriptive terms. Later, values ranging from one for very underdone, to five for very overdone were assigned to the descriptive terms.

Shear values for the pectoralis major muscle were measured according to a standard procedure on the Warner-Bratzler shearing apparatus. The portion of the pectoralis major muscle that remained after the palatability samples were removed was cooled to room temperature, and a one-inch core, as nearly as possible parallel to the long fiber axis, was taken from the thickest portion. Each core was sheared four times, and the average value for the four readings was used as the shear value for the core.

Press fluid yields were determined on the pectoralis major muscle with a Carver Laboratory press. The portion of the thickest part of the muscle remaining after the core was removed was ground and stored overnight in covered jars in a refrigerator maintained at approximately 42° F. On the following day the meat was allowed to return to room temperature and pressed according to the method described by Goertz (1952). The fluids were collected in a graduated centrifuge tube and read the following morning. The volume of serum, fat and total press

fluid was recorded. The press fluid yields were determined in duplicate.

Mean values for the data collected at each cooking period were used for all statistical analyses. Palatability factors, cooking losses, cooking time, shear values and press fluid yields were considered. Analyses of variance were run for each of these factors to determine whether or not there were differences between the birds in which the temperature of the pectoralis major muscle was the end point and those in which the temperature of the thigh was the end point. Analyses of variance also were used to pick out any differences that occurred between the birds cooked to 85° C. and those cooked to 90° C., regardless of the muscle in which the temperature was measured. In addition analyses of variance and least significant differences were used to determine any differences the four treatments (cooking to end-point temperatures of 85° in the pectoralis major, 85° in the thigh, 90° in the pectoralis major and 90° C. in the thigh) made on the doneness of the light meat, dark meat or juice of the birds. Correlation coefficients were determined to find if any relationship existed between tenderness scores and shear values, juiciness scores and press fluid yields, and juiciness scores and total cooking losses.

RESULTS AND DISCUSSION

The roasting of a turkey presents a problem, according to Lowe (1955), because the different muscles within a bird vary

considerably in their tenderness. If, when roasting whole turkey, it is cooked so that the breast is in its prime, the thigh muscles may be slightly tough. This variation in tenderness may be accounted for, in part, by the kind and amount of connective tissue present in the breast and thigh. The breast contains a small amount of collagenous and very little elastic connective tissue as contrasted to the larger amounts of connective tissue present in the leg and thigh muscles.

The breast and thigh muscles of poultry vary in other respects. The breast is composed of two muscles, whereas the thigh is made up of many small muscles. The dark meat is characterized, too, by larger amounts of fat and muscle pigment than the light meat.

In the present study internal temperatures of 85° and 90° C. in the pectoralis major and in the thigh muscles were used as end points for cooking turkey halves. Both the light and dark meat from all birds were tested for palatability and degree of doneness. The terms breast and pectoralis major muscle will be used interchangeably in the following discussion.

Rate of Heat Penetration

In general, the rise in temperature during roasting was rapid and steady in both the pectoralis major and thigh muscles. The average increase in temperature for each 20-minute interval of the cooking period for the pectoralis major and for the thigh muscles of the 40 turkey halves is shown in Table 2. After the

first 100 minutes of cooking, the means represented a decreasing number of birds for each 20-minute interval. The average figures for the rise in temperature of the muscles for periods beyond 160 minutes probably were not typical of the rate the turkeys cooked as they represented only one or two halves.

Table 2. Average increase in temperature (° C.) in the pectoralis major and thigh muscles during each 20 minutes of the cooking period.

Minutes	Pectoralis major	Thigh	Number of halves
0- 20	12.0	12.8	40
20- 40	13.6	16.1	40
40- 60	13.8	14.8	40
60- 80	12.0	12.8	40
80-100	8.7	9.8	40
100-120	6.3	9.1	38
120-140	5.3	6.3	27
140-160	3.9	3.5	10
160-180	3.0	3.3	2
180-200	2.0	1.0*	2
200-220	3.0	0.0	1

* Temperature in one half reached 100° C.

During the first 20 minutes in the oven the heat penetrated the breast and the thigh muscles at about the same rate. After this initial period the average rise in temperature was steady in both muscles, but it was more rapid in the thigh than in the

pectoralis major. A lag in the rate at which the temperature of the muscles increased was evident in both muscles after 80 minutes of cooking, but it was more pronounced in the pectoralis major than in the thigh. For example, in the interval between 100 and 120 minutes the thigh temperature rose 9.1° C., whereas that of the breast rose only 6.3° C. The progressive decline in the rate at which the temperature of the muscles rose continued until the turkeys were removed from the oven. Considerable coagulation of proteins with the absorption of heat probably was taking place during this period. The fact that the lag in temperature occurred earlier in the pectoralis major than in the thigh muscles indicates that coagulation began in the breast before it began in the thigh.

When the birds were removed from the oven, the temperature was higher in the thigh muscles than in the pectoralis major muscle in 38 of the 40 halves. It should be noted that after 80 minutes in the oven, the thermometer in the thigh registered higher than that in the pectoralis major in 24 of the half birds, and after 120 minutes, 33 had a higher temperature in the thigh than in the breast muscle. These findings are in agreement with Alexander et al. (1951) who reported that the temperature of the thigh was considerably higher than in the breast in well-done birds. The comparative size of the muscles involved might be a factor affecting this difference in temperature as these workers observed only a slight difference between the thigh and breast temperatures of well-done Beltsville Small White females.

