DONENESS OF WHOLE TURKEYS ROASTED TO CERTAIN END POINT TEMPERATURES

by

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INTRODUCTION

Roasting turkeys presents a problem in that it is difficult to determine exactly when the point of optimum doneness is reached. Additional experimentation is needed before a suitable end point temperature can be recommended that consistently will produce optimumly done roasted turkeys.

Subjective tests for doneness such as feeling the flesh of the drumstick, moving the joints of the leg and pricking the flesh have been found to give inconsistent results. When a turkey tested for doneness in this manner is carved, it is sometimes observed that not all muscles are of the desired doneness. Determining internal end point temperatures by inserting a thermometer into the flesh of either the breast or the thigh also has been considered as a possible guide to doneness. Recent research conducted in this laboratory with turkey halves has indicated that this method of determining doneness will give fairly consistent results. Whole unstuffed birds present problems that differ from those noted when roasting half birds.

The objectives of this study were to compare the degree of doneness of whole unstuffed turkey hens roasted to end point temperatures of 85° and 90°C. in the breast and of 90° and 95°C. in the thigh muscles, and also to determine which of these temperatures consistently produced the most desirable degree of doneness. A comparison of the rate of heat penetration in the breast and the thigh muscles of whole and half birds should indicate

differences in rate of cooking that might exist when whole birds are roasted to the same end point temperatures as those used in studies of half turkeys. Such differences might be attributable to the effect of heat on the greater exposed surface of a whole turkey than of a half bird, and also to the difference of the position of the whole or half carcass in the pan. The data obtained from these observations should be beneficial in helping to develop a standard procedure for roasting turkeys.

REVIEW OF LITERATURE

An understanding of the physical and chemical composition of raw, partially cooked and fully cooked poultry muscle is needed to study the effect of various end point temperatures on the doneness of roasted whole turkeys. It is important, too, to trace the changes produced in muscle when heat is applied. The extent of these changes is dependent upon the degree of doneness reached in the muscle during cooking.

Physical Composition of Poultry Muscle

The relationship of the amount and distribution of muscle, connective and fatty tissue is important to palatability. According to Lowe (1955), the texture or the grain is determined largely by the arrangement of these three components within a given muscle. Strandine et al. (1949) observed the texture of a transverse section of a muscle and concluded that several palatability factors, especially tenderness, were dependent upon

the structure of muscle.

Muscle Tissue. Skeletal or striated muscle is composed of parallel groups of fibers referred to as bundles or fasciculi (Lowe, 1955). Szent-Györgyi (1951) indicated that a fiber within a bundle was actually a mass of contractile matter of cellular origin enclosed in a membrane, the sarcolemma. Lowe (1955) noted that fibers are composed of fibrils that are bathed in sarcoplasm and give the muscle an appearance of having longitudinal striations. These fibrils, too, are composed of alternate dark and light bands that give a cross striated appeárance to the whole muscle (Lowe, 1955). The distinctness of these cross striations, as well as the longitudinal ones, differs depending on whether the muscle is stretched, contracted or at rest. Histologically, the muscle fibers of raw poultry are characteristically wavy, kinky and twisting, and appear to be rhythmic in over-all design, according to Lowe (1948).

Connective Tissue. Collagenous and elastic connective tissues are an integral part of muscle tissue and are characterized by a small number of cells and a large amount of intercellular substance (Lowe, 1955). They form a soft net-like structure that helps to support the organs and the tissues of the body (Bate-Smith, 1942). Each individual muscle is surrounded by a layer of connective tissue referred to as a muscle sheath or epimysium. The bundles of fibers within a muscle are in turn surrounded by a layer of connective tissue, the perimysium. Lowe (1955) referred to the connective tissue within the fasciculi

that surrounds the individual muscle fibers as the endomysium or sarcolemma.

Collagenous Connective Tissue. The cellular portion of connective tissue is composed predominantly of collagenous fibers and is called collagenous connective tissue. It is characterized by a lack of elasticity, although the fibers may be stretched until the wavy structure is straight (Lowe, 1948). The fibers of collagenous tissue are slender and birefringent.

Elastic Connective Tissue. A second cellular component of connective tissue, Lowe (1955) stated, includes connective tissue composed predominately of elastic fibers. The fibers of elastic connective tissue differ from those of collagenous tissue in that they are more slender, more birefringent and elastic as the name implies.

Ground Substance. The large amount of ground substance or intercellular material of connective tissue was described by Miller and Kastellic (1956) as the mucinous and adhesive substance that holds the fibers of elastic and collagenous tissue together. According to Lowe (1955), this ground substance has no visible structure.

Fatty Tissue. A discussion of muscular structure is not complete without the consideration of fatty or adipose tissue. This tissue consists mainly of diffuse connective tissue in which the cells have become loaded with particles of fat. Bate-Smith (1942) noted that any connective tissue might become adipose tissue.

Lowe (1955) observed that first, fat is deposited subcutaneously and around the internal organs; next, around and between the muscles and finally, intramuscularly. Most of the fat that is deposited intramuscularly is found first between the fasciculi and then between some of the muscle fibers.

The amount of fat in a muscle varies considerably. In some muscles, as the breast muscle of poultry, fat may be found in small quantities even in highly finished birds (Lowe, 1948). A variation in deposition of intramuscular fat in different poultry muscles was observed by Goertz et al. (1955). They noted that the fat in the gluteus primus muscle was deposited in small clumps throughout the muscle, whereas the fat cells in the pectoralis major were found to be concentrated in larger clumps in a few areas.

Chemical Composition and Effect of Heat on Poultry Muscle

Muscle of poultry is composed primarily of protein, fat and water (Lowe, 1955). Other components are pigments, enzymes, inorganic and organic acids, non-nitrogenous extractives as lactic acid, nitrogenous extractives as creatine and urea, carbohydrates and vitamins. Some of these components are concentrated more in the muscular fluids, whereas others are found to a greater extent in the muscle fibers.

Muscle Proteins. The protein of poultry muscle is largely intracellular or protoplasmic and intercellular or structural (Lowe, 1955).

Intracellular Proteins. The intracellular proteins include myosin, actin and non-myosin fraction, according to Lowe (1955). Globulin X, myogen and myalbumin are included in Bate-Smith's (1942) list of the non-myosin fraction.

Lowe (1955) described myosin as an inactive skeleton that was activated by the presence of attached globular proteins called protins. Found in the contractile elements of muscle, myosin is a globulin that is a simple protein (Gortner and Gortner, 1949). Szent-Györgyi (1951) observed that myosin was a hydrophilic colloid that was precipitated by small concentrations of neutral salts. Myosin contained large amounts of the dicarboxylic amino acids, aspartic and glutamic, and of the basic acids, asparagine, lysine and histidine.

Closely related to myosin is actin. Szent-Györgyi (1951) observed that actin, a globular protein, existed also in the fibrous form. Actin, a typical hydrophilic colloid, was soluble in water, precipitated at its isoelectric point in the presence of salts and was destroyed by weak alkalies. Similarly to myosin, actin had large amounts of the dicarboxylic and basic amino acids.

The contractility of muscle is dependent upon the chemical response of actin and myosin. Both actin and myosin in the form of actomyosin affect the contractility of muscle although neither alone has this power (Lowe, 1955; Szent-Györgyi, 1951). Szent-Györgyi (1951) noted that the contractile matter consisted of approximately 75 percent myosin and 25 percent actin. Actomyosin,

even when dilute, was found to behave as a continuous gel by Szent-Györgyi (1951).

Intercellular Proteins. Collagen and elastin are the two main intercellular proteins found in the connective tissue of poultry. Collagen is found in collagenous connective or white fibrous tissue and elastin, in elastic or yellow connective tissue. Gortner and Gortner (1949) listed both collagen and elastin as simple proteins of the albuminoid group. These two intercellular proteins are insoluble in salt solutions.

Effect of Heat on Muscle Proteins. Heat affects both the intracellular and the intercellular proteins. When meat is cooked, part or all of the protoplasmic or intracellular fiber proteins are coagulated by heat (Lowe, 1948). Some denaturation was found by Lowe (1955) to take place even at internal temperatures of 60°C. or below, as the firmness of meat cooked to these temperatures was altered visibly from that of raw meat. A lag in internal temperature around 76° to 78°C. in poultry roasted at low temperatures (212° to 248°F.) was noted by Lowe (1948) as an indication that considerable protein coagulation was taking place, as coagulation of protein is endothermic in nature in which heat is absorbed. Lowe (1955) added that the degree of doneness of cooked meat is dependent largely upon the amount of coagulation of the intracellular proteins. In general, the rate of coagulation is linearly related to the increase in internal temperature for any protein.

The intercellular or structural proteins, collagen and

elastin, also are affected by heat during cooking. Winegarden et al. (1952) stated that the collagenous tissue of beef heated to 95°C. for 64 minutes was found to differ from uncooked fibers in physical structure, in that, the cooked fibers lost their waviness and appeared to be fused together. The degree of change in the collagenous tissue increased as time and temperature of heating were increased. Little or no structural change was noted in collagenous tissue heated for 64 minutes at 60°C. or for short periods at 65°C.

Gortner and Gortner (1949) indicated that collagen was changed to gelatin in the presence of water and sufficient moisture. However, the internal temperature of muscle rarely reaches the boiling point and the pH of muscle is not favorable for much conversion of collagen to gelatin during cooking (Lowe, 1948).

Structure of elastic connective tissue was found by Winegarden and co-workers (1952) to change slightly, if at all, when heated for 64 minutes at 95°C. Lowe (1948) also observed that this type of connective tissue showed little change during heating. Winegarden et al. (1952) indicated that elastin softened similarly to collagen during heating but to a much lesser degree.

The ground substance or matrix of less dense tissue also changed during cooking and was considered by Lowe (1955) as the source of granular tissue in cooked meat. When microscopic sections prepared from beef roasts and braised cuts that had been cooked to internal temperatures of 70° and 90°C. were observed, granular tissue was noted that was not evident in slides made from raw muscle.

Muscle Pigment. Myoglobin is the muscle pigment that is responsible for the characteristic purplish-red color of fresh meat. Muscle color may be affected by pH and the concentration of myoglobin. Lowe (1955) observed that myoglobin was darker at a high pH than at a low pH. Lawrie (1950) indicated that the leg and thigh muscles of poultry contained nearly 10 times more myoglobin than did the breast muscles and explained the difference in color of these muscles on this basis.

Myoglobin is unstable to heat. Thus, when meat is cooked to a temperature of 65° to 70°C., the globin portion of the myoglobin molecule coagulates and a brown or gray color is obtained (Lowe, 1955).

Chemical Composition of Poultry Muscle. The chemical composition varies with the breed and age of the bird. Variation also is found among individual birds of similar age and breed as well as between the dark and light meat. In general, turkey muscle contained a relatively high percent of protein, whereas it was low in fat content (Scott, 1956). The roasted meat of a 24-week-old Broad Breasted White turkey hen weighing about 14 pounds, live weight, was found to contain 22 percent protein, 10 percent fat and 66 percent moisture. Scott (1956) found that roasted white meat of an adult turkey hen contained 35 percent protein, eight percent fat and 56 percent moisture; whereas the dark meat from a similar bird contained 30 percent protein, 12 percent fat and the same moisture content as the white meat.

Factors Affecting Rate of Heat Penetration

Several factors may affect the rate of heat penetration in turkeys during roasting. Birds frozen and defrosted prior to roasting may not cook at the same rate as those not frozen. Other factors are the initial internal temperature of the poultry, the position of the bird in the pan during roasting, oven temperature and the length of roasting time.

Fresh Chilled and Frozen Defrosted Poultry. Marsden et al. (1952), who roasted frozen defrosted and fresh chilled turkeys to the same internal end point temperature, observed that the frozen defrosted birds required a shorter cooking period, in minutes per pound, than fresh chilled birds. Work by Callow (1957) offered a possible explanation by indicating that the muscle protein underwent partial denaturation and the muscle structure became more open during freezing. The combined action of these factors might be influential in increasing the cooking rate of frozen defrosted poultry muscle more rapidly than that for fresh chilled birds.

Initial Internal Temperature of Poultry. The length of roasting time also is dependent upon the initial temperature of the bird just previous to roasting (Lowe, 1955). Poultry that had a low initial temperature required a longer cooking time than poultry muscle that had a high initial temperature. For example, meat that had an initial temperature of 0° to 5°C. required a longer cooking time than meat that had an initial internal temperature of 20°C. Castellani et al. (1953) and

Iacono et al. (1956) both reported similar results. Castellani et al. (1953) included comparisons of turkeys defrosted overnight in a refrigerator and birds defrosted for eight hours at room temperature. Iacono et al. (1956) compared roasting times of frozen turkeys and of frozen defrosted turkeys. The turkeys that were not defrosted prior to roasting required a third longer roasting time than did the defrosted turkeys. This agreed with Lowe's (1955) statement that meat still frozen at the start of cooking required a longer cooking time as heat was needed to melt the ice before the internal temperature of the poultry muscle could be raised above the freezing temperature.

Position of the Turkey during Roasting. Whether the breast of the turkey is up or down during the roasting procedure is also of importance in determining doneness when the open pan method is used. Lowe (1955) observed this to be true and explained that the part of the bird nearest the pan was partially protected. Therefore, this lower portion heated more slowly than the upper portion that was subjected to the hot circulating air in the oven.

Oven Temperature and Time of Roasting Poultry. Turkeys have been roasted at a wide range of oven temperatures and for varying periods of time. Cooking time was noted by Lowe (1948) as dependent upon the method of cooking, the oven temperature, the size and shape of the bird and the initial temperature of the poultry carcass at the beginning of roasting. Generally, shorter roasting times are required for poultry cooked at the higher oven temperatures. Alexander et al. (1948) roasted turkeys at different oven temperatures. Turkeys under 10 pounds were roasted at 225°F. and

birds from 10 to 23 pounds were roasted at 275° to 300°F. Birds over 23 pounds were roasted at 225° to 269°F. Average cooking times per pound for these three groups were 21.9, 24.0 and 23.6 minutes, respectively.

An oven temperature of 350°F. was used for roasting 13 pound unstuffed turkeys in a 1956 study by Iacono and co-workers. In this study, both defrosted and frozen turkeys were roasted to an end point temperature of 185°F. in various positions of the muscle. At the oven temperature used by these workers, a total of 240 minutes was needed to bring the temperature of the right breast to the required end point temperature as indicated by a thermocouple.

A study by Lowe et al. (1953) showed that the oven temperatures and times required for cooking turkey in aluminum foil were different than those needed for roasting birds without foil. Since aluminum foil delayed heat penetration, oven temperatures of 450°F. to 500°F. and considerably shorter cooking times were needed to produce turkey meat similar to that roasted at 300° and 350°F. Superior flavor and juiciness scores were reported for the pectoralis major muscles of birds roasted without foil than with foil (Edgar, 1953). No differences in flavor or juiciness were observed for the thigh samples roasted by either method. Juiciness differences between the foil-wrapped birds and the unwrapped birds were not detected organoleptically for dark or light meat. It also was observed that foil-wrapped birds roasted at the 300° and 350°F. temperatures were dry and required long cooking times.

A United States Department of Agriculture bulletin (1958) recommended that an oven temperature of 325°F. be used for roasting turkeys irrespective of the size of the birds. Ferguson (1957) used 325°F. as the oven temperature to roast frozen defrosted turkey halves to various end point temperatures. Birds roasted to 90°C. in the breast required an average of 25.7 minutes per pound.

Methods for Determining the Degree of Doneness of Roasted Whole Turkeys

According to Alexander et al. (1951), a well-done turkey is juicy, tender and easily disjointed. It is difficult to determine this optimum doneness when roasting turkey as there are problems of cooking both tender and less tender muscles at the same time. Also, the individual muscles are of varying sizes, so some smaller muscles may reach the desired doneness before larger muscles (Lowe, 1955). Thus, of prime importance is the use of a reliable method to determine when the most muscles are of optimum doneness.

Various methods may be employed for determining the doneness of turkey. Generally, research workers are guided by oven temperature and time combinations, or by internal temperatures taken at various locations in the poultry carcass. Homemakers often resort to various subjective measures and to cooking time, in minutes per pound, in an attempt to determine optimum doneness.

Internal End Point Temperatures. Various studies have been made in which internal end point temperatures were taken at

different areas in the carcass. In these studies, end point temperatures were taken in various areas in the thigh or the breast muscles or in the stuffing.

In 1956, Cooley conducted a study in which frozen defrosted turkey halves were roasted at 325°F. to internal end point temperatures of 85° and 90°C. in the pectoralis major and in the thigh muscles. Turkeys roasted to 90°C. in the pectoralis major were considered the most done, whereas those roasted to 85°C. in the thigh were the least done. Birds roasted to the other end point temperatures were intermediate in the degree of doneness.

Ferguson (1957) roasted frozen defrosted turkey halves at 325°F. to 85° and 90°C. in the breast muscle and to 90° and 95°C. in the thigh. She reported that both end point temperatures of 90°C. in the pectoralis major and 95°C. in the thigh gave nearly optimumly done turkeys. The lower temperatures (85°C. in the breast muscle and 90°C. in the thigh) both gave indications of underdoneness. Thus, 90°C. in the pectoralis major was recommended as the internal end point temperature that gave optimum doneness and was preferred over the 95°C. thigh temperature, as some difficulty was encountered when attempting to insert a thermometer correctly into the thigh muscles.

In a study by Iacono et al. (1956), a defrosted turkey was roasted at 350°F. to an internal end point temperature of 185°F. in various muscles. The thermocouples placed in the right breast muscle showed that 240 minutes were required to reach the desired end point temperatures. Only 197 minutes were required by the left rear breast muscle to attain this end point. The

right drumstick required 207 minutes and the left thigh, 216 minutes to reach the same end point temperature. Initial internal temperatures of the muscles were not reported.

Alexander et al. (1951) investigated the relationship between end point temperatures and subjective tests for determining doneness of roast turkeys of various ages, sexes and breeds. These workers observed that the thigh might be the most promising portion of the bird for insertion of a thermometer as these temperatures were nearly alike for the birds of the more desired doneness. These workers questioned, however, whether internal temperature alone, especially if taken in only one location, could indicate doneness of a whole bird adequately.

Oven Temperature and Time of Roasting. Time in minutes per pound, and a combination of time and oven temperature have been used as guides to determine doneness for roasted turkeys. The former method was used experimentally by Cook et al. (1949). These workers found that as the weight of the turkey increased, the length of time required for optimum doneness also increased, whereas the oven temperatures required decreased.

Both Goertz (1952) and Lewis (1955) used the combination of time and oven temperature for determining the end point of fresh and defrosted turkey halves roasted at 300°F. In the 1952 study, fresh turkey halves were roasted to an internal temperature of 85°C. in the pectoralis major muscle or until the birds were roasted to 26 minutes per pound, which ever was the shorter period. The 1955 study used end points of 85°C. in the thigh or 26 minutes per pound, which ever was the longer cooking period. In this

study, fresh and defrosted turkey halves also were used.

Visual Methods. Visual or subjective methods also have been used to determine doneness in several studies. Alexander et al. (1951) used subjective tests in conjunction with end point temperature to ascertain degree of doneness of turkeys of varying ages, weights and body conformation. Both tenderness of the light and the dark meat as indicated by pricking with a fork and softness of the tendons were considered indications of doneness. Internal temperatures of 80° to 95°C. in the pectoralis major and from 90° to 94°C. in the thigh produced turkeys of desired doneness. End point temperatures of the stuffing were similar to those of the breast. These workers concluded that end point temperatures were a less reliable means of determining doneness than were the subjective tests used. Similarly, Swickard et al. (1953) determined doneness of turkeys for their study by noting the ease of movement of the drumstick-thigh joint and the feel of the flesh of the drumstick. In a non-technical bulletin, the United States Department of Agriculture (1958) recommended that a turkey be considered done when the leg joints moved easily and when the flesh on the drumstick was soft and pliable when pressed with the fingers.

PROCEDURE

Forty-eight Broad Breasted White turkey hens, were purchased from the Royal Turkey Farm at Hesston, Kansas. These birds were started on a commercial 28 percent protein ration and later placed on a 24 to 26 percent protein feed. In addition, the

turkeys were given free range on milo and corn. Birds, weighing approximately 10 to 12 pounds were processed, packaged and frozen in Cry-O-Vac bags at the plant. Whole frozen turkeys were transported to and kept in frozen storage at a Manhattan locker plant. When needed, eight turkeys at a time were removed and stored in a chest-type freezer in the Foods Research Laboratory. This freezer was maintained at -10°F.

A balanced incomplete block design (Type V, Cochran and Cox, 1957) was used to determine the order of roasting the turkeys to the end point internal temperatures of 85° and 90°C. in the pectoralis major (breast) and 90° and 95°C. in the thigh muscles. One block consisted of the two different treatments or the two end point temperatures used at one cooking period. Six blocks were needed to compare each one of the end point temperatures with each other temperature. This study included four repetitions each consisting of six randomly arranged blocks (Table 1). Thus, there were 12 replications of each treatment.

Previous to each cooking period, two wrapped birds were defrosted at room temperature for 19 hours. Thermograph records of room temperatures were kept during each of the defrosting periods.

Although the turkeys were not stuffed, the openings at the anterior and the posterior ends were closed by sewing with thread, to minimize unnecessary exposure of the inside cavity and to prevent drying. The trussed birds, with the wing-tips folded under the shoulders and the legs and the tail secured with twine, were placed breast-up on "v" racks in shallow open pans.

Table 1. Balanced incomplete block design for roasting whole turkeys.

Cooking period	Treatments			
1	90°C.	Breast	90°C.	Thigh
2	85°C.	Breast	95°C.	Thigh
3	90°C.	Thigh	95°C.	Thigh
4	85°C.	Breast	90°C.	Breast
5	85°C.	Breast	90°C.	Thigh
6	90°C.	Breast	95°C.	Thigh
7	90°C.	Breast	90°C.	Thigh
8	90°C.	Thigh	95°C.	Thigh
9	85°C.	Breast	90°C.	Thigh
10	90°C.	Breast	95°C.	Thigh
11	85°C.	Breast	90°C.	Breast
12	85°C.	Breast	95°C.	Thigh
13	90°C.	Breast	95°C.	Thigh
14	85°C.	Breast	90°C.	Breast
15	85°C.	Breast	95°C.	Thigh
16	85°C.	Breast	90°C.	Thigh
17	90°C.	Breast	90°C.	Thigh
18	90°C.	Thigh	95°C.	Thigh
19	85°C.	Breast	95°C.	Thigh
20	85°C.	Breast	90°C.	Breast
21	85°C.	Breast	90°C.	Thigh
22	90°C.	Breast	90°C.	Thigh
23	90°C.	Thigh	95°C.	Thigh
24	90°C.	Breast	90°C.	Thigh

Centigrade thermometers were inserted into the mid-portions of both the right and the left breast muscles, and in both the right and the left thigh muscles, and the internal temperatures were noted (Plate I). Although thermometers were placed in both the right and the left sides of the breast and the thigh muscles of each bird, the right side was chosen arbitrarily as the site of taking the pre-determined end point temperature. In this study, the right side was defined as the side on the right when the anterior portion of the turkey was in a breast-up position facing the worker.

The turkeys were roasted in a rotary hearth gas oven pre-heated and maintained at 325°F. until a pre-designated internal end point temperature was reached. During roasting, internal temperatures were recorded every 20 minutes until the desired end point temperature was obtained. Immediately after removal from the oven, the birds were weighed and other appropriate weights were taken in order that total, volatile and dripping cooking losses could be determined. Then the turkeys were covered loosely with aluminum foil, and allowed to cool for approximately one to one and one-half hours.

After cooling, the roasted turkeys were prepared for pre-carving evaluations by partially slitting the skin and the breast flesh along the keel bone, the skin and the flesh of the drumstick, the wings at the shoulder joints, and the thighs at the body (Plate II). An experienced panel of three to four judges then scored the external and the internal characteristics of the turkeys (Form III, Appendix). The birds were scored within

EXPLANATION OF PLATE I

Roasted turkey with thermometers in the right and left breast and thigh muscles.

PLATE I

EXPLANATION OF PLATE II

Roasted turkey prepared for panel evaluation of external and internal doneness.

PLATE II

a range of from one to seven points. Birds that appeared very underdone or very overdone were scored one or seven, respectively. Optimum doneness was designated by a score of four. External tests made were similar to those that might be used by the homemaker when evaluating doneness of turkey, such as feeling the flesh of the drumstick, the ease of movement of the drumstick, the pricking of the wings and the drumsticks with a fork, and the general impressions of external doneness. In addition to these tests, evaluations of internal doneness were made by observing the appearance of the light meat under the skin and next to the bone, of the dark meat of the drumstick under the skin and next to the bone, and of the exposed joints at the thigh and the shoulder areas. Finally, a score of overall doneness based on observations of external and internal doneness was given.

Next, the turkeys were carved for palatability testing. The left and the right pectoralis major muscles and the left and the right gluteus primus muscles of each roasted bird were removed. Portions of the light meat to be used for shear tests and for press fluid determinations were set aside in appropriately marked and covered jars, and the remaining central portion of each cooked muscle was divided into samples for organoleptic tests (Plate III). The dark meat was used only for organoleptic tests (Plate IV).

Two panels were used for the palatability determinations. One panel tasted the light meat and the second panel the dark meat. Each panel was composed of seven experienced judges, with three to seven judging at each period. The samples of meat were

EXPLANATION OF PLATE III

Left. Pectoralis major muscle.

Right. Pectoralis major muscle sampling for objective and subjective tests.

1. Palatability samples.
2. Shear core.
3. Position from which core was removed.
4. Portion ground for press fluid samples.

PLATE III

1. Palatability samples.
2. Shear core.
3. Position from which core was removed.
4. Portion ground for press fluid samples.

EXPLANATION OF PLATE IV

Left. Palatability samples from thigh muscles.

Right. Thigh muscles.

PLATE IV

sectioned so that at every tasting period, each judge would be served a sample cut from the same position each time. Also, the four samples of meat were coded according to a system of randomized numbers.

The eating quality of the light and the dark meat was determined by evaluating flavor, juiciness and tenderness by use of a seven-point scale with a score of one indicating an undesirable quality and seven a very desirable quality (Form II, Appendix). The texture of each sample was evaluated by placing the number of the coded sample next to one of 10 descriptive words. Doneness of meat was judged by use of the same scale that was used by the committee in evaluating doneness of the whole uncarved bird.

The judges also scored the juice samples that exuded from the turkeys during cooling and carving for doneness by noting the appearance, especially the color (Plate V). Duplicate samples of juice were obtained from each of the two turkeys tested per cooking period, and these were presented also in random order to the judges. Numerical scoring of the juice samples was the same as for doneness of meat. The juice samples were evaluated after the meat samples had been tasted, in order that the appearance of the juice would not affect the scores given the meat samples.

One-inch cores were removed from the anterior end of the cooked pectoralis major muscles of the right and the left sides of each turkey. Shear values for each core were determined in quadruplicate on the Warner-Bratzler shearing apparatus by the

EXPLANATION OF PLATE V

Samples of juice that exuded during the carving of turkeys.

PLATE V

method described by Hay (1952).

The remaining breast meat from each side of the turkeys was ground separately, placed into appropriately marked jars and refrigerated overnight. The following day, press fluids on the ground samples were determined in duplicate by use of the Carver Laboratory Press, according to the method used by Hay (1952). Thus the volume of serum, fat and total press fluid was obtained for the left and the right pectoralis major muscles of each roasted turkey.

Statistical analyses were run on mean values for data obtained at each cooking period. The data for the light and the dark meat samples were analyzed separately since evaluations were made by two separate palatability committees. Also, where data for both the right and the left sides were available, only that for the right sides were considered in the statistical analyses, as the end point temperatures were determined for the right sides only.

Data analyzed by analysis of variance included palatability scores, shear values, press fluid yields and scores for the subjective tests conducted prior to carving. Palatability scores included those given for flavor, juiciness, tenderness, doneness of the exuded juice and doneness of the meat samples. Scores for both the internal and the external characteristics of the roasted turkeys were analyzed. The internal doneness factors included observations of the general appearance, the pricking of the wings and the drumstick with a fork, the ease of movement of the drumstick and the feel of the flesh of the drumstick. Appearance of the flesh of the light meat under the skin and next to the keel

bone, the drumstick meat under the skin and next to the bone, and the exposed joints of the wing and the thigh areas were considered as factors indicating internal doneness. Data obtained for observations of over-all external and internal doneness also were included in the analyses. Wherever a significance was found for any of these factors, least significant differences were tabulated.

Correlation coefficients were determined to compare data obtained for each end point temperature. Mean scores for palatability factors were compared with doneness values for the exuded juice and for the meat samples. Other comparisons included press fluid yields with juiciness scores for light meat and shear values with data for tenderness for light meat samples. Many of the tests for degree of doneness conducted before carving were compared with organoleptic scores for doneness of light and of dark samples.

T tests were run for data obtained for flavor, juiciness, tenderness and doneness of meat for both the light and the dark samples to determine similarities between data for the right and the left sides of turkeys roasted to each end point temperature.