In a comparison of the temperatures in the pectoralis major and in the thigh just before roasting with the length of total cooking time, it did not follow that birds with low initial temperatures required longer cooking times (Table 10, Appendix). The internal temperatures of the breast and thigh muscles varied somewhat when the turkeys were placed in the oven, even though all the birds were defrosted at room temperature for 21 hours. This variation might have been caused, in part, by fluctuation of the temperature of the room during thawing. Records from a recording thermometer showed an 11 degree Fahrenheit range (75° to 86° F.) in the temperature of the room during the 10 defrosting periods. The initial temperatures of the breast muscle varied from 5° to 20° C., whereas the initial temperatures in the thigh ranged from 1° to 17° C. Edgar (1953) also found that cooking time was not lengthened appreciably by low initial temperatures in the birds.

Organoleptic and Objective Tests

A palatability committee scored the turkey halves for flavor, juiciness, tenderness and doneness. In addition, cooking losses, cooking time, shear values and press fluid yields were determined. A summary of the results of the statistical analyses is given in Table 3 and average of mean scores for the organoleptic and objective evaluations are given in Table 4.

Flavor. When the temperatures in the pectoralis major and in the thigh were compared as end points for roasting, the flavor scores were significantly different in only one instance. The

Table 3. Summary of analyses of variance for roasted turkey halves.

Factors	Pectoralis major vs. Thigh	85° C. vs. 90° C.
Flavor, light meat	ns	ns
Flavor, dark meat	* P.M.	ns
Juiciness, light meat	ns	** 85° C.
Juiciness, dark meat	ns	* 85° C.
Tenderness, light meat	ns	ns
Tenderness, dark meat	* P.M.	ns
Shear values	ns	ns
Total press fluid yields	ns	*** 85° C.
Cooking time	** P.M.	*** 90° C.
Cooking losses		
Total	** P.M.	*** 90° C.
Volatile	ns	*** 90° C.
Dripping	*** P.M.	ns

P.M. - Pectoralis major muscle
ns - non significant
* - significant at the 5% level
** - significant at the 1% level
*** - significant at the 0.1% level

Table 4. Average of mean palatability scores* and objective test means for roasted turkey halves.

Factors	85° C. Pectoralis major	85° C. Thigh	90° C. Pectoralis major	90° C. Thigh
Flavor, light meat	5.5	5.4	5.5	5.6
Flavor, dark meat	5.5	5.4	5.7	5.6
Juiciness, light meat	4.9	5.2	4.4	4.8
Juiciness, dark meat	5.0	5.1	4.6	5.0
Tenderness, light meat	5.8	5.8	6.1	5.9
Tenderness, dark meat	5.5	5.2	5.6	5.3
Shear, lbs.	12.9	11.6	12.6	11.9
Total press fluid, ml./25 g.	9.5	9.6	8.8	8.9
Cooking time, min./lb.	20.7	19.0	25.0	20.4
Cooking losses				
Total, percent	20.0	16.4	24.1	19.3
Volatile, percent	8.0	7.0	11.6	9.2
Dripping, percent	12.0	9.3	12.6	10.1

* Maximum score of seven

dark meat scores were higher ($P<.05$) when the end point temperatures were taken in the pectoralis major than when taken in the thigh (Table 3). Averages of mean palatability scores for dark and light meat differed only in the birds cooked to the temperature of 90° C. in the pectoralis major muscle (Table 4). In this group, the dark meat was rated slightly higher than the light. In all other groups the dark meat received the same score as the light. Dark meat from the turkeys cooked to an internal temperature of 90° C. in the breast and both light and dark meat from those cooked to 90° C. in the thigh rated slightly higher than the samples from the birds cooked to 85° C. in either muscle, but the difference was not significant.

Tenderness. Tenderness of the dark meat was significantly greater when the internal temperature of the pectoralis major rather than the thigh muscles was used as end-point temperature. The light meat from all birds scored somewhat more tender than the dark meat (Table 4). This disagrees with the work of Marsden et al. (1952) who found the leg (thigh) meat more tender than the breast. Goertz et al. (1955) also found the gluteus primus more tender than the pectoralis major. The difference in results might be explained, in part, by the fact that these workers used only the gluteus primus muscle, a thin muscle exposed to the heat and probably more done than the muscle under it. A composite of two thigh muscles was used in the present study.

Shear values for cores taken from the light meat were higher for the birds roasted to an end-point temperature in the

pectoralis major than in the thigh, but the difference was not significant (Table 4). A significant correlation was found between tenderness and shear value ($r = -0.327$). The low negative r value, even though significant should be interpreted with caution because when tenderness scores and shear values were averaged for a given treatment, the higher scores were associated with the higher shear values.

Juiciness. Turkey halves roasted to the lower temperature used in this study were juicier than those roasted to the higher temperature. The dark meat was significantly more juicy and the light meat very significantly more juicy in the birds cooked to 85° C. than in those cooked to 90° C. (Table 3). The dark meat was more juicy than the light in all birds except those cooked to 85° C. in the thigh muscle (Table 4). This observation is in agreement with the findings of Marsden et al. (1952) in that the thigh muscle was considered more juicy than the breast, probably because of the richness of the juice rather than the actual percentage of water present. However, Goertz et al. (1955) and Lewis (1955) found light meat to be more juicy than dark. As was pointed out earlier, these workers used only the gluteus primus muscle for sampling, whereas in the present study a composite of the gluteus primus and semitendinosus muscles was sampled.

Press fluid yields were related to internal temperature and to juiciness. Press fluid yields were increased ($P<.001$) by decreasing the end-point temperature from 90° C. to 85° C. (Table 3). Slightly greater press fluid yields were obtained

when the temperature was measured in the thigh than in the breast, but the difference was not significant. The juiciness scores for the light meat and the press fluid yields on breast meat samples showed a very highly significant correlation ($r = +0.618$). There was a correlation ($P<.001$), too, between total cooking losses and juiciness scores for the light meat ($r = -0.609$). Some of these findings tend to disagree with the work of Goertz (1952) and Lewis (1955) neither of whom found a significant correlation between the juiciness scores and press fluid yields in a comparison of the same muscle as used in the present study.