RESULTS AND DISCUSSION

End point temperatures of 85° and 90°C. in the pectoralis major muscle and 90° and 95°C. in the thigh muscles were used in roasting whole turkeys. The end point temperatures always were taken in the right sides of the turkeys; however, subjective and objective measurements were made on the right and left side

of each turkey roasted. Results of t tests for comparison of organoleptic scores for the right and the left sides indicated that generally palatability scores for a given factor were similar for right and left sides (Table 2). When significant differences between the two existed, scores for the right generally were higher than those for the left. All other statistical data reported in this discussion will be that from the right sides of the birds. Data for both the right and the left sides are included in the Appendix.

Flavor, juiciness, tenderness and doneness scores and objective measurements were determined on samples of light and dark meat from the breast and the thigh areas of both sides of each whole turkey. Hence, for greater clarity in the following discussion, the terms breast, or pectoralis major, and thigh will be used to designate the area of the turkey in which the end point temperature was determined. The terms light and dark will be used to describe samples of meat taken from each bird for subjective and objective testing regardless of the muscle in which the final internal temperature was taken.

Rate of Heat Penetration

The internal temperatures of the pectoralis major and thigh muscles were recorded every 20 minutes during roasting of the whole turkeys. After the 100-to 120-minute interval, the data represent a decreasing number of birds for each interval. Only one turkey roasted to 95°C. in the thigh remained in the oven during the 140- to 160-minute period.

Table 2. Summary of t values for organoleptic scores for right and left sides of roasted whole turkeys.

Factors	Pectoralis major		Thigh	
	85°C.	90°C.	90°C.	95°C.
Flavor				
Light	1.797	0.059	1.523	1.111
Dark	0.661	0.722	0.307	2.274 *R
Juiciness				
Light	2.533 *R	0.267	0.431	0.133
Dark	1.482	0.868	2.655 *L	0.049
Tenderness				
Light	2.696 *L	0.764	1.356	2.069
Dark	0.530	2.766 *R	1.216	0.190
Doneness of meat				
Light	1.994	1.213	0.682	0.543
Dark	0.262	2.383 *R	1.335	1.476

*R right side significantly greater score at the 5% level than left side.
*L left side significantly greater score at the 5% level than right side.

The average initial temperatures recorded in the pectoralis major and in the thigh muscles were similar for birds given all treatments (Fig. 1). The initial internal temperatures for the pectoralis major and the thigh muscles of the individual turkeys ranged from 12° to 22°C. Thermograph recordings of room temperatures kept during each 19-hour defrosting period varied from 62° to 82°F. Indications are that these temperature variations probably were responsible for some of the differences in initial temperatures of the turkeys.

The internal temperatures of the turkeys began to rise immediately after they were placed in a preheated 325°F. oven.

At the end of the first 20-minute period, the internal temperatures of the thigh increased faster than those of the pectoralis major. The temperatures recorded in the breast muscles increased most during the 20- to 40-minute interval and increased slowly thereafter until the birds were removed from the oven. The thigh temperatures also increased most during the 20- to 40-minute period. Thereafter, the thigh temperatures increased similarly to those in the pectoralis major muscle for the same interval and remained higher than those of the pectoralis major throughout the entire roasting period. The rate of increase in heat penetration was greatest for the birds roasted during the first few cooking periods. This might have been caused by a possible movement of the thermometer bulb away from the center of the muscle thus causing the temperature of the outer portion of the muscle to be registered instead of the center of the muscle. After these first few cooking periods, adjustments of

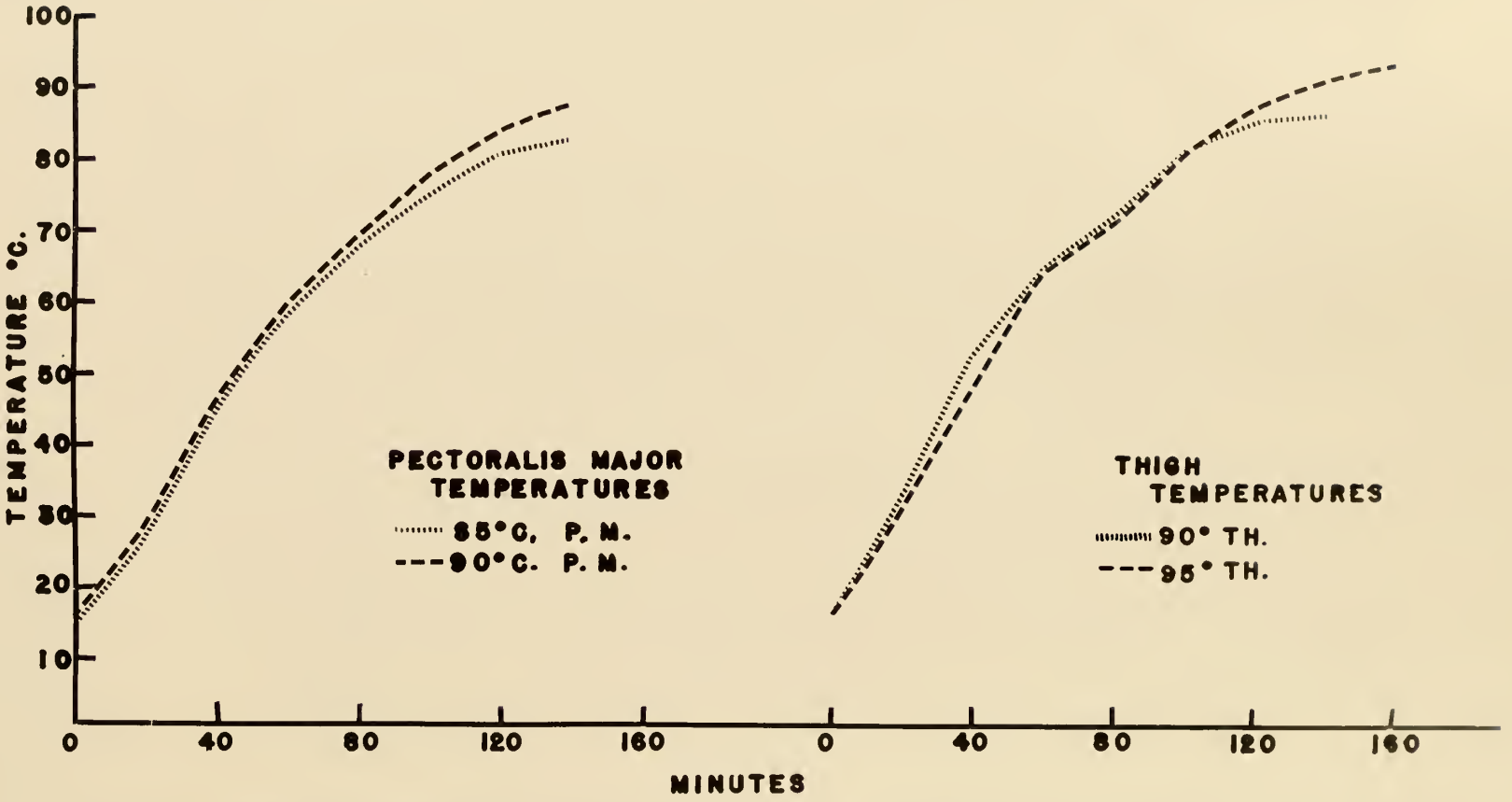

Fig. 1. Rate of heat penetration curves for muscles of roasted whole turkeys.

the thermometers were made whenever the temperature appeared to be increasing too rapidly.

Ferguson (1957), in a study with half birds, reported that the rate of heat penetration in the breast was rapid and nearly similar for each of the first three 20-minute intervals, whereas the internal temperatures in the thigh muscles rose slowly at first and then gradually increased. The most rapid increases were noted after the birds had been in the oven an hour. The differences between Ferguson's (1957) findings and those reported in this study might be that whole birds instead of half birds were studied. This would involve a difference in the position of the muscles in the pan during roasting and also a difference in the surface area.

In the present study, higher thigh temperatures than breast temperatures were reported for 44 out of 48 birds at the time they were removed from the oven. One turkey had the same end point temperature for both the thigh muscles and the breast and the other three turkeys had only slightly higher end point temperatures in the pectoralis major than in the thigh. Alexander et al. (1951), also concerned with the roasting of whole turkeys, reported considerably higher thigh temperatures than breast temperatures in well-done birds.

Subjective and Objective Tests

Shortly after removal from the oven and before the roasted whole turkeys were carved, four judges scored the birds for doneness by observing the general appearance, the ease of

pricking with a fork, the feel of the drumstick with the fingers and the ease of the movement of the thigh-drumstick joint. Next, the whole birds were cut to expose the flesh under the skin and near the bone of the breast and the drumstick; the joints near the shoulders and the thigh also were exposed. The committee then scored internal doneness at these areas and assigned an overall doneness score based on external and internal appearances. After an additional cooling time of one and one-half to two hours, two experienced palatability committees, one for the light and one for the dark meat, scored samples taken from the roasted whole turkeys for flavor, tenderness, juiciness and doneness of meat and juice. Shear force values, press fluid yields and cooking times also were determined. Adjusted treatment means (Cochran and Cox, 1957) for these subjective and objective tests are reported in Tables 3 and 4.

Doneness of Light Meat. Doneness of the light meat was affected significantly by roasting whole birds to the different end point temperatures (Table 3). Light meat of birds roasted to 85°C. in the pectoralis major or to 90°C. in the thigh was significantly less done than that of turkeys roasted to 90°C. in the breast and for those cooked to 95°C. in the thigh muscles. Adjusted mean scores for light meat from birds roasted to 90°C. in the pectoralis major or to 95°C. in the thigh approached optimum doneness. The light meat of birds roasted to end points of 85°C. in the breast and of 90°C. in the thigh received scores that were mid-way between slightly underdone and optimum doneness, as based on a seven-point scale in which four represented

Table 3. Significance of variance ratio, least significant differences and adjusted treatment means for tests for doneness of roasted whole turkeys.

Factors	F[1]	Lsd[2]	Pectoralis major: 85°C.	Pectoralis major: 90°C.	Thigh: 90°C.	Thigh: 95°C.
Doneness						
Light	*	0.45	3.48	3.94	3.42	3.97
Dark	***	0.20	3.75	4.32	3.78	4.15
Juice	***	0.46	3.05	3.78	2.69	3.92
General appearance	***	0.40	3.74	4.22	3.81	4.62
Fork prick, drumstick	***	0.25	3.50	4.18	3.68	4.75
Fork prick, wing	***	0.29	2.99	3.48	3.07	3.70
Feel of drumstick	***	0.32	3.30	4.02	3.51	4.37
Movement of joint	***	0.31	3.00	3.80	3.17	4.11
Breast flesh under skin	***	0.28	3.54	4.12	3.76	4.38
Drumstick flesh under skin	***	0.33	3.76	4.45	4.03	4.89
Breast flesh near bone	***	0.24	3.68	4.18	3.85	4.33
Drumstick flesh near bone	***	0.29	3.58	4.12	3.86	4.28
Shoulder area near joint	***	0.27	3.21	3.68	3.19	3.92
Thigh area near joint	***	0.30	3.28	3.88	3.37	4.19
General external and internal appearance	***	0.27	3.24	4.09	3.51	4.36

[1]variance ratio.
[2]least significant differences at the 5% level.
* significant at the 5% level.
*** significant at the 0.1% level.

Table 4. Significance of variance ratio, least significant differences and adjusted treatment means for flavor, tenderness and juiciness factors of roasted whole turkeys.

Factors	F[1]	Lsd[2]	Pectoralis major: 85°C.	Pectoralis major: 90°C.	Thigh: 90°C.	Thigh: 95°C.
Flavor						
Light	ns	----	5.39	5.48	5.27	5.26
Dark	*	0.29	5.70	5.85	5.70	6.07
Tenderness						
Light	ns	----	5.41	5.77	5.34	5.96
Dark	*	0.18	5.66	5.95	5.77	5.87
Shear force values, lbs.	ns	----	11.24	9.33	11.40	8.68
Juiciness						
Light	*	0.45	5.35	4.95	5.44	4.87
Dark	ns	----	5.33	5.24	5.39	5.36
Press fluids, ml./25 g.	**	0.28	9.09	8.67	9.06	8.78
Cooking losses, %						
Total	***	1.40	10.79	13.62	11.24	13.87
Dripping	***	0.67	2.36	4.00	2.95	4.37
Volatile	***	0.94	7.85	9.19	7.72	9.16
Cooking time, min./lb.	***	0.60	12.21	13.21	12.08	13.38

[1]variance ratio.
[2]least significant differences at the 5% level.
ns non-significant at the 5% level.
* significant at the 5% level.
** significant at the 1% level.
*** significant at the 0.1% level.

optimum doneness. None of the light samples roasted in this study received a score of five or over, which indicated that none were overdone. The light meat of only four turkeys received scores below three indicating that underdoneness of the light meat also was seldom noted in birds roasted to any of the end point temperatures used. Two of these four instances of underdoneness were reported in light meat of turkeys roasted to 85°C. in the pectoralis major; one, to 90°C. in the breast muscles, and the fourth, in a bird roasted to 90°C. in the thigh.

Doneness of Dark Meat. A significant difference ($P < .001$) existed between doneness of the dark meat and certain of the end point temperatures (Table 3). Dark meat received only one score that indicated underdoneness. The adjusted treatment means showed that the dark meat was slightly more done than the light meat samples. Dark meat samples from turkeys roasted to 85°C. in the breast and to 90°C. in the thigh muscles were similar and significantly less done than dark meat from birds roasted to 90° or to 95°C. in the pectoralis major or the thigh, respectively. The dark meat of turkeys roasted to the latter two temperatures also was similar in doneness.

Doneness of Juice. In most comparisons varying end point temperature had a significant ($P < .001$) effect on the degree of doneness of the juice that exuded from the turkeys during carving (Table 3). A significant difference was not observed when juice samples from birds roasted to 85°C. in the breast muscles or to 90°C. in the thigh were compared, nor was a significant difference found when comparisons were made of

samples from turkeys roasted to 90°C. in the pectoralis major or to 95°C. in the thigh muscles. Cooley (1956), who studied half birds, also found significant differences in doneness of juice attributable to end point temperatures, whereas Ferguson (1957) who also worked with half birds did not find significant differences in doneness of exuded juice. In most instances in the present study, all average scores given the duplicate juice samples were considerably less than scores given for doneness of either the light or the dark meat samples for the same bird. Sixteen out of the 48 juice samples were judged underdone and two of these 16 were considered very underdone; none were considered overdone.