Total cooking losses were definitely greater ($P<.01$) when the end-point temperature was taken in the pectoralis major than in the thigh and when 90° rather than 85° C. was used for the terminal temperature ($P<.001$). Dripping losses during cooking were greater ($P<.001$) when the end-point temperature was taken in the pectoralis major than when it was taken in the thigh, however, the differences in dripping losses attributed to temperature were non significant. Volatile losses were increased considerably ($P<.001$) when the birds were cooked to 90° instead of 85° C. No difference in volatile losses could be assigned to the muscle in which the end-point temperature was taken.

There was an apparent relationship between total cooking time and total cooking losses as the birds that cooked the longest time also had the largest total cooking losses (Table 4). Total cooking times were significantly longer ($P<.001$) when the breast rather than the thigh temperature was used as an end point.

The increase in cooking time caused by the increase in temperature was proportionately greater when the end-point temperature was taken in the pectoralis major muscle than in the thigh. The average number of minutes per pound for cooking all of the birds was shorter than the time used by Goertz et al (1955) whose cooking times ranged from 25.2 minutes to 26 minutes, and for that of Lewis (1955) who cooked all birds 26 minutes or longer. An oven temperature of 300° F. was used in both of these studies, as compared to 325° F. in the present investigation.

Doneness. Tests for doneness included the rating of the dark and light meat samples and the appearance of the juice by the palatability committee. Also, the carver made observations on the ease of movement of the joints, the softness of the muscles when pressure was applied and the color of the muscles and juice from the carcass.

Dark and light meat doneness ratings followed a similar pattern. Both dark and light meat from birds cooked to 90° C. in the pectoralis major rated significantly more done ($P<.05$) than the meat from all other birds (Table 5). The meat from birds cooked to 90° C. in the thigh and 85° C. in the pectoralis major were rated significantly more done ($P<.05$) than that from the birds cooked to 85° C. in the thigh. Meat from birds cooked to 90° C. in the thigh and from those cooked to 85° C. in the breast received similar ratings for degree of doneness. On the basis of ratings given to the dark and light meat, birds given all treatments except those cooked to 85° C. in the thigh were considered done. Turkey halves cooked to 90° C. in the

pectoralis major were rated midway between done and slightly overdone.

The judges rated the juice that exuded from the birds as they were carved less done than samples of meat from the same bird. From the appearance of the juice, all birds except those cooked to 90° C. in the breast muscle were considered somewhat underdone (Table 5). These birds were followed by those cooked to 90° C. in the thigh, 85° C. in the pectoralis major and 85° C. in the thigh. The juice ratings for the degree of doneness showed significant differences between any two groups of birds except between those cooked to 90° C. in the thigh and those cooked to 85° C. in the pectoralis major. Differences between the mean ratings for the doneness of these two groups of birds lack only 0.02 of a point of being significant.

The juice from the birds cooked to 90° C. was considered more done ($P<.001$) than that from those cooked to 85° C. Likewise, juice from birds in which the end-point temperature was measured in the pectoralis major was rated more done ($P<.01$) than juice from birds in which the end-point temperature was taken in the thigh. Analyses of variance data for doneness of the juice are presented in Table 21, Appendix.

The carver's observations were related somewhat to the appearance of the juice. An underdone color was noted in the muscle and juice in some of the birds. In most cases the appearance of the juice from these same birds was rated underdone by the palatability committee. The carver noted that the ease of disjointing differed little from one bird to another. At three

of the 10 cooking periods the birds cooked to 90° C. in the pectoralis major were considered crumbly and difficult to slice.

Table 5. Average ratings for degree of doneness of roasted turkey halves.

	Juice[1]	Light meat[2]	Dark meat[3]
90° C. Pectoralis major	3.23	3.46	3.43
	*	*	*
90° C. Thigh	2.74	3.18	3.03
	near *	ns	ns
85° C. Pectoralis major	2.39	3.01	3.10
	*	*	*
85° C. Thigh	1.96	2.72	2.69

[1] lsd 0.37, $P<.05$
[2] lsd 0.23, $P<.05$
[3] lsd 0.21, $P<.05$
ns - non-significant
* - significant ($P<.05$)

Doneness was associated with other palatability factors. As would be expected, the turkeys that were rated the most done (90° C. in the pectoralis major muscle) received the highest average score for tenderness and the lowest average score for juiciness, whereas the turkeys that were the least done (85° C. in the thigh muscle) scored the highest for juiciness and the lowest for tenderness. The underdone turkeys also rated slightly lower than all others in flavor.

The turkey halves cooked to 90° C. in the pectoralis major

were rated the most done, required the longest time to cook (25 minutes per pound) and lost the most weight during cooking (24.1 percent). On the other hand, turkeys cooked to 85° C. in the thigh were the least done and required the shortest cooking time (19 minutes per pound) and had the smallest cooking losses (16.4 percent). This was in agreement with Lowe (1955) who stated that the more well done meat was cooked, the greater was the cooking losses.

The birds rated most done reached higher internal temperatures in both the breast and thigh muscles than any other group of birds, and those rated the least done had the lowest internal temperatures in the breast and thigh. When a temperature of 90° C. was obtained in the pectoralis major, the average thigh temperature was 97.2° C.; when a temperature of 85° C. was reached in the thigh, the average pectoralis major temperature was 82.3° C.

Average doneness ratings for birds cooked to 85° C. in the pectoralis major were similar to those for birds cooked to 90° C. in the thigh. Also, the average cooking times for these two groups of birds differed by less than one minute per pound and the total cooking losses by less than one percent. In addition, average juiciness and tenderness scores were much the same for both groups; however, the press fluid yields and shear values did not follow this pattern.

Judges' ratings for degree of doneness showed that the birds cooked to 90° C. in the thigh were slightly more done than those cooked to 85° C. in the pectoralis major. This was noted

especially in the ratings for the appearance of the juice. Records show that the birds removed from the oven at an internal temperature of 90° C. in the thigh registered an average pectoralis major temperature of 86.3° C. The turkey halves cooked to an end point of 85° C. in the pectoralis major had an average thigh temperature of 94.2° C.

Under the conditions of this experiment there was a relationship between internal temperature of the breast and thigh and degree of doneness of the meat. A temperature of 85° C. in the thigh muscle did not, in most cases, cook the birds sufficiently. Birds cooked to 85° C. in the pectoralis major and 90° C. in the thigh were considered about done when judged by tasting the meat, but underdone when measured by the appearance of the juice. A temperature of 90° C. in the pectoralis major muscle produced some birds that were rated overcooked when tasted, but done when the appearance of the juice was evaluated. These birds were scored highest for flavor and tenderness and generally were considered the most desirable of all the birds used in the experiment. It was evident from this study that the appearance of the juice gave a more accurate picture for judging optimum doneness of the whole bird than did the isolated samples of dark and light meat. The carver's opinion of the appearance of the carcass at the time of carving, in general, agreed with the ratings for the appearance of the juice.

SUMMARY

Forty paired halves of Broad Breasted Bronze turkeys were used to evaluate the temperatures of 85° and 90° C. in the pectoralis major and in the thigh muscles as an indication of doneness. Turkeys roasted at 325° F. to the above end-point temperatures were compared for cooking losses, cooking time, press fluid yields, shear values and palatability factors including tenderness, juiciness, flavor and degree of doneness.

The rate of heat penetration was studied from data obtained by recording the internal temperatures of the thigh and pectoralis major muscles every 20 minutes during the cooking period. The average rise in temperature during cooking was steady in both muscles, but more rapid in the thigh than in the pectoralis major. After the birds had been in the oven 80 minutes, there was a lag in the rate at which the temperature of the muscles increased and the rate continued to diminish during the remainder of the cooking time. The lag in the rate at which the temperature rose appeared earlier and was more pronounced in the pectoralis major than in the thigh, which indicated that coagulation of proteins began earlier in the breast than in the thigh.

There was a direct relationship between the end-point temperatures of 85° and 90° C. and several of the factors considered. Birds cooked to 85° C. were juicier ($P<.05$) and the volume of press fluid obtained from the pectoralis major muscle was greater ($P<.05$) than for those cooked to 90° C. Moreover, the average total and volatile cooking losses and average cooking

time were greater for the birds cooked to 90° C. than for those cooked to 85° C. ($P<.001$).

Flavor and tenderness of the dark meat scored higher ($P<.05$) in the birds in which the pectoralis major rather than the thigh temperature was the end point. Total cooking ($P<.01$) and dripping ($P<.001$) losses also were greater for the birds in which the end-point temperature was taken in the breast than for those in which it was taken in the thigh. The relationship between the end-point temperature of the pectoralis major and the optimum doneness of the meat was greater than the relationship between the thigh end-point temperature and optimum doneness.

Turkeys roasted to 85° C. in the thigh were rated the least done of any of the birds. They had the lowest cooking losses (16.4 percent), the shortest cooking time (19.0 minutes per pound), the greatest press fluid yields, the highest scores for juiciness and the lowest scores for flavor.

Turkey halves cooked to the temperature of 90° C. in the thigh and 85° C. in the pectoralis major were significantly more done than those cooked to 85° C. in the thigh and less done than those cooked to 90° C. in the pectoralis major. Turkeys cooked to 85° C. in the pectoralis major required an average cooking time of 20.7 minutes per pound and showed mean total cooking losses of 20 percent. The birds cooked to 90° C. in the thigh gave results similar to the above in that their average cooking time was 20.4 minutes per pound and their mean total cooking losses were 19.3 percent. The average cooking time for the birds in these groups was approximately a minute longer than that for

the birds cooked to 85° C. in the thigh. However, the average total cooking losses were about midway between the losses recorded for the turkeys cooked to 85° C. in the thigh and 90° C. in the pectoralis major. Palatability scores for the birds cooked to 85° C. in the pectoralis major and those cooked to 90° C. in the thigh showed a marked similarity. They differed mainly in that the birds cooked to 90° C. in the thigh rated somewhat higher for doneness than those cooked to 85° C. in the breast.

Turkeys cooked to 90° C. in the pectoralis major were considered the most done of any of the birds in the study. The cooking losses for these birds were greatest (24.1 percent), the tenderness and flavor scores highest and the press fluid yields and juiciness scores the lowest of those for all the birds cooked. Cooking time was 25.0 minutes per pound, the longest average time required to cook any of the birds used in this study.

In this experiment, the appearance of the juice that exuded when the birds were carved was a better guide to the degree of doneness of the whole birds than the doneness ratings for the samples of the dark and light meat. Birds cooked to 85° C. in the thigh were considered underdone by ratings of both meat and juice and birds cooked to 90° C. in the pectoralis major were considered done by both criteria. Meat from the birds cooked to the internal temperatures of 85° C. in the pectoralis major and 90° C. in the thigh was rated done, but the appearance of the juice was considered somewhat underdone.

The birds cooked to the end-point temperature of 85° C. in the thigh were markedly underdone and those cooked to 85° C. in

the pectoralis major and 90° C. in the thigh were not always acceptable. The birds cooked to 90° C. in the pectoralis major were nearer the general concept of optimum doneness than those cooked to the other internal temperatures.

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APPENDIX

Form I. Weight losses of roasted turkey halves before and after cooking.