Doneness of Whole Turkey. The ease of pricking the wings with a fork and the observances made of the breast flesh near the bone both were affected significantly ($P < .001$) by certain of the four end point temperatures used in this study (Table 3). When these two factors were considered as indications of doneness, turkeys roasted to 85°C. in the pectoralis major and those roasted to 90°C. in the thigh were of similar degree of doneness. Also, these two methods indicated that birds were of nearly equal doneness when roasted to 90°C. in the pectoralis major or to 95°C. in the thigh. The adjusted mean scores for turkeys roasted to 85°C. in the breast or to 90°C. in the thigh as judged by fork pricking the wing indicated that the birds were slightly underdone, whereas scores given turkeys roasted to the same end points, but judged for doneness by observing

the breast flesh near the bone were considerably closer to a score for optimum doneness. Of the turkeys roasted to 90°C. in the breast or to 95°C. in the thigh, fork pricking the wing produced scores that were nearly mid-way between slightly underdone and done; birds were scored somewhat higher than done but not slightly overdone when the basis for doneness was the observance of the breast flesh near the bone.

Turkeys roasted to 85°C. in the breast or to 90°C. in the thigh were of similar doneness when judged by using the appearance of the breast flesh under the skin and of the shoulder area near the joint as the basis for doneness (Table 3). Birds cooked to 90°C. in the pectoralis major were judged significantly ($P < .05$) more done than birds roasted to 85°C. in this muscle. The adjusted mean scores for turkeys roasted to 95°C. in the thigh indicated that the birds of this group were more done than the birds of the other three groups, as judged by the appearance of the breast flesh and the shoulder area near the joint. Adjusted treatment means for the appearance of the shoulder area near the joint were nearly all within the slightly underdone range except for birds roasted to 95°C. in the thigh. The scores for these birds approached optimum doneness. When appearance of the breast flesh under the skin was used as a criteria for doneness, scores were all within the range of mid-way from slightly underdone to done and mid-way from done to slightly overdone.

In most cases, all factors related to the doneness of dark

meat were affected significantly ($P < .001$) by certain of the end point temperatures used in this study (Table 3). However, when either the feel of the drumstick or the movement of the thigh-drumstick joint was used to determine the degree of doneness, turkeys roasted to 85°C. in the pectoralis major or to 90°C. in the thigh were similarly done.

Also when feel of the drumstick was considered, degree of doneness was nearly the same for turkeys roasted to 90°C. in the breast or to 95°C. in the thigh. However, when movement of the thigh-drumstick joint was noted, birds cooked to 95°C. in the thigh were significantly ($P < .001$) more done than those cooked to 90°C. in the breast. Turkeys roasted to 95°C. in the thigh and judged by both criteria were scored within the done to slightly overdone range, whereas birds roasted to 90°C. in the breast were near optimum doneness as based on the movement of the thigh-drumstick joint.

When judges used the ease of fork pricking the drumstick, observing the appearance of the drumstick under the skin and near the bone, or noting the appearance of the thigh area near the joint, turkeys roasted to 85°C. in the breast or to 90°C. in the thigh were of similar doneness (Table 3). If only the appearance of the drumstick flesh near the bone was noted, birds cooked to 90°C. in the breast or to 95°C. in the thigh muscles were similarly done. For the other factors, turkeys roasted to 95°C. in the thigh were significantly more done than those cooked to 90°C. in the pectoralis major muscle, and these in

turn were more done than the remaining two groups of turkeys roasted. When turkeys roasted to 90°C. in the breast were judged by pricking the drumstick with a fork, or by observing the drumstick flesh near the bone, adjusted treatment means were near a score for optimum doneness. Observations of the drumstick flesh near the bone, of the thigh area near the joint or of the flesh of the drumstick under the skin indicated a similar stage of doneness in birds roasted to 95°C. in the thigh. When either the fork pricking of the drumstick or the appearance of the drumstick flesh under the skin was used as a criteria for determining doneness, birds roasted to 95°C. in the thigh were considered almost slightly overdone.

The degree of doneness, as determined by both general appearance and general external and internal appearance, was affected significantly ($P < .05$) by end point temperature with one exception (Table 3). This exception was when turkeys roasted to 85°C. in the breast or to 90°C. in the thigh were judged for general appearance. These birds were scored about the same in doneness.

Generally, turkeys roasted to 95°C. in the thigh were significantly ($P < .05$) more done than any of the other three groups of turkeys studied (Table 3). Birds cooked to 90°C. in the breast were significantly ($P < .05$) more done than those roasted to 90°C. in the thigh or to 85°C. in the pectoralis major. Turkeys roasted to 85°C. in the breast were considered the least done of any of the other three groups. The birds roasted to 90°C. in the breast or to 95°C. in the thigh were

considered to be of optimum doneness, although generally, the adjusted treatment means for scores given birds from each treatment group were lower when general external and internal appearance was observed than when general appearance alone was considered. Thus it would seem that judging the degree of doneness by scores for all external and internal factors revealed that the turkeys were less done than indicated by general appearance scores.

Flavor. In general, varying the end point temperature did not alter the flavor of either the light or the dark meat significantly (Table 4). An exception was that the flavor of dark meat from turkeys roasted to 95°C. in the thigh was significantly ($P < .05$) higher than that for dark meat of birds cooked to 85°C. in the breast or to 90°C. in the thigh muscles. The adjusted flavor means for the light meat from birds for all treatments were similar. Flavor of the dark meat from turkeys roasted to 95°C. in the thigh was scored desirable, whereas in all other instances, flavor of both light and dark samples was scored between moderately desirable and desirable.

Tenderness. Tenderness means for light meat samples were similar regardless of the end point temperature to which the turkeys were roasted. Mean scores for tenderness of the dark meat samples varied significantly ($P < .05$) when certain end point temperatures were compared (Table 4). No significant difference in tenderness of the dark meat was observed when turkeys were cooked to 90°C. in the pectoralis major or to

95°C. in the thigh, or when turkeys roasted to 85°C. in the breast muscles or to 90°C. in the thigh were compared. Similarly, tenderness of dark meat from turkeys roasted to either of the two end point temperatures used for the thigh were not significantly different. Adjusted tenderness means most closely approaching a score of six, indicating desirability, were those for light meat from birds roasted to 95°C. in the thigh muscles and for dark meat from turkeys cooked to 90°C. in the pectoralis major.

Shear force values for cores removed from the pectoralis major muscles were not affected significantly by varying the end point temperature (Table 4). These values for the breast meat of turkeys roasted to end points of 90°C. in the breast and to 95°C. in the thigh were higher, but not significantly so, than that of birds roasted to 85°C. in the pectoralis major and to 90°C. in the thigh muscles. The differences in shear force values of individual turkeys for each treatment group were considerable. For example, average shear values ranging from 7.80 to 22.38 pounds were obtained for cores from right and left sides of turkeys roasted to 90°C. in the thigh. It is doubtful that such extreme differences were the result of the particular end point temperature used. Possibly some of the less tender birds were frozen before rigor had resolved completely. Organoleptic scores for tenderness of the light meat and for shear values were significantly ($P < .001$) correlated ($r = -0.864$) for turkeys roasted to 90°C. in the thigh

(Table 5). A highly significant correlation coefficient ($r = -0.787$) also was found for tenderness scores and shear values for birds cooked to an end point of 90°C. in the pectoralis major.

Juiciness. Varying the end point temperatures did not significantly affect the juiciness of the dark meat from whole turkeys (Table 4). Generally, significant differences also were not observed in the juiciness of light meat from turkeys roasted to the four end points. However, the light meat from birds roasted to 85°C. in the pectoralis major was found to be significantly juicier than light meat samples from turkeys roasted to an end point temperature of 95°C. in the thigh muscles. Also, light meat from turkeys roasted to 90°C. in the thigh was significantly juicier than light samples from birds cooked to either 90°C. in the pectoralis major or to 95°C. in the thigh. Generally, adjusted means for juiciness scores were similar for both light and dark samples from birds cooked to end points of 85°C. in the breast and of 90°C. in the thigh muscles. Light meat samples, however, were less juicy than those for dark meat from turkeys cooked to 90°C. in the pectoralis major or to 95°C. in the thigh. Adjusted scores for the light samples from birds in these two treatment groups were slightly less than moderately desirable, whereas all other scores were slightly above moderately desirable.

Roasting turkeys to certain of the various end point temperatures had a significant ($P < .01$) effect on the press fluid

Table 5. Correlation coefficients (r values) for doneness and other palatability factors, juiciness and press fluid yields, and tenderness and shear values for light meat of roasted whole turkeys.

Factors	Pectoralis major		Thigh	
	85°C.	90°C.	90°C.	95°C.
Doneness of light meat vs.				
Flavor, light	.765**	.836***	.332 ns	.212 ns
Juiciness , light	-.409 ns	-.431 ns	-.863***	-.331 ns
Tenderness, light	.950***	.812**	.790**	.659*
Doneness of juice	.281 ns	.688*	.228 ns	.382 ns
General external doneness	.239 ns	.105 ns	-.219 ns	-.520 ns
Fork prick of wing	-.052 ns	.159 ns	-.350 ns	-.240 ns
Appearance of breast flesh under skin	.132 ns	.331 ns	-.491 ns	-.261 ns
Appearance of breast flesh near bone	.057 ns	.325 ns	-.519 ns	-.431 ns
Appearance of shoulder area near joint	.063 ns	.455 ns	-.514 ns	-.312 ns
General external and internal doneness	.071 ns	.236 ns	-.321 ns	-.416 ns
Juiciness of light meat vs.				
Press fluid yields	-.249 ns	.044 ns	-.450 ns	.123 ns
Tenderness of light meat vs.				
Shear values	-.516 ns	-.787**	-.864***	-.392 ns

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

yields from the pectoralis major muscles. Similarity was observed when press fluid yields from the breast muscles of turkeys roasted to 90°C. in the pectoralis major and that from birds cooked to 95°C. in the thigh were compared. These yields were significantly less ($P < .05$) than those from birds roasted to 85°C. in the breast or to 90°C. in the thigh. The press fluid yields from the latter group of turkeys also were similar. No significant correlation coefficients were noted between juiciness scores for light meat and press fluid yields from the pectoralis major muscle (Table 5).

Cooking Losses. Total dripping and volatile cooking losses for whole turkeys were affected significantly ($P < .001$) by the end point temperatures (Table 4). Total dripping and volatile cooking losses for turkeys roasted to an end point temperature of 90°C. in the pectoralis major were similar to those determined for birds cooked to 95°C. in the thigh. The cooking losses from these two groups of turkeys were significantly ($P < .05$) greater than those reported for turkeys roasted to 85°C. in the breast or to 90°C. in the thigh. Generally, as cooking time in minutes per pound increased, cooking losses also tended to increase.

Cooking Time. Cooking time, in minutes per pound, was affected significantly ($P < .001$) by varying the end point temperature (Table 4). In general, use of the higher breast or thigh end point temperatures required a longer cooking time than roasting turkeys to the lower end points in the breast or thigh

muscles. Thus, turkeys roasted to 90°C. in the pectoralis major and to 95°C. in the thigh had similar cooking times, in minutes per pound, as did birds roasted to end points of 85°C. in the breast or to 90°C. in the thigh.

In Ferguson's study (1957), half turkeys roasted to 90°C. in the pectoralis major and to 95°C. in the thigh required an average of 159 minutes total cooking time for both groups. In the present study, whole unstuffed turkeys ranging from 10.08 to 12.08 pounds, roasted to the same end point temperatures required an average of only 145 minutes total cooking time, or about 13.30 minutes per pound. At an oven temperature of 325°F., the time range required to cook unstuffed chilled roasters weighing from six to 12 pounds is between 150 and 210 minutes (U.S.D.A., 1958). In the present study, the short time required to reach the internal temperatures may have been caused partly by the rapid penetration of heat into the interior of the turkey through the abdominal openings, some of which, though previously closed by sewing with thread, came open as the skin shrank during roasting. Even though the samples of light and dark meat from birds roasted to 90°C. in the pectoralis major and 95°C. in the thigh were considered of optimum doneness, juice scores indicated slightly less than optimum doneness. Other indications of underdoneness were discovered when the roasted carcasses were examined, when boned, near the back areas that were protected during roasting.

Relationships between Doneness of Meat and Other Palata-

bility Factors. When correlation coefficients were determined for individual palatability factors and doneness evaluations related to light meat, few significant r values were obtained (Table 5). A significant ($P < .01$) r value was noted for flavor scores and doneness of light meat for turkeys roasted to 85°C. in the pectoralis major; a significant correlation coefficient ($P < .001$) was obtained between these same two factors for birds cooked to an end point of 90°C. in the pectoralis major. A significant ($P < .001$) r value of -0.863 existed between doneness and juiciness of light samples for turkeys roasted to 90°C. in the thigh. Tenderness of light meat was significantly ($P < .001$) related ($r = 0.950$) to doneness of light meat samples from birds cooked to an end point temperature of 85°C. in the breast, and correlation coefficients were significant ($P < .01$) when these same two factors were compared for turkeys roasted to 90°C. in the pectoralis major or to 90°C. in the thigh muscles. Significant relationships also existed between tenderness and shear values for light meat samples from turkeys cooked to 90°C. in the thigh ($P < .001$) and also from those roasted to 90°C. in the pectoralis major ($P < .01$). None of the various methods used for determining external and internal doneness appeared to be related to the doneness of light meat of the turkeys in any of the treatment groups.

Correlation coefficients also were determined for evaluations of palatability and doneness of dark meat (Table 6). The relationship between flavor and doneness of dark meat of turkeys

Table 6. Correlation coefficients (r values) for doneness and other palatability factors for dark meat and for doneness of juice, internal and external doneness factors of roasted whole turkeys.

Factors	Pectoralis major		Thigh	
	85°C.	90°C.	90°C.	95°C.
Doneness of dark meat vs.				
Flavor, dark	.733**	-.319 ns	.443 ns	.248 ns
Juiciness, dark	-.293 ns	-.694*	-.056 ns	-.335 ns
Tenderness, dark	.226 ns	.324 ns	.640*	.575*
Doneness of juice	.816**	.732**	.082 ns	.170 ns
General external appearance	.848***	.277 ns	.210 ns	.495 ns
Fork prick of drumstick	.757**	.422 ns	.584*	.457 ns
Movement of joint	.807**	.532 ns	.461 ns	.533 ns
Feel of drumstick	.712**	.608*	.442 ns	.535 ns
Appearance of drumstick flesh under skin	.706*	.504 ns	.695*	.552 ns
Appearance of drumstick flesh near bone	.660*	.574 ns	.432 ns	.516 ns
Appearance of thigh area near joint	.702*	.474 ns	.786**	.745**
General external and internal doneness	.845***	.559 ns	.643*	.556 ns
Doneness of juice vs.				
General external doneness	.876***	.590*	-.082 ns	.148 ns
General external and internal doneness	.776**	.803**	.043 ns	.270 ns

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

roasted to 85°C. in the breast was highly significant. A significant negative r value was obtained when juiciness of dark meat from birds cooked to 90°C. in the breast was compared to doneness of the dark samples. Comparisons of tenderness and doneness of dark samples resulted in significant correlation coefficients for birds roasted to either of the two thigh end point temperatures. Doneness of juice was related significantly ($P < .01$) to doneness of the dark meat of turkeys roasted to 85° or to 90°C. in the pectoralis major muscle. A significant correlation coefficient ($P < .001$) was obtained when doneness of dark meat was compared with the general external appearance of turkeys cooked to 85°C. in the breast. Scores for fork pricking the drumstick of turkeys roasted to 85°C. in the breast and 90°C. in the thigh were significantly ($P < .001$ and $P < .05$, respectively) correlated with doneness of the dark meat. Doneness of dark meat for turkeys cooked to 85°C. in the breast was related significantly ($P < .01$) to movement of the thigh-drumstick joint and to the feel of the drumstick. The feel of the drumstick of turkeys cooked to 90°C. in the pectoralis major was significantly ($P < .05$) related to doneness of dark meat. Significant ($P < .05$) correlation coefficients were obtained when doneness of dark meat was compared with the appearance of the drumstick flesh under the skin of birds cooked to 85°C. in the pectoralis major and those roasted to 90°C. in the thigh. Doneness of dark meat from turkeys roasted to 85°C. in the breast was related

significantly ($P < .05$) to both appearance of the drumstick flesh near the bone and of the thigh area near the joint. Significant ($P < .01$) r values were noted for the latter factor when compared with doneness of dark meat samples of turkeys cooked to the two thigh end points. A significant ($P < .05$) correlation coefficient existed for doneness of dark meat and general external and internal doneness for birds roasted to 90°C. in the thigh; a very highly significant r value was obtained for these same two factors for turkeys roasted to an end point of 85°C. in the pectoralis major.

Relationships between Doneness of Juice and External and Internal Doneness Factors. The scores for doneness of juice that exuded from the turkeys during carving and cooling were compared with scores for general external and for general external and internal appearance. A significant r value was obtained when doneness of the juice from turkeys roasted to 90°C. in the breast and the general external doneness were compared. However, when these same two factors were compared for birds cooked to 85°C. in the pectoralis major, a very highly significant r value was obtained. Highly significant correlation coefficients were noted for doneness of juice and for general external and internal doneness of turkeys roasted to the two pectoralis major end point temperatures. No significant relationships between doneness of juice and both general external doneness and general external and internal doneness were noted for turkeys roasted to either end point temperatures

recorded in the thigh muscles.

SUMMARY

Forty-eight whole defrosted unstuffed Broad Breasted White turkey hens each weighing 10 to 12 pounds, were roasted in a 325°F. oven to internal end point temperatures of 85° and 90°C. in the pectoralis major and of 90° and 95°C. in the thigh muscles.

Internal temperatures in the breast and thigh muscles were recorded every 20 minutes during roasting. At the end of the first 20-minute period, the thigh internal temperatures increased faster than those in the breast muscle. Maximum temperature increase of both areas took place during the 20- to 40-minute period. A lag in the increase in internal temperature indicated that coagulation of the thigh took place near 60°C., and at a slightly lower temperature for the breast muscle. At the time of removal from the oven, higher thigh than breast temperatures were recorded for nearly all of the turkeys.

The pre-carving evaluations for doneness of the turkeys indicated that turkeys roasted to 85°C. in the breast or to 90°C. in the thigh were similar, and they both were less done than birds cooked to 90°C. in the pectoralis major or to 95°C. in the thigh. Turkeys roasted to 95°C. in the thigh generally were significantly ($P<.05$) more done than those roasted to 90°C. in the pectoralis major, especially when areas near the thighs were compared. When doneness observations were made near

the pectoralis major, these two groups of turkeys were similarly done.

Light meat from birds cooked to 90°C. in the pectoralis major or to 95°C. in the thigh muscles was significantly ($P < .05$) more done than that from turkeys cooked to either 85°C. in the breast or 90°C. in the thigh. A few instances of underdoneness were noted, whereas none of the samples were overdone. Very highly significant differences between doneness of dark meat and certain end points existed and indicated a doneness pattern similar to that for light meat. The dark meat was slightly more done than the light meat from turkeys of all treatments. Doneness of juice was affected similarly by varying the end point of roasting. In general, the juice was judged considerably less done than either the light or the dark meat from the same turkey.

Flavor generally was not affected by the end point temperature to which the turkeys were roasted. One exception to this was observed when flavor of dark meat of birds cooked to 95°C. in the thigh was significantly better than that of similar samples from turkeys roasted to 85°C. in the breast or to 90°C. in the thigh muscles. Roasting turkeys to the various internal end point temperatures used in this study had no significant effect on the adjusted mean values for tenderness of light meat, but dark meat from birds roasted to 85°C. in the breast or 90°C. in the thigh were significantly less tender than similar samples from birds roasted to the other two end points.

Shear force values for light meat samples were not affected by varying the end point.

Varying the internal end point temperatures did not significantly affect the juiciness of the dark meat from the turkeys roasted in this study. Also, significant differences usually were not observed in juiciness of light meat from birds cooked to the four end points. Juiciness of dark meat from birds cooked to all end points and of light meat samples from turkeys roasted to the two lower breast and thigh temperatures was similar; light meat of turkeys cooked to the other two end points was considerably less juicy. These differences in the juiciness of the light meat were reflected in the similar and significant effect that variation of the end point internal temperatures had on press fluid yields.

Total, dripping and volatile cooking losses for turkeys roasted to 90°C. in the pectoralis major or to 95°C. in the thigh were significantly ($P < .05$) higher than those for birds cooked to 85° or to 90°C. in the breast or in the thigh muscles, respectively. Cooking time, in minutes per pound, also was affected significantly ($P < .05$) by varying the end point temperatures. Generally, cooking losses increased as cooking time, in minutes per pound, increased.

Generally, whole unstuffed turkeys roasted to internal end points of 85°C. in the breast or to 90°C. in the thigh, as evaluated by the subjective and objective measurements used in this study, were not optimumly done. Birds roasted to 90°C.

in the breast or to 95°C. in the thigh were of optimum doneness in most instances. Pre-carving evaluations, particularly as based on observations of the thigh area, indicated that turkeys roasted to 95°C. in the thigh were more done than were birds cooked to the 90°C. pectoralis major end point.

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APPENDIX

Form I. Weight losses of roasted whole turkeys before and after cooking.

I. Losses by weight — Grams

A. Before cooking

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

B. After cooking

1. Weight of pan, rack, thermometers, bird and drippings.
2. Weight of pan, rack, thermometers, and drippings.
3. Volatile loss (A3 - B1).
4. Weight of bird and platter.
5. Weight of platter.
6. Cooked weight of bird (B4 - B5).
7. Total cooking loss (A1 - B6).
8. Dripping loss (B7 - B3).

II. Losses as percent of weight — Percent

A. Volatile loss (B3/A1).

B. Total cooking loss (B7/A1).

C. Dripping loss (B8/A1).

Form II. Score card for turkey.

NAME_____ DATE_____

EATING QUALITY			DONENESS	
Sample	Flavor	Juiciness	Tenderness	Meat	Juice*
1					
2					
3					
4					

Descriptive Terms for Flavor, Juiciness, and Tenderness:

7 - very desirable
6 - desirable
5 - mod. desirable
4 - sl. desirable
3 - sl. undesirable
2 - mod. undesirable
1 - undesirable

Descriptive Terms for Doneness of Meat and Juice:

7 - very overdone
6 - mod. overdone
5 - sl. overdone
4 - done
3 - sl. underdone
2 - mod. underdone
1 - very underdone

*The number of the juice sample is not necessarily the same as the meat sample.

TEXTURE

Place the sample number by the word which best describes its texture:

Very fine_____
Fine_____
Mod. fine_____
Mod. coarse_____
Coarse_____
Very coarse_____
Stringy_____
Powdery_____
Dry_____
Fiber separation_____

Comments:

Form III. Score card for doneness of whole turkey.

Name_____ DATE_____

	1	2
I. EXTERNAL CHARACTERISTICS:		
General Appearance:		
Fork Pricking:		
Drumstick		
Wing		
Movement of Joint:		
Feel of Drumstick:		
II. INTERNAL CHARACTERISTICS:		
Appearance of Flesh under Skin		
Breast		
Drumstick		
Appearance of Flesh next to Bone		
Breast		
Drumstick		
Appearance near Joints		
Shoulder		
Thigh		
III. GENERAL DONENESS		

Please base your scores on composite of whole bird.

Descriptive Terms for Scoring:

7 - very overdone
6 - mod. overdone
5 - sl. overdone
4 - done
3 - sl. underdone
2 - mod. underdone
1 - very underdone

Explanation of Terms and Abbreviations for Appendix Tables

Codes for treatments

Treatment I - turkeys roasted to 85°C. in the pectoralis major.
Treatment II - turkeys roasted to 90°C. in the pectoralis major.
Treatment III - turkeys roasted to 90°C. in the thigh.
Treatment IV - turkeys roasted to 95°C. in the thigh.

Codes for meat samples

Sample one - from the right side of the turkey assigned the smaller treatment number at each cooking period.
Sample two - from the left side of the turkey assigned the smaller treatment number at each cooking period.
Sample three - from the right side of the turkey assigned the larger treatment number at each cooking period.
Sample four - from the left side of the turkey assigned the larger treatment number at each cooking period.

Codes for juice samples

Samples one and two - duplicate samples taken from juice that exuded during cooking from the turkey assigned the smaller treatment number at each cooking period.
Samples three and four - duplicate samples taken from juice that exuded during cooking from the turkey assigned the larger treatment number at each cooking period.

The number of the juice sample was not necessarily the same as the number of the meat sample.

Sides of a whole turkey.

R - right side.
L - left side.

In this study, the right side was defined as the side on the right when the anterior portion of the turkey was in a breast-up position facing the worker.

Average increase in temperature obtained during roasting of whole turkeys.

** - one figure only.
* - average of nine to 11 figures.
other averages include 12 figures.

Grand average refers to average of right and left sides of breasts or of thighs of whole turkeys.

Significance of statistical data

* - significant at the 5% level.
** - significant at the 1% level.
*** - significant at the 0.1% level.

Abbreviations

A - general appearance
BB - breast flesh near bone
BS - breast flesh under skin
D - dripping cooking loss
DB - drumstick flesh near bone
DF - degrees of freedom
DS - drumstick flesh under skin
F - feel of drumstick
G - general external and internal doneness
L - left
M - movement of joint
PD - fork prick of drumstick
PF - press fluids
PW - fork prick of wing
R - right
SJ - shoulder area near joint
T - total cooking loss
TJ - thigh area near joint
V - volatile cooking loss

Basis for scoring doneness of juice, meat and whole birds

7 - very overdone
6 - moderately overdone
5 - slightly overdone
4 - done
3 - slightly underdone
2 - moderately underdone
1 - very underdone

Basis for scoring flavor, juiciness and tenderness

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

Basis of reporting mechanical tests and cooking data

Cooking losses, percent
Dripping
Volatile
Total
Cooking time, min./lb.
Press fluid yields, ml./25 g.
Shear force values, lbs.
Total cooking time, min.
Weight, lbs.

Table 7. Balanced incomplete block design for treatments and randomization of meat and juice samples.[1]

Cooking period	Treatments		Meat samples				Juice samples			
1	II	III	4	2	3	1	1	3	4	2
2	I	IV	1	2	3	4	3	4	1	2
3	III	IV	2	1	3	4	3	1	4	2
4	I	II	3	4	1	2	2	1	3	4
5	I	III	4	2	3	1	3	1	2	4
6	II	IV	3	4	2	1	3	4	1	2
7	II	III	2	3	4	1	3	1	2	4
8	III	IV	3	2	1	4	3	2	4	1
9	I	III	1	2	3	4	4	1	2	3
10	II	IV	1	4	2	3	4	2	3	1
11	I	II	3	4	1	2	4	1	2	3
12	I	IV	3	2	1	4	4	3	2	1
13	II	IV	4	1	2	3	2	3	4	1
14	I	II	4	3	1	2	2	3	1	4
15	I	IV	2	4	1	3	1	2	3	4
16	I	III	2	1	4	3	4	2	1	3
17	II	III	3	2	4	1	1	3	4	2
18	III	IV	4	1	2	3	2	4	1	3
19	I	IV	2	3	1	4	4	1	3	2
20	I	II	3	1	4	2	2	1	4	3
21	I	III	1	3	4	2	3	2	4	1
22	II	IV	3	2	4	1	1	2	4	3
23	III	IV	2	4	1	3	4	2	3	1
24	II	III	4	1	2	3	1	3	2	4

[1]For explanation of terms and abbreviations used in this table, see Appendix, page 69 and 70.

Table 8. Pectoralis major internal temperatures (°C.) recorded every 20 minutes in whole turkeys roasted to 85°C. in the pectoralis major muscle.[1]

	Minutes															
	0		20		40		60		80		100		120		140	
	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L
	18	17	38	40	58	60	71	74	80	81	81	83				
	16	15	29	28	49	47	61	58	71	67	77	75	84	83		
	14	13	23	24	41	43	56	57	66	66	76	75	84	84		
	15	15	27	28	48	45	60	59	71	70	80	79	83	85		
	15	14	24	28	41	46	55	60	65	70	74	79	81	86		
	18	18	30	30	48	47	61	60	71	70	74	78	80	85		
	18	17	28	26	45	41	59	54	69	66	74	76	80	82		
	19	18	27	27	43	44	56	58	66	68	74	76	82	83		
	16	17	22	25	36	42	50	56	59	66	69	75	76	82	83	87
	14	14	24	25	44	44	58	58	67	68	76	78	83	85		
	18	18	27	25	43	39	55	52	65	64	75	73	80	83		
	12	13	21	25	38	38	54	53	65	65	74	74	81	82		
Avg.	16	16	27	28	44	45	58	58	68	68	75	77	81	84	83	87

[1]For explanation of terms and abbreviations used in this table see Appendix, page 69 and 70.