I. Losses by weight — Grams

A. Before cooking

1. Weight of bird
2. Weight of pan, rack and thermometer
3. Weight of pan, rack, thermometer and bird

B. After cooking

1. Weight of pan, rack, thermometer, bird and drippings
2. Volatile loss (A3 - B1)
3. Weight of bird and platter
4. Weight of platter
5. Cooked weight of bird (B3 - B4)
6. Total cooking loss (A2 - B5)
7. Weight of pan, rack, thermometer and drippings
8. Dripping loss (B7 - A3)

II. Losses as percent of weight — Percent

A. Volatile loss (B ÷ A1)

B. Total cooking loss (B6 ÷ A1)

C. Dripping loss (B8 ÷ A1)

Date_____

Form II. Score card for turkey

NAME_____

Sample number	Eating Quality: Flavor	Juiciness	Tenderness	Remarks	*Doneness: Underdone: Very	Underdone: Slightly	Done	Overdone: Slightly	Overdone: Very
1									
2									
3									
4									
5									
6									
7									

DESCRIPTIVE TERMS FOR FLAVOR, JUICINESS, AND TENDERNESS

7 - very desirable
6 - desirable
5 - moderately desirable
4 - slightly desirable
3 - slightly undesirable
2 - moderately undesirable
1 - undesirable

Sample Number					
1					
2					
3					
4					

APPEARANCE of JUICE

*Please check (✓) degree of doneness.

Table 6. Internal temperature (° C.) recorded each 20 minutes in turkey halves roasted to 85° C. in the pectoralis major.

Minutes											
0	20	40	60	80	100	120	140	160	180	200	220	Total
Pectoralis major												
9	30	46	58	71	79	81	85					140
17	35	47	61	71	79							118
14	22	32	48	60	67	74	78	82				168
12	27	40	52	65	77	80						136
20	26	38	50	62	72	79	83					148
18	36	51	63	72	82*	80	83					154
19	34	48	62	72	78	78						148
12	24	40	54	67	78	82*	82					155
10	25	40	54	65	74	83	85					140
-	19	30	43	55	67	75	80					152
Thigh												
1	12	31	43	60	72	82	93					
17	36	52	64	74	84							
8	15	28	45	60	70	80	87	93				
14	32	49	65	77	85	95						
17	30	47	62	76	84	90	90					
13	25	41	55	66	76	84	90					
14	22	38	50	64	68	80						
3	12	30	46	64	75	80	89					
5	14	35	47	61	72	82	92					
-	25	42	58	68	80	86	93					

* Thermometer adjusted

Table 7. Internal temperature (° C.) recorded each 20 minutes in turkey halves roasted to 85° C. in the thigh muscle.

Minutes											
0	20	40	60	80	100	120	140	160	180	200	220	Total
Thigh												
3	22	40	53	63	72	81						132
12	32	49	61	70	78	85						120
15	22	36	49	65	77	85						120
7	24	40	56	66*	57	70	78	85				160
17	31	45	58	70	82							115
15	27	40	55	65	76*	78						137
14	22	35	50	62	73	85						120
4	12	30	45	60	70	80						130
10	25	42	58	70	78*	81	85					140
-	28	47	63	75	75	81						130
Pectoralis major												
10	23	38	53	65	78	80						
15	27	40	54	64	73	81						
15	25	37	54	65	74	82						
14	22	35	47	60	68	75	84	87				
18	27	42	55	67	74							
19	29	40	53	64	73	80						
18	28	40	54	64	72	77						
8	19	33	48	60	70	79						
13	24	38	52	65	74	82	87					
-	17	28	44	60	67	75						

* Thermometer adjusted

Table 8. Internal temperature (° C.) recorded each 20 minutes in the turkey halves roasted to 90° C. in the pectoralis major.

Minutes												
0	20	40	60	80	100	120	140	160	180	200	220	Total
Pectoralis major												
5	26	39	53	65	75	80	85	89				163
13	28	44	58	70	78	85						139
15	21	32	44	55	63	69	76	80	84	86	89	227
19	28	42	55	67	72	79	84	88				170
17	34	50	64	74	81*	80	83	87				172
16	24	34	48	58	67	74	83	87	89			185
14	23	35	48	60	69	76	84	89				164
11	21	34	48	61	70	78	85					158
16	24	40	55	65	74	79	85	86	-	90		200
-	25	39	53	65	73	80	85					153
Thigh												
2	24	41	51	63	72	84	93	97				
10	30	45	61	73	85	92						
7	16	30	46	62	73	80	90	95	100	100	100	
11	20	35	50	65	73	82	89	93				
15	35	52	65	78	88	94	97	99	96			
12	20	32	48	63	73	87	85	100				
9	14	32	49	61	71	80	88	95				
5	18	35	49	62	72	84	91					
8	18	38	51	66	75	87	92	96	98	100		
-	17	32	48	60	70	77	85	96				

* Thermometer adjusted

Table 9. Internal temperature (° C.) recorded each 20 minutes in turkey halves roasted to 90° C. in thigh.

Minutes											
0	20	40	60	80	100	120	140	160	180	200	220	Total
Thigh												
3	18	38	50	63	72	81	82					146
14	30	45	59	70	80	89						123
10	25	41	57	71	82	88						126
14	26	40	55	68	78	86*	86					152
12	25	-	54	65	75	84	89					143
16	28	43	57	68	78	84	90					140
13	22	35	50	62	72	83						135
3	21	40	56	68	76	84	88					144
3	12	25	39	53	65	75	85					154
-	25	41	54	67	75	85*	78	88				164
Pectoralis major												
8	32	50	63	74	82	84	88					
18	32	48	60	72	78	84						
15	22	39	53	65	73	82						
20	32	49	60	71	78	80	83					
15	23	-	48	60	70	77	83					
17	28	38	51	62	70	80	87					
16	30	45	58	67	75	80						
8	18	32	47	61	70	76	83					
12	22	32	52	65	75	84	87					
-	25	37	52	65	73	80	85	88				

* Thermometer adjusted

Table 10. Initial temperature in the pectoralis major and in the thigh muscles, and average cooking times for roasted turkey halves.

85° C. Pectoralis major:		85° C. Thigh		:90° C. Pectoralis major:		90° C. Thigh	
° C.	min./lb.	° C.	min./lb.	° C.	min./lb.	° C.	min./lb.
9	20.2	5	18.9	5	24.1	3	20.9
10	19.6	4	17.8	11	23.4	3	22.1
12	20.1	7	21.6	13	20.3	3	23.0
12	21.6	10	19.4	14	23.2	10	17.3
14	23.3	12	18.5	15	31.3	12	19.1
17	17.8	12	18.6	16	29.3	13	20.3
18	20.9	14	18.0	16	27.2	14	16.6
19	19.7	15	21.0	17	25.5	14	21.3
20	22.4	17	17.1	19	25.0	16	18.2
Av.	20.7		19.0		25.0		20.4

Table 11. Initial temperature (° C.) in pectoralis major and thigh muscles for roasted turkey halves.

85° C. Pectoralis major:		85° C. Thigh		:90° C. Pectoralis major:		90° C. Thigh	
P.M.*	Thigh	Thigh	P.M.*	P.M.	Thigh	Thigh	P.M.
9	1	5	10	5	2	3	8
10	5	4	8	11	5	3	8
12	14	7	14	13	10	3	12
12	3	10	13	14	9	10	15
14	8	12	15	15	7	12	15
17	17	12	15	16	8	13	16
18	13	14	18	16	12	14	18
19	14	15	19	17	15	14	20
20	17	17	18	19	11	16	17

* Pectoralis major

Table 12. Average flavor scores for roasted turkey halves.

85° C. Pectoralis major		85° C. Thigh		90° C. Pectoralis major		90° C. Thigh	
Light	Dark	Light	Dark	Light	Dark	Light	Dark
5.7	5.7	5.5	5.2	5.2	4.8	5.5	5.2
5.8	5.2	6.0	5.5	5.8	6.2	5.7	5.3
6.0	5.4	5.2	5.2	5.8	5.6	5.8	5.6
5.7	5.5	5.5	5.7	5.5	5.7	6.0	6.0
5.8	5.6	5.6	5.4	6.0	5.8	5.8	5.8
4.0	5.6	5.2	5.2	4.4	5.4	5.2	5.2
5.6	5.4	5.4	5.6	5.2	6.0	5.2	5.6
5.6	5.4	5.2	5.2	6.0	5.8	5.6	5.2
5.2	5.6	5.8	5.6	5.6	6.0	5.6	6.0
5.8	6.0	4.5	5.5	5.5	6.0	5.5	5.8
Av. 5.5	5.5	5.4	5.4	5.5	5.7	5.6	5.6

Table 13. Average tenderness scores for roasted turkey halves.

85° C. Pectoralis major:		85° C. Thigh		90° C. Pectoralis major:		90° C. Thigh	
Light	Dark	Light	Dark	Light	Dark	Light	Dark
6.2	5.5	6.2	5.4	5.7	5.6	5.8	5.7
4.8	5.0	5.8	4.0	6.2	5.7	6.2	4.8
6.0	5.6	5.6	5.2	6.2	5.8	6.0	5.6
5.7	5.4	5.7	5.8	6.0	5.8	6.2	5.8
6.6	6.0	5.8	5.8	6.6	6.2	6.6	5.6
6.0	6.0	6.4	5.6	6.4	6.0	6.0	5.4
6.0	4.6	5.8	5.0	5.8	5.2	5.6	4.8
5.4	5.6	5.4	4.8	5.6	5.4	5.2	4.8
5.8	5.6	6.0	5.2	6.2	5.8	6.0	5.8
5.8	5.3	5.3	5.3	5.8	4.8	5.8	5.0
Av. 5.8	5.5	5.8	5.2	6.1	5.6	5.9	5.3

Table 14. Average juiciness scores for roasted turkey halves.

85° C. Pectoralis major:		85° C. Thigh		:90° C. Pectoralis major:		90° C. Thigh	
Light	Dark	Light	Dark	Light	Dark	Light	Dark
4.7	5.2	4.2	4.7	5.2	4.8	4.7	4.8
4.5	5.0	5.3	5.3	4.2	4.7	4.3	5.2
3.8	4.0	5.0	4.8	3.0	3.6	5.0	4.8
5.0	5.3	4.7	4.8	4.5	4.3	3.8	4.8
4.4	4.4	4.8	4.5	4.2	4.2	5.0	4.6
5.0	5.4	5.0	5.2	4.4	4.8	4.6	5.2
5.4	5.0	5.6	5.2	4.4	5.0	5.2	5.0
5.6	5.2	6.4	5.4	5.0	4.8	6.0	5.6
5.0	5.4	5.2	5.0	4.2	4.8	5.0	5.2
5.3	5.3	6.0	6.0	5.0	5.3	4.3	4.5
Av. 4.9	5.0	5.2	5.1	4.4	4.6	4.8	5.0

Table 15. Analysis of variance mean squares for palatability factors of roasted turkey halves.