Table 9. Thigh internal temperatures (°C.) recorded every 20 minutes in whole turkeys roasted to 85°C. in the pectoralis major muscle.[1]

	Minutes															
	0		20		40		60		80		100		120		140	
	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L
	18	20	38	33	60	52	76	67	84	77	88	82				
	18	17	35	41	57	62	68	68	78	77	85	85	91	92		
	15	14	35	32	55	49	70	65	83	79	87	85	95	91		
	17	16	28	34	44	49	60	65	72	78	81	85	89	87		
	16	16	29	37	48	56	67	71	81	76	85	83	87	88		
	17	16	31	39	53	58	68	65	80	77	82	84	87	86		
	19	19	33	32	53	49	70	63	78	74	85	82	90	88		
	20	19	29	34	45	54	62	69	74	80	82	87	88	92		
	18	17	33	29	54	50	67	65	76	75	82	82	87	88	92	94
	15	14	30	31	50	46	65	61	75	72	84	79	89	86		
	17	18	36	30	55	46	67	59	77	70	87	78	94	87		
	14	15	28	27	49	45	64	61	74	73	82	83	88	90		
Avg.	17	17	32	33	52	51	67	65	78	76	84	83	90	88	92	94

[1] For explanation of terms and abbreviations used in this table see Appendix, page 69 and 70.

Table 10. Pectoralis major internal temperatures (°C.) recorded every 20 minutes in whole turkeys roasted to 90°C. in the pectoralis major muscle.[1]

	Minutes															
	0		20		40		60		80		100		120		140	
	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L
	16	17	38	41	59	60	71	73	81	85	88	85	89	90		
	15	15	31	29	49	45	64	59	73	69	81	77	86	93	89	87
	19	20	29	27	48	46	60	58	70	68	78	78	84	85	89	92
	16	15	25	25	43	43	57	56	67	67	76	76	82	82	88	88
	15	13	27	25	45	44	59	58	70	69	80	77	86	84		
	15	15	24	25	42	44	56	58	67	69	75	77	82	83	87	89
	17	15	26	26	44	44	58	58	68	68	77	76	84	83	88	89
	17	18	29	25	45	37	59	50	68	61	76	69	82	77	87	83
	17	16	24	27	37	38	50	52	62	63	70	73	79	81	86	89
	16	17	23	23	38	37	53	51	63	62	73	71	81	80	87	85
	18	18	28	28	40	42	56	53	66	68	75	78	83	84	90	91
	22	21	31	29	47	45	61	58	72	68	81	77	86	83		
Avg.	17	17	28	28	45	44	59	57	69	68	78	76	84	84	88	88

[1]For explanation of terms and abbreviations used in this table, see Appendix, page 69 and 70.

Table 11. Thigh internal temperatures (°C.) recorded every 20 minutes in whole turkeys roasted to 90°C. in the pectoralis major muscle.[1]

	Minutes															
	0		20		40		60		80		100		120		140	
	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L
	18	17	33	27	54	40	71	55	82	66	96	76	99	83		
	18	17	40	41	59	59	72	71	84	82	90	87	89	91	94	95
	21	19	34	34	55	54	68	65	77	75	84	83	87	88	93	94
	17	15	29	36	48	49	63	64	75	76	82	84	87	88	93	93
	15	14	33	32	56	55	70	69	82	79	89	87	93	92		
	17	15	43	39	62	61	74	73	80	81	84	88	90	92	93	97
	18	17	31	32	49	50	64	66	75	74	83	84	88	89	96	95
	18	19	37	34	55	54	72	69	79	78	84	84	89	88	97	94
	17	18	28	32	43	45	58	61	71	74	80	83	86	90	94	94
	18	18	31	33	52	52	70	67	76	75	85	82	90	87	95	93
	17	17	29	29	48	47	64	62	72	74	80	82	86	88	93	94
	23	21	38	32	52	49	65	64	77	77	84	85	87	90		
Avg.	18	17	34	33	53	51	68	66	78	76	85	84	89	89	94	94

[1]For explanation of terms and abbreviations used in this table, see Appendix, page 69 and 70.

Table 12. Pectoralis major internal temperatures (°C.) recorded every 20 minutes in whole turkeys roasted to 90°C. in the thigh muscle.[1]

	Minutes															
	0		20		40		60		80		100		120		140	
	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L
	17	17	37	36	57	57	69	69	80	79	88	86				
	19	18	39	40	57	58	70	72	80	82	89	91				
	15	14	24	24	41	41	55	54	65	66	74	74	81	82		
	19	17	29	28	45	46	58	60	68	70	75	78	81	83		
	14	13	26	29	42	43	55	56	66	66	74	75	80	83		
	15	15	26	25	45	43	58	56	68	66	78	77	84	84		
	16	15	23	22	39	39	51	52	63	64	73	73	80	79		
	19	18	24	22	38	36	52	49	63	62	72	70	80	79		
	15	14	26	24	43	42	57	56	68	67	75	75	83	83		
	11	11	15	18	31	35	46	50	57	60	65	69	74	76	82	83
	17	18	26	27	41	42	55	55	67	66	75	75	83	83		
	20	20	29	28	46	44	60	58	70	68	79	77	84	82		
Avg.	16	16	27	27	44	44	57	57	68	68	76	77	81	81	82	83

[1]For explanation of terms and abbreviations used in this table see Appendix, page 69 and 70.

Table 13. Thigh internal temperatures (°C.) recorded every 20 minutes in whole turkeys roasted to 90°C. in the thigh muscle.[1]

	Minutes															
	0		20		40		60		80		100		120		140	
	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L
	18	17	38	33	60	52	74	65	84	81	86	89				
	18	18	41	43	62	62	75	78	83	86	88	91				
	15	14	33	36	55	57	70	71	82	84	80	82	85	92		
	18	18	34	33	53	52	64	66	76	79	81	86	86	89		
	15	15	31	32	52	51	65	65	76	78	84	84	85	87		
	17	15	33	34	55	51	66	65	77	79	85	86	88	87		
	18	16	34	33	57	54	63	65	75	75	82	83	87	89		
	18	18	30	34	50	48	61	63	72	72	82	80	88	87		
	17	14	30	28	47	45	60	61	70	73	80	81	86	88		
	14	15	25	29	46	46	54	59	65	72	73	80	79	84	87	89
	18	19	29	28	44	44	60	58	73	70	81	78	88	85		
	21	20	34	35	53	53	65	67	74	78	82	85	86	89		
Avg.	17	17	33	33	53	51	65	65	76	77	82	84	86	88	87	89

[1]For explanation of terms and abbreviations used in this table, see Appendix page 69 and 70.

Table 14. Pectoralis major internal temperatures (°C.) recorded every 20 minutes in whole turkeys roasted to 95°C. in the thigh muscles.[1]

	Minutes																	
	0		20		40		60		80		100		120		140		160	
	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L
	17	17	37	37	55	57	68	71	79	82	83	87	89	90				
	18	18	35	35	55	54	68	67	77	77	83	86	90	91				
	20	20	29	31	46	48	59	61	68	70	78	80	84	87				
	15	14	22	24	38	41	52	54	62	64	70	73	79	80	86	87	91	92
	14	14	29	24	45	44	59	57	69	67	79	78	86	85	92	92		
	17	17	24	26	40	45	50	58	62	69	70	78	78	84	93	88		
	16	15	26	27	43	47	56	59	66	69	75	78	83	84	89	90		
	20	19	25	26	39	43	53	56	63	66	71	74	80	81	85	86		
	15	15	23	23	39	39	54	55	64	65	73	74	80	81	86	88		
	14	13	20	22	37	39	49	54	60	65	68	75	76	84	84	89		
	16	16	24	27	40	43	52	53	63	65	71	75	80	83	86	89		
	18	18	27	27	42	41	56	54	66	64	75	74	81	80	88	86		
Avg.	16	16	27	25	43	45	56	58	66	68	75	78	82	84	88	88	91	92

[1]For explanation of terms and abbreviations used in this table, see Appendix, page 69 and 70.

Table 15. Thigh internal temperatures (°C.) recorded every 20 minutes in whole turkeys roasted to 95°C. in the thigh muscles.[1]

	Minutes																	
	0		20		40		60		80		100		120		140		160	
	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L
	19	19	43	36	62	53	77	69	83	79	88	86	90	90				
	20	19	38	38	60	60	75	74	82	82	89	89	91	90				
	20	20	32	35	53	52	67	64	77	71	85	83	93	90				
	16	15	30	31	50	52	66	68	76	80	82	81	87	86	91	90	94	95
	15	14	27	34	46	57	60	70	70	78	80	86	86	91	92	97		
	17	16	32	35	53	57	64	65	76	79	85	80	87	86	86	91		
	17	15	31	28	52	46	64	61	72	74	80	81	87	87	91	93		
	20	18	32	36	53	56	66	53	75	75	82	81	88	87	93	90		
	16	15	29	30	46	50	62	64	73	75	80	82	87	88	94	94		
	15	14	27	33	45	48	60	63	73	73	80	81	87	88	91	92		
	16	17	27	32	43	47	56	60	69	71	80	80	86	87	94	93		
	18	19	31	32	48	49	61	62	70	73	79	82	86	88	92	95		
Avg.	17	17	32	33	51	52	65	64	75	76	82	83	88	88	92	93	94	95

[1]For explanation of terms and abbreviations used in this table, see Appendix, page 69 and 70.

Table 16. Average increase in temperature (°C.) in the right pectoralis major and in the right thigh muscles during roasting of whole turkeys.[1]

Minutes	Pectoralis major				Thigh				Grand average	
	85°C.		90°C.		90°C.		95°C.			
	Breast	Thigh	Breast	Thigh	Breast	Thigh	Breast	Thigh	Breast	Thigh
0 - 20	11	15	11	16	10	15	10	14	11	16
20 - 40	18	20	17	19	17	20	16	19	17	19
40 - 60	14	15	14	15	13	12	13	14	13	14
60 - 80	10	11	10	10	11	11	10	10	10	11
80 - 100	7	6	8	8	8	6	8	7	8	7
100 - 120	6*	6*	6	4	7*	5*	8	5	7	5
120 - 140	7**	5**	5*	6*	8**	8**	7*	4*	6	6
140 - 160							5**	3**	5	3

[1]For explanation of terms and abbreviations used in this table, see Appendix, page 69 and 70.

Table 17. Average increase in temperature (°C.) in the left pectoralis major and in the left thigh muscles during the roasting of whole turkeys.[1]

Minutes	Pectoralis major				Thigh			
	85°C.		90°C.		90°C.		95°C.	
	Breast	Thigh	Breast	Thigh	Breast	Thigh	Breast	Thigh
0 - 20	12	16	11	16	11	16	11	16
20 - 40	17	18	16	18	17	18	18	19
40 - 60	14	14	13	14	13	14	13	13
60 - 80	10	11	11	10	11	12	10	10
80 - 100	8	7	8	8	9	6	9	7
100 - 120	7*	5*	7	5	7*	5*	6	5
120 - 140	5**	6**	6*	5*	7**	5**	6*	5*
140 - 160							5**	3**

[1]For explanation of terms and abbreviations used in this table, see Appendix, page 69 and 70.

Table 18. Mean squares for fork pricking of drumstick and wing, feel of drumstick, movement of the joint, and general appearance.[1]

Sources of variation	D/F	External doneness				
		Fork Pricking		Feel of drumstick	Movement of joint	General appearance
		Drumstick	Wing			
Muscle-temperature combination (adjusted)	3	2.520***	0.902***	1.873***	2.184***	1.328***
Cooking period (block, unadjusted)	23	0.858	0.628	0.655	0.523	0.402
Error	21	0.058	0.079	0.097	0.091	0.152
Total	47					

[1]For explanation of terms and abbreviations used in this table, see Appendix, page 69 and 70.

Table 19. Mean squares for doneness of breast and drumstick flesh under skin, breast and drumstick flesh next to bone, shoulder and thigh areas near joints and for general external and internal doneness.[1]

Sources of variation	D/F	External doneness						General external and internal doneness
		Under skin		Next to bone		Near joints		
		Breast	Drumstick	Breast	Drumstick	Shoulder	Thigh	
Muscle-temperature combination (adjusted)	3	1.103***	1.944***	0.718***	0.747***	1.036***	1.473***	2.128***
Cooking period (block, unadjusted)	23	0.357	0.467	0.240	0.274	0.686	0.528	0.602
Error	21	0.073	0.099	0.055	0.074	0.066	0.086	0.062
Total	47							

[1]For explanation of terms and abbreviations used in this table, see Appendix, page 69 and 70.

Table 20. Mean doneness scores for meat samples from the right sides and for juice samples for roasted whole turkeys.[1]

	Pectoralis major						Thigh					
	85°C.			90°C.			90°C.			95°C.		
	Light	Dark	Juice	Light	Dark	Juice	Light	Dark	Juice	Light	Dark	Juice
1	3.50	3.71	3.00	3.20	4.71	3.00	4.00	4.00	2.75	4.50	4.71	3.64
	2.75	2.67	1.70	3.50	3.67	2.10	4.17	3.17	3.00	4.67	3.83	2.92
	4.25	3.43	2.55	3.75	4.33	4.10	3.50	3.43	3.64	3.50	4.33	3.80
	3.80	4.14	3.42	4.33	4.40	4.12	2.33	3.80	2.50	4.50	4.29	3.85
5	3.40	3.71	2.42	4.17	4.00	3.23	3.67	4.14	2.46	4.17	4.00	4.31
6	3.50	4.00	3.65	3.80	3.86	4.25	3.60	4.14	2.75	4.17	4.29	4.23
7	3.80	4.29	4.00	3.67	5.00	4.17	3.20	4.29	2.67	4.33	4.33	4.17
8	2.83	3.71	2.77	4.00	4.57	4.67	3.25	4.25	2.62	3.83	4.14	3.92
9	3.40	4.29	3.58	4.25	4.75	4.50	4.20	3.86	2.33	3.60	4.29	4.17
10	3.40	3.67	2.36	2.67	4.17	3.33	3.75	3.60	1.62	3.40	3.67	3.36
11	2.50	3.33	3.17	3.80	3.75	4.00	3.75	3.83	3.20	4.00	3.75	4.00
12	3.25	3.60	2.62	4.33	4.33	4.33	3.67	4.00	3.67	4.00	4.00	4.00
Avg.	3.36	3.71	2.94	3.79	4.30	3.82	3.57	3.88	2.77	4.06	4.14	3.86

[1]For explanation of terms and abbreviations used in this table, see Appendix, page 69 and 70.