Source of variation	D/F	Mean squares and significance					
		Flavor		Juiciness		Tenderness	
		Light	Dark	Light	Dark	Light	Dark
Blocks	9	0.43 ns	0.16*	0.75 ns	0.44*	0.31*	0.54*
Muscles	1	0.00 ns	0.21*	1.33 ns	0.42 ns	0.05 ns	0.76*
Error (a)	9	0.21	0.04	0.40	0.13	0.07	0.14
Temperature	1	0.08 ns	0.30 ns	1.98**	0.65*	0.32 ns	0.21 ns
T x M	1	0.13 ns	0.01 ns	0.01 ns	0.18 ns	0.02 ns	0.01 ns
Error (b)	18	0.07	0.08	0.15	0.09	0.11	0.07
Total	39						

ns - non significant
* - significant at the 5% level
** - significant at the 1% level

Table 16. Average shear values (pound/square inch) for pectoralis major muscle of roasted turkey halves.

85° C. Pectoralis major:	85° C. Thigh	90° C. Pectoralis major:	90° C. Thigh
11.5	12.4	14.7	14.0
11.3	11.2	12.4	10.2
18.1	12.5	13.3	13.4
10.5	9.5	8.5	10.0
12.1	10.9	11.8	9.7
10.6	8.4	10.5	8.0
10.8	10.5	8.8	13.5
13.7	15.5	17.2	14.8
15.3	12.1	12.3	13.1
15.4	12.8	16.3	11.9
Av. 12.9	11.6	12.6	11.9

Table 17. Average press fluid yields (ml./25 g.) for pectoralis major muscle of roasted turkey halves.

85° C. Pectoralis major:		85° C. Thigh		90° C. Pectoralis major:		90° C. Thigh	
Total	Fat	Total	Fat	Total	Fat	Total	Fat
9.2	0.7	9.7	0.4	9.8	0.6	8.7	0.5
10.8	0.7	10.5	0.5	9.9	0.8	10.3	0.5
8.3	0.5	9.0	0.7	7.0	0.6	8.8	0.2
9.4	0.5	9.3	0.5	8.9	0.7	7.4	0.3
9.0	0.4	9.7	0.3	8.1	0.2	10.1	0.3
9.1	0.2	8.7	0.7	8.9	0.3	8.7	0.6
9.6	0.5	8.7	0.5	9.0	0.3	8.7	0.5
10.5	0.3	10.7	0.3	9.2	0.3	10.3	0.4
9.5	0.3	9.4	0.3	8.1	0.2	7.7	0.2
9.7	0.2	10.1	0.3	9.2	0.3	9.1	0.2
Av. 9.5	0.4	9.6	0.5	8.8	0.4	8.9	0.4

Table 18. Average cooking losses (percent) for roasted turkey halves.

85° C. Pectoralis major:			85° C. Thigh			90° C. Pectoralis major:			90° C. Thigh		
V[1]	D[2]	T[3]	V	D	T	V	D	T	V	D	T
5.9	10.9	16.8	5.1	11.5	16.6	7.1	15.2	22.3	9.8	8.6	18.4
4.5	12.4	16.9	4.6	9.7	14.3	7.2	14.0	21.1	6.7	10.1	16.8
8.8	16.4	25.2	6.6	8.7	15.4	18.9	12.1	31.0	5.2	10.1	15.3
5.9	14.1	20.0	6.4	14.1	20.5	8.6	14.4	23.0	11.9	12.2	24.1
10.4	11.8	22.2	7.4	5.5	12.8	13.8	10.7	24.5	10.0	6.3	16.3
9.9	11.2	21.1	8.4	8.4	16.8	13.0	13.9	26.9	7.9	13.9	21.8
6.2	10.6	16.9	6.4	7.5	13.9	11.2	11.1	22.3	8.1	10.1	18.2
9.0	11.2	20.2	7.1	10.2	17.3	12.1	11.9	24.0	9.0	8.6	17.6
8.9	10.7	19.6	9.8	9.9	19.7	14.1	11.9	26.0	10.6	10.4	21.0
10.2	10.8	21.1	8.6	7.9	16.5	9.5	10.5	19.9	13.2	10.4	23.6
Av. 8.0	12.0	20.0	7.0	9.3	16.4	11.6	12.6	24.1	9.2	10.1	19.3

[1] Volatile losses

[2] Dripping losses

[3] Total losses

Table 19. Analysis of variance mean squares for objective measurements of roasted turkey halves.

Source of variation	D/F	Mean square and significance					
		Volatile loss	Dripping loss	Total loss	Shear	Press fluid	Min./lb.
Blocks	9	11.16 ns	8.05*	11.99 ns	16.93**	1.72 near*	6.77 ns
Muscles	1	26.00 ns	67.00***	176.61**	10.54 ns	0.17 ns	101.12**
Error (a)	9	8.32	2.32	15.81	2.76	0.55	8.10
Temperature	1	82.57***	4.06 ns	123.17***	0.01 ns	4.11***	80.09***
T x M	1	4.73 ns	0.08 ns	3.55 ns	1.04 ns	0.01 ns	20.74*
Error (b)	18	3.35	2.88	2.52	2.21	0.24	4.42
Total	39						

ns - non significant
* - significant at the 5% level
** - significant at the 1% level
*** - significant at the 0.1% level

Table 20. Average scores for doneness of roasted turkey halves.[1]

85° C. Pectoralis major:			85° C. Thigh			90° C. Pectoralis major:			90° C. Thigh		
Light	Dark	Juice	Light	Dark	Juice	Light	Dark	Juice	Light	Dark	Juice
3.3	2.8	2.8	3.3	3.0	1.5	2.5	2.7	3.1	3.2	3.0	1.8
2.5	2.7	1.8	2.5	2.4	1.8	3.2	3.2	2.8	2.8	2.7	2.1
3.6	3.8	3.3	2.6	2.6	2.8	4.0	4.2	4.0	2.8	3.2	2.0
2.8	3.0	3.0	3.3	3.3	1.1	4.3	3.8	4.0	3.8	3.6	4.0
3.6	3.6	3.2	2.2	2.4	2.2	3.6	3.6	3.2	3.2	3.2	3.0
2.8	3.2	1.6	3.0	2.8	2.0	3.2	3.6	3.0	3.4	2.8	3.6
3.0	3.0	2.2	3.0	3.0	1.2	3.6	3.4	4.0	3.0	2.8	3.2
2.6	3.0	1.2	2.0	2.2	3.2	3.4	3.2	3.0	2.8	2.8	2.0
2.6	2.6	2.8	3.0	3.2	1.3	3.8	3.8	3.4	3.0	3.2	2.4
3.3	3.3	2.0	2.3	2.0	2.5	3.0	2.8	1.8	3.8	3.0	3.3
Av. 3.01	3.10	2.39	2.72	2.69	1.96	3.46	3.43	3.23	3.18	3.03	2.74