Table 21. Mean doneness scores for meat samples from the left sides and for juice samples of roasted whole turkeys.[1]

	Pectoralis major						Thigh					
	85°C.			90°C.			90°C.			95°C.		
	Light	Dark	Juice	Light	Dark	Juice	Light	Dark	Juice	Light	Dark	Juice
	3.25	3.29	3.00	3.60	3.57	2.83	3.80	3.29	2.67	3.75	3.71	3.64
	3.50	2.83	1.70	3.00	3.17	2.10	4.17	3.33	2.83	4.67	3.67	2.92
	4.00	3.00	2.55	4.25	3.67	4.10	4.50	3.29	3.64	4.00	4.00	3.60
	3.60	3.71	3.25	3.67	4.40	4.12	2.67	3.40	2.50	3.83	4.14	3.85
	3.60	3.86	2.42	3.50	3.71	3.15	3.17	3.29	2.54	4.00	3.57	4.31
	4.33	3.71	3.65	4.20	4.43	4.25	3.40	3.86	2.75	3.83	3.71	4.15
	4.00	4.29	4.00	3.50	4.50	4.17	2.80	3.86	2.67	3.67	4.33	4.25
	3.17	3.71	2.69	4.00	4.57	4.75	3.00	3.75	2.62	3.33	4.29	3.77
	4.20	4.57	3.58	4.00	4.25	4.50	3.40	4.14	2.42	4.40	4.00	4.17
	4.20	3.67	2.36	2.83	4.00	3.33	3.75	4.00	1.62	3.60	3.67	3.36
	2.33	3.83	3.17	3.40	3.75	3.87	4.00	4.00	3.20	4.60	4.00	3.87
	3.25	3.80	2.62	3.67	4.00	4.33	3.33	4.33	3.67	4.00	4.50	4.00
Avg.	3.62	3.69	2.92	3.64	4.00	3.79	3.50	3.71	2.76	3.97	3.97	3.82

[1]For explanation of terms and abbreviations used in this table, see Appendix, page 69 and 70.

Table 22. Mean doneness scores for general appearance, feel of drumstick and movement of joint of roasted whole turkeys.[1]

Pectoralis major						Thigh					
85°C.			90°C.			90°C.			95°C.		
A	F	M	A	F	M	A	F	M	A	F	M
3.67	3.00	3.00	3.25	3.25	2.75	3.00	2.75	2.75	4.00	3.67	4.00
2.75	2.25	2.00	4.00	3.25	3.25	3.67	3.00	2.33	3.67	3.00	2.67
3.75	3.00	3.00	4.33	4.00	3.67	3.75	3.50	3.50	4.33	4.33	4.00
3.67	3.00	2.67	4.33	4.00	4.00	4.00	3.67	3.00	4.25	4.00	3.75
3.67	3.33	3.33	3.00	3.33	3.33	3.25	3.25	3.00	4.00	4.00	4.00
4.33	3.33	3.00	4.33	4.00	4.00	4.00	3.50	3.00	4.33	4.33	3.67
4.67	4.00	4.00	4.33	4.67	4.00	4.00	3.67	3.33	5.33	5.00	4.33
4.00	4.00	3.33	5.00	5.00	4.67	4.00	4.33	3.67	5.00	4.33	4.00
4.67	3.67	3.67	4.00	4.67	4.33	3.00	3.00	2.67	5.00	4.67	4.00
3.33	2.67	2.67	4.50	4.50	4.25	4.67	4.00	3.67	4.67	3.67	3.67
4.00	3.50	3.00	4.67	4.67	4.00	4.33	3.33	3.33	4.67	5.00	4.33
4.00	3.67	3.00	4.67	4.33	4.33	4.00	4.00	3.67	5.00	5.33	5.33
Avg. 3.88	3.28	3.06	4.20	4.14	3.88	3.81	3.50	3.16	4.52	4.28	3.98

[1]For explanation of terms and abbreviations used in this table, see Appendix, page 69 and 70.

Table 23. Mean doneness scores for fork pricking of drumstick and wing of roasted whole turkeys.[1]

	Pectoralis major				Thigh			
	85°C.		90°C.		90°C.		95°C.	
	PD	PW	PD	PW	PD	PW	PD	PW
	2.67	2.33	3.00	2.25	3.00	2.25	3.67	3.33
	2.25	1.75	3.25	2.50	2.67	2.00	3.67	2.67
	3.50	2.75	4.33	3.33	3.50	2.75	4.33	3.33
	3.33	3.00	4.33	3.67	4.33	3.00	4.50	3.75
	3.33	3.00	4.00	3.33	3.25	3.25	4.33	3.67
	3.33	3.00	4.33	4.00	3.67	2.67	4.33	3.67
	4.67	3.33	4.33	3.67	4.67	3.00	5.33	4.33
	3.67	3.67	5.33	3.67	4.33	4.00	4.67	4.00
	4.67	3.67	4.67	3.67	3.33	3.33	5.00	4.00
	2.67	2.33	4.75	4.25	4.33	3.67	4.00	3.00
	4.00	3.25	5.00	4.00	4.00	3.33	5.33	3.67
	4.00	3.33	4.33	4.00	4.00	4.00	5.67	4.33
Avg.	3.51	2.95	4.30	3.53	3.76	3.10	4.57	3.65

[1]For explanation of terms and abbreviations used in this table, see Appendix, page 69 and 70.

Table 24. Mean doneness scores for breast and drumstick flesh under the skin of roasted whole turkeys.[1]

	Pectoralis major				Thigh			
	85°C.		90°C.		90°C.		95°C.	
	BS	DS	BS	DS	BS	DS	BS	DS
	3.33	3.67	3.75	4.00	3.50	3.75	4.00	5.00
	2.75	3.00	3.75	4.00	2.67	3.33	3.33	3.67
	3.00	3.75	4.00	4.33	4.00	4.00	4.00	4.67
	3.67	3.33	4.67	4.33	4.00	4.00	4.25	4.50
	4.00	4.00	3.33	4.00	3.75	3.50	4.33	4.00
	4.00	4.00	4.67	4.67	3.67	4.00	4.33	4.33
	4.33	4.33	4.33	4.67	4.00	4.33	5.00	5.67
	3.67	4.33	5.00	5.00	3.67	4.33	4.00	5.00
	4.33	4.33	4.33	5.33	3.67	4.00	4.00	4.67
	3.00	3.33	4.25	4.50	3.67	4.33	4.33	4.67
	3.75	3.75	4.33	5.00	4.00	4.00	4.67	5.67
	3.33	3.67	4.33	4.33	4.00	4.33	4.67	6.00
Avg.	3.60	3.79	4.23	4.51	3.72	3.99	4.24	4.82

[1]For explanation of terms and abbreviations used in this table, see Appendix, page 69 and 70.

Table 25. Mean doneness scores for breast and drumstick flesh near the bone of roasted whole turkeys.[1]

	Pectoralis major				Thigh			
	85°C.		90°C.		90°C.		95°C.	
	BB	DB	BB	DB	BB	DB	BB	DB
	3.67	3.67	3.75	3.75	3.50	3.50	4.33	4.00
	3.00	3.00	4.25	3.25	3.00	3.33	3.33	3.33
	3.50	3.25	4.00	4.00	4.00	4.00	4.33	4.00
	4.00	4.00	4.33	4.00	4.00	4.00	4.00	4.25
	4.00	4.00	4.00	3.67	3.50	3.75	4.33	3.67
	4.00	4.00	4.67	4.67	4.00	4.00	4.00	4.00
	4.67	4.33	4.33	4.33	4.33	4.33	4.67	4.67
	4.00	4.33	5.00	4.67	3.67	3.67	4.33	4.67
	4.00	4.00	4.33	4.00	4.00	3.67	4.00	4.33
	3.00	2.67	4.25	4.25	3.67	4.00	4.00	4.33
	4.00	3.25	4.00	4.33	3.67	3.67	4.33	4.67
	3.67	3.67	4.33	4.33	4.00	4.00	4.67	4.67
Avg.	3.79	3.68	4.27	4.10	3.78	3.83	4.19	4.22

[1]For explanation of terms and abbreviations used in this table, see Appendix, page 69 and 70.

Table 26. Mean doneness scores for shoulder and thigh areas near joints and for general external and internal doneness of roasted whole turkeys.[1]

	Pectoralis major						Thigh					
	85°C.			90°C.			90°C.			95°C.		
	SJ	TJ	G	SJ	TJ	G	SJ	TJ	G	SJ	TJ	G
	3.00	2.33	2.67	2.25	3.00	3.33	2.00	2.25	2.67	3.67	4.00	3.67
	1.75	2.25	2.00	2.25	3.50	3.25	2.33	2.00	2.67	3.33	3.33	3.00
	2.50	3.25	3.00	3.67	4.33	4.33	2.75	3.00	3.67	3.67	4.33	4.33
	3.67	3.67	3.33	4.00	4.00	4.33	3.33	3.67	3.33	4.00	4.00	4.25
	3.67	3.67	3.33	3.67	3.33	3.33	2.75	3.00	3.25	3.67	3.67	4.00
	3.67	4.00	3.50	4.00	4.33	4.33	3.33	3.67	3.67	3.67	4.00	4.33
	4.00	4.33	4.33	3.67	4.00	4.33	4.00	4.00	4.00	4.00	4.67	4.83
	3.83	4.17	4.00	4.33	4.67	5.00	3.67	3.67	3.67	4.00	4.33	4.50
	3.67	3.67	4.17	4.00	4.00	4.00	3.33	3.33	3.33	4.00	4.00	4.33
	2.33	2.67	2.67	4.00	4.00	4.50	3.33	3.67	4.00	4.00	4.00	4.00
	3.25	3.50	3.62	4.00	3.67	4.33	3.67	3.67	3.67	4.33	4.00	4.67
	3.33	3.33	3.33	4.33	4.33	4.33	4.00	4.00	4.00	4.33	4.33	5.17
Avg.	3.22	3.40	3.33	3.68	3.93	4.12	3.21	3.33	3.49	3.89	4.06	4.26

[1]For explanation of terms and abbreviations used in this table, see Appendix, page 69 and 70.

Table 27. Mean squares for flavor, juiciness and press fluid yields.[1]

Sources of variation	D/F	Flavor		Juiciness		Press fluid
		Light	Dark	Light	Dark	
Muscle-temperature combination (adjusted)	3	0.090	0.247*	0.651*	0.035	0.352**
Cooking period (block, unadjusted)	23	0.355	0.131	0.407	0.189	0.220
Error	21	0.120	0.076	0.185	0.109	0.072
Total	47					

[1]For explanation of terms and abbreviations used in this table, see Appendix, page 69 and 70.

Table 28. Mean squares for tenderness, shear values, and doneness of meat and juice.[1]

Sources of variation	D/F	Tenderness		Shear	Doneness		
		Light	Dark		Light	Dark	Juice
Muscle-temperature combination (adjusted)	3	0.689	0.129*	14.926	0.678*	0.629***	2.766***
Cooking period (block, unadjusted)	23	0.682	0.198	10.263	0.306	0.268	0.677
Error	21	0.555	0.031	8.556	0.192	0.039	0.201
Total	47						

[1]For explanation of terms and abbreviations used in this table, see Appendix, page 69 and 70.

Table 29. Mean squares for cooking losses (total, dripping, and volatile) and cooking time.[1]

Sources of variation	D/F	Cooking losses			Cooking time
		Total	Dripping	Volatile	min/lb
Muscle-temperature combination (adjusted)	3	20.268***	6.905***	5.197***	3.595***
Cooking period (block, unadjusted)	23	2.929	1.206	1.164	1.261
Error	21	1.395	0.412	0.809	0.330
Total	47				

[1]For explanation of terms and abbreviations used in this table, see Appendix, page 69 and 70.

Table 30. Mean flavor scores for samples from right sides of roasted whole turkeys.[1]

Pectoralis major				Thigh			
85°C.		90°C.		90°C.		95°C.	
Light	Dark	Light	Dark	Light	Dark	Light	Dark
5.25	6.00	4.60	5.29	5.40	5.86	5.75	6.00
5.50	5.17	5.25	5.83	5.67	5.50	5.67	5.67
6.00	5.57	6.25	6.17	5.75	5.14	6.25	6.33
5.60	5.86	6.33	6.00	5.00	5.60	5.33	6.29
5.20	5.57	5.50	6.14	5.67	6.14	5.00	5.71
5.00	5.71	5.40	6.14	5.40	5.57	5.00	6.29
5.60	6.00	5.17	5.33	5.00	5.57	5.50	6.17
4.83	5.43	5.80	6.57	5.50	6.00	5.17	5.57
5.40	6.00	5.50	5.75	5.00	5.71	5.20	6.29
5.40	5.50	4.17	5.67	5.33	6.00	4.60	6.17
4.00	5.67	5.80	5.75	5.25	5.17	5.40	6.25
5.50	6.00	6.00	6.00	5.33	6.00	4.50	5.67
Avg. 5.27	5.71	5.48	5.89	5.36	5.69	5.28	6.03

[1]For explanation of terms and abbreviations used in this table, see Appendix, page 69 and 70.

Table 31. Mean flavor scores for samples from left sides of roasted whole turkeys.[1]

Pectoralis major				Thigh			
85°C.		90°C.		90°C.		95°C.	
Light	Dark	Light	Dark	Light	Dark	Light	Dark
5.25	5.71	5.20	5.71	6.00	5.57	5.50	6.14
5.50	5.33	4.75	5.50	5.50	5.17	6.00	5.00
6.25	5.14	6.00	5.83	6.50	5.86	6.00	6.33
5.80	5.86	6.00	6.00	4.67	5.40	5.17	6.14
5.20	5.86	5.17	5.71	5.33	5.43	5.33	5.43
5.17	6.00	5.40	6.00	5.60	5.43	5.33	6.14
5.40	6.00	5.33	6.17	4.80	5.43	5.67	5.83
4.83	5.57	5.60	6.57	5.50	6.25	4.83	5.57
5.80	6.14	6.00	6.00	4.80	6.14	5.40	6.43
5.40	5.33	4.67	6.00	6.00	5.60	4.40	5.50
4.17	6.50	5.40	5.75	6.00	4.83	6.00	6.25
5.50	5.80	6.33	6.33	6.00	6.67	5.00	5.50
Avg. 5.36	5.77	5.49	5.96	5.56	5.65	5.39	5.86

[1]For explanation of terms and abbreviations used in this table, see Appendix, page 69 and 70.

Table 32. Mean juiciness scores and press fluid yields for samples from right sides of roasted whole turkeys.[1]

Pectoralis major						Thigh					
85°C.			90°C.			90°C.			95°C.		
Juiciness		Press	Juiciness		Press	Juiciness		Press	Juiciness		Press
Light	Dark	fluid	Light	Dark	fluid	Light	Dark	fluid	Light	Dark	fluid
5.50	6.14	8.65	5.40	5.14	9.25	5.20	6.14	9.40	4.50	5.00	8.50
6.25	6.00	8.80	5.75	6.00	8.15	5.17	5.83	9.25	4.67	5.67	9.20
5.25	5.00	8.75	5.50	5.00	8.50	5.75	4.86	8.75	5.50	5.33	8.40
5.00	5.14	9.00	5.33	5.20	9.25	7.00	5.20	8.70	4.67	5.29	8.55
5.20	5.29	9.45	4.67	5.29	8.70	5.33	5.00	9.15	4.67	4.86	8.95
5.50	5.43	9.00	5.00	6.14	9.05	5.00	5.57	9.50	5.00	5.71	8.70
5.60	5.14	8.95	4.50	4.50	7.95	5.60	5.14	9.15	4.33	5.17	8.20
5.33	5.14	8.80	4.80	5.29	8.90	5.75	5.25	9.60	4.83	5.29	8.55
5.80	5.43	9.15	4.75	5.25	8.60	4.00	5.43	9.25	5.20	5.86	9.00
4.60	5.50	9.25	5.33	4.67	8.20	5.75	5.00	9.40	4.40	5.50	8.95
5.67	5.00	9.50	5.20	5.50	8.50	5.25	5.33	8.95	4.00	5.75	8.70
5.25	5.00	9.60	5.00	5.00	9.00	5.33	5.33	9.15	4.24	5.17	8.35
Avg. 5.41	5.35	9.08	5.10	5.25	8.67	5.43	5.34	9.19	4.67	5.38	8.67

[1]For explanation of terms and abbreviations used in this table, see Appendix page 69 and 70.

Table 33. Mean juiciness scores and press fluid yields for samples from left side of roasted whole turkeys.[1]

Pectoralis major						Thigh					
85°C.			90°C.			90°C.			95°C.		
Juiciness		Press	Juiciness		Press	Juiciness		Press	Juiciness		Press
Light	Dark	fluid	Light	Dark	fluid	Light	Dark	fluid	Light	Dark	fluid
5.50	6.00	9.65	5.60	6.00	9.30	5.20	6.43	9.30	5.25	5.57	8.60
5.00	6.00	9.05	5.50	6.00	9.15	5.17	5.83	9.05	4.50	5.33	9.05
5.50	5.43	9.25	4.75	5.33	8.25	4.75	5.00	9.10	4.75	5.67	8.75
4.20	5.00	9.35	5.67	5.00	8.70	5.67	6.00	9.15	4.83	5.29	8.60
5.00	5.43	9.10	5.17	5.14	9.30	4.67	5.14	9.40	4.83	5.43	9.20
4.17	5.43	8.95	4.60	5.43	9.20	4.60	5.71	9.45	3.83	5.71	8.65
5.20	5.00	9.00	5.17	5.00	8.35	6.00	5.29	8.90	5.00	5.33	8.40
5.33	5.43	8.75	5.00	5.00	8.90	6.50	5.75	9.70	5.33	5.14	8.95
5.40	5.29	9.10	5.00	5.50	8.55	5.20	5.86	9.50	4.20	5.57	8.90
4.40	5.67	9.45	5.17	5.00	8.45	5.25	5.40	9.15	4.80	5.33	8.70
5.17	5.50	9.20	4.40	5.50	8.70	5.00	5.33	9.40	4.40	5.50	8.75
5.50	5.20	9.40	5.67	5.33	9.20	6.00	5.00	9.20	4.00	4.67	9.25
Avg. 5.03	5.45	9.19	5.14	5.35	8.84	5.33	5.56	9.28	4.64	5.38	8.82

[1]For explanation of terms and abbreviations used in this table see Appendix, page 69 and 70.

Table 34. Mean tenderness scores and shear values for samples from the right sides of roasted whole turkeys.[1]

Pectoralis major						Thigh					
85°C.			90°C.			90°C.			95°C.		
Tenderness			Tenderness			Tenderness			Tenderness		
Light	Dark	Shear	Light	Dark	Shear	Light	Dark	Shear	Light	Dark	Shear
5.50	5.86	13.69	4.40	6.43	12.56	6.60	5.86	10.88	6.25	6.14	8.00
4.25	5.83	9.00	6.00	6.00	10.81	6.50	5.50	9.15	6.67	5.83	7.00
6.25	5.29	7.81	6.50	6.00	7.25	5.50	5.29	8.88	6.25	5.83	6.94
6.00	5.43	13.50	6.33	6.00	7.19	3.00	5.60	22.38	6.17	6.00	7.81
5.20	5.71	14.00	6.17	5.71	8.62	5.00	5.71	13.56	6.00	5.57	8.69
5.67	5.71	11.31	5.40	6.14	10.56	5.20	6.14	14.62	6.50	6.00	8.56
6.40	6.43	5.94	5.33	5.83	7.94	5.40	5.86	12.25	6.17	5.83	6.44
4.33	5.14	16.85	6.20	6.43	9.50	6.00	6.00	7.80	5.83	5.57	9.50
5.60	5.86	10.65	5.75	6.00	7.55	5.40	6.00	8.05	6.00	6.14	9.50
5.20	6.00	8.88	4.17	6.00	12.00	5.75	4.80	9.65	4.80	5.83	8.62
3.67	5.67	14.75	5.20	5.75	10.25	6.00	6.00	9.19	5.80	5.75	7.94
5.50	4.80	13.85	6.33	6.00	6.62	6.00	6.00	9.44	5.75	5.67	12.00
Avg. 5.30	5.64	11.68	5.65	6.02	9.24	5.53	5.73	11.32	6.02	5.85	8.42

[1]For explanation of terms and abbreviations used in this table, see Appendix, page 69 and 70.

Table 35. Mean tenderness scores and shear values for samples from the left sides of roasted whole turkeys.[1]

Pectoralis major						Thigh					
85°C.			90°C.			90°C.			95°C.		
Tenderness			Tenderness			Tenderness			Tenderness		
Light	Dark	Shear	Light	Dark	Shear	Light	Dark	Shear	Light	Dark	Shear
5.75	5.00	12.31	5.20	5.57	13.44	6.00	5.86	9.00	6.25	5.86	9.25
5.50	5.50	9.75	5.50	5.67	11.00	6.50	5.67	7.75	6.67	5.50	7.19
6.25	5.00	8.12	6.25	5.67	7.31	6.50	5.14	8.75	6.25	5.83	6.88
5.80	5.14	10.19	5.67	5.50	7.88	4.67	5.60	14.00	5.67	5.57	7.75
5.40	5.43	15.25	5.33	5.00	10.31	4.83	5.00	14.06	5.67	5.71	7.44
6.33	6.00	8.19	5.40	5.71	9.20	5.40	5.86	8.00	5.67	5.86	8.00
6.60	6.29	6.75	5.50	5.50	9.12	5.00	5.43	14.15	5.67	5.50	9.31
5.00	5.43	12.45	6.00	6.57	7.06	6.25	5.75	8.00	5.00	5.86	13.00
6.20	6.00	8.40	6.00	6.00	9.65	5.80	6.14	6.85	5.40	6.29	7.85
5.80	6.00	7.69	4.67	6.17	8.81	6.00	5.40	11.15	5.20	6.00	10.06
4.33	5.83	17.69	5.00	5.75	9.50	6.25	5.83	7.69	5.80	6.00	5.69
5.00	5.40	11.15	6.00	6.00	7.25	6.00	5.67	9.94	6.00	6.00	11.00
Avg. 5.66	5.58	10.66	5.54	5.76	9.21	5.77	5.61	9.94	5.77	5.83	8.62

[1]For explanation of terms and abbreviations used in this table, see Appendix, page 69 and 70.

Table 36. Average cooking losses (percent) for roasted whole turkeys.[1]

Pectoralis major						Thigh					
85°C.			90°C.			90°C.			95°C.		
V	D	T	V	D	T	V	D	T	V	D	T
8.08	1.68	10.70	7.88	3.09	11.56	7.20	2.89	11.10	8.85	4.21	13.74
6.28	0.84	7.62	9.05	3.66	13.15	6.61	2.77	10.27	7.81	4.11	12.64
7.91	2.13	10.79	10.26	3.77	14.75	8.69	1.97	11.40	8.44	3.06	12.31
7.85	2.64	11.10	9.67	2.49	12.75	7.76	3.26	11.62	8.01	5.58	14.12
7.79	2.74	11.52	9.72	2.02	12.43	7.87	2.63	11.22	8.78	2.89	12.28
7.86	2.73	11.20	9.83	5.02	15.50	5.96	2.30	8.91	8.22	4.10	12.99
8.73	2.86	12.42	9.21	4.69	14.71	7.46	3.59	11.28	9.61	4.58	14.84
8.18	3.34	12.09	8.81	5.26	14.66	7.78	3.05	11.04	8.65	4.84	13.27
8.65	2.80	11.62	9.62	4.37	14.14	7.27	2.79	10.43	9.54	3.57	13.32
5.76	4.00	9.96	11.05	5.44	16.63	8.89	2.75	11.89	9.94	5.17	15.30
9.57	3.07	12.92	8.68	4.19	13.04	7.44	1.89	9.69	9.54	5.48	15.08
8.68	2.51	11.36	8.21	3.58	11.94	8.90	3.58	12.66	10.22	4.14	14.48
Avg. 7.94	2.61	11.11	9.33	3.96	13.77	7.65	2.79	10.96	8.98	4.31	13.70

[1]For explanation of terms and abbreviations used in this table, see Appendix, page 69 and 70.

Table 37. Average weight and cooking times for whole turkeys roasted to 85°C. and 90°C. in the pectoralis major.[1]

	85°C.			90°C.		
	Weight, lbs.	Total cooking time, min.	Cooking time min./lb.	Weight, lbs.	Total cooking time, min.	Cooking time min./lb.
	10.77	116	10.77	11.50	125	10.87
	10.70	124	11.87	10.43	143	13.71
	10.85	125	11.52	10.81	144	13.32
	10.53	128	12.16	10.88	148	13.60
	10.95	135	12.33	10.50	135	12.86
	10.35	133	12.85	11.12	147	13.22
	10.40	136	13.08	10.15	148	14.58
	10.16	130	12.80	11.11	149	13.41
	11.49	147	12.79	10.38	149	14.35
	11.13	127	11.41	11.23	153	13.62
	10.55	133	12.61	10.42	141	13.53
	10.44	134	12.84	10.34	133	12.86
Avg.	10.69	131	12.25	10.74	143	13.33

[1]For explanation of terms and abbreviations used in this table, see Appendix, page 69 and 70.

Table 38. Average weight and cooking times for whole turkeys roasted to 90°C. and 95°C. in the thigh.[1]

	90°C.			95°C.		
	Weight, lbs.	Total cooking time, min.	Cooking time, min./lb.	Weight, lbs.	Total cooking time, min.	Cooking time min./lb.
	10.93	115	10.52	10.83	139	12.83
	10.60	118	11.13	11.63	134	11.52
	11.39	137	12.03	10.30	134	13.01
	10.60	134	12.64	12.08	161	13.33
	10.73	136	12.67	10.52	148	14.07
	11.33	126	11.12	10.97	145	13.22
	11.50	138	12.00	11.26	155	13.77
	10.21	126	12.34	11.16	149	13.35
	11.77	134	11.38	10.08	144	14.29
	10.91	148	13.57	11.64	152	13.06
	10.49	127	12.11	10.70	145	13.55
	10.97	135	12.31	11.08	155	13.99
Avg.	10.95	131	11.98	11.02	147	13.33

[1]For explanation of terms and abbreviations used in this table, see Appendix, page 69 and 70.

Table 39. Average organoleptic scores and mechanical test measurements for combined right and left sides of roasted whole turkeys.[1]

Factors	Pectoralis major		Thigh	
	85°C.	90°C.	90°C.	95°C.
Flavor				
Light	5.31	5.48	5.46	5.33
Dark	5.74	5.93	5.67	5.94
Juiciness				
Light	5.22	5.12	5.38	4.66
Dark	5.40	5.30	5.45	5.38
Press fluid yields	9.13	8.75	9.23	8.74
Tenderness				
Light	5.60	5.60	5.65	5.89
Dark	5.61	5.89	5.67	5.84
Shear values	11.17	9.22	10.63	8.52
Doneness of meat				
Light	3.49	3.71	3.54	4.01
Dark	3.70	4.15	3.79	4.05
Doneness of juice	2.93	3.80	2.76	3.84

[1]For explanation of terms and abbreviations used in this table, see Appendix, page 69 and 70.

DONENESS OF WHOLE TURKEYS ROASTED TO CERTAIN END POINT TEMPERATURES

by

MARY ANN NEWTON WATSON

B. S., Montana State College, 1954

AN ABSTRACT OF A THESIS

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Forty-eight whole defrosted unstuffed Broad Breasted White turkey hens each weighing 10 to 12 pounds, were roasted in a 325°F. oven to internal end point temperatures of 85° and 90°C. in the pectoralis major and of 90° and 95°C. in the thigh muscles.

Internal temperatures in the breast and thigh muscles were recorded every 20 minutes during roasting. At the end of the first 20-minute period, the thigh internal temperatures increased faster than those in the breast muscle. Maximum temperature increase of both areas took place during the 20- to 40-minute period. A lag in the increase in internal temperature indicated that coagulation of the thigh took place near 60°C., and at a slightly lower temperature for the breast muscle. At the time of removal from the oven, higher thigh than breast temperatures were recorded for nearly all of the turkeys.

The pre-carving evaluations for doneness of the turkeys indicated that turkeys roasted to 85°C. in the breast or to 90°C. in the thigh were similar, and they both were less done than birds cooked to 90°C. in the pectoralis major or to 95°C. in the thigh. Turkeys roasted to 95°C. in the thigh generally were significantly ($P < .05$) more done than those roasted to 90°C. in the pectoralis major, especially when areas near the thighs were compared. When doneness observations were made near the pectoralis major, these two groups of turkeys were similarly done.

Light meat from birds cooked to 90°C. in the pectoralis major or to 95°C. in the thigh muscles was significantly ($P < .05$) more done than that from turkeys cooked to either 85°C. in the breast or 90°C. in the thigh. A few instances of underdoneness were noted, whereas none of the samples were overdone. Very highly significant differences between doneness of dark meat and certain end points existed and indicated a doneness pattern similar to that for light meat. The dark meat was slightly more done than the light meat from turkeys of all treatments. Doneness of juice was affected similarly by varying the end point of roasting. In general, the juice was judged considerably less done than either the light or the dark meat from the same turkey.

Flavor generally was not affected by the end point temperature to which the turkeys were roasted. One exception to this was observed when flavor of dark meat of birds cooked to 95°C. in the thigh was significantly better than that of similar samples from turkeys roasted to 85°C. in the breast or to 90°C. in the thigh muscles. Roasting turkeys to the various internal end point temperatures used in this study had no significant effect on the adjusted mean values for tenderness of light meat, but dark meat from birds roasted to 85°C. in the breast or 90°C. in the thigh were significantly less tender than similar samples from birds roasted to the other two end points. Shear force values for light meat samples were not affected by varying the end point.

Varying the internal end point temperatures did not significantly affect the juiciness of the dark meat