[1] Descriptive terms for doneness ratings
1 Very underdone
2 Slightly underdone
3 Done
4 Slightly overdone
5 Very overdone

Table 21. Analysis of variance mean squares for doneness ratings for roasted turkey halves.

Source of variation	D/F	Juice	Light meat	Dark meat
Temperature	1	6.25***	2.07 ns	1.12 ns
Muscle	1	2.11**	0.81 ns	1.64 ns
Temperature x muscle	1	0.27 ns	4.54***	2.93***
Error	36	0.24	0.08	0.08
Total	39			

ns - non significant
** - significant at the 1% level
*** - significant at the 0.1% level

Table 22. Total checks for doneness given by judges of roasted turkey halves.

	Very underdone	Slightly underdone	Done	Slightly overdone	Very overdone
85° C. Pectoralis major					
Light	1	9	28	13	0
Dark	1	6	33	8	1
Juice	10	13	27	2	0
85° C. Thigh					
Light	5	9	31	7	0
Dark	3	15	25	6	0
Juice	14	23	14	1	0
90° C. Pectoralis major					
Light	0	5	22	24	2
Dark	0	3	25	17	3
Juice	1	6	24	20	1
90° C. Thigh					
Light	0	10	28	12	2
Dark	0	8	34	8	0
Juice	2	22	16	12	0

COMPARISON OF TWO INTERNAL TEMPERATURES IN THE BREAST AND IN THE THIGH MUSCLES AS AN INDICATION OF DONENESS IN ROASTED TURKEY HALVES

by

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INTRODUCTION

The need for a standardized procedure for roasting turkey has been recognized by research workers. One of the major problems is the lack of a satisfactory method for determining the optimum end point of cooking. The purpose of the present experiment was to study the effect of four end points of cooking on the degree of doneness of turkey halves. These end points were the internal temperatures of: (1) 85° C. in the pectoralis major muscle; (2) 85° C. in the thigh muscles; (3) 90° C. in the pectoralis major; and (4) 90° C. in the thigh.

MATERIALS AND METHODS

Twenty frozen Broad Breasted Bronze turkey hens were used for this experiment. At each of 10 cooking periods defrosted paired halves from two birds were roasted at 325° F. to end-point temperatures of 85° and 90° C., measured in the pectoralis major and in the thigh muscles. Halves receiving these four treatments were compared for the rate of heat penetration, cooking time, cooking losses, press fluid yields, shear values and palatability factors including tenderness, juiciness and flavor. In addition, the degree of doneness of the birds was determined from the appearance of the juice that exuded when the turkeys were carved, as well as from samples of dark and light meat.

RESULTS

The rate of heat penetration was rapid and steady in the pectoralis major and in the thigh muscles during the first 80 minutes of cooking. After this time interval, there was a lag in the rate at which the temperature of the muscles increased, and the rate of rise in temperature continued to diminish during the remainder of the cooking period. When the birds were removed from the oven, the temperatures were lower in the pectoralis major than in the thigh muscles.

Turkeys roasted to 85° C. in the thigh were rated the least done of any of the birds in this study. They had the lowest cooking losses (16.4 percent), the shortest cooking time (19.0 minutes per pound), the greatest press fluid yields (9.6 ml. per 25 g.), the highest scores for juiciness and the lowest scores for flavor.

Turkey halves cooked to 85° C. in the pectoralis major and 90° C. in the thigh rated more done ($P<.05$) than those cooked to 85° C. in the thigh and less done ($P<.05$) than those cooked to 90° C. in the pectoralis major. Birds cooked to 85° C. in the pectoralis major required an average cooking time of 20.7 minutes per pound and had mean total cooking losses of 20.0 percent, whereas those cooked to 90° C. in the thigh had an average cooking time of 20.4 minutes per pound and mean total cooking losses of 19.3 percent. This similarity in results also was noted in the palatability scores for the birds in these two groups.

Turkeys cooked to the end-point temperature of 90° C. in the pectoralis major were the most done of all the birds. The cooking losses for these birds were the greatest (24.1 percent); the cooking time (25.0 minutes per pound) the longest; the flavor and tenderness scores the highest; and the press fluid yields (8.8 ml. per 25 g.) and juiciness scores the lowest for all the birds cooked.

In this experiment, the appearance of the juice that exuded when the birds were carved was a better guide to the degree of doneness of the whole birds than the doneness ratings for the samples of the dark and light meat. Birds cooked to 85° C. in the thigh were considered underdone by ratings of both meat and juice and birds cooked to 90° C. in the pectoralis major were considered done by both criteria. Meat from the birds cooked to the internal temperatures of 85° C. in the pectoralis major and 90° C. in the thigh was rated done, but the appearance of the juice was considered somewhat underdone.

The birds cooked to the end-point temperature of 85° C. in the thigh were markedly underdone and those cooked to 85° C. in the pectoralis major and 90° C. in the thigh were not always acceptable. The birds cooked to 90° C. in the pectoralis major were nearer the general concept of optimum doneness than those cooked to the other internal temperatures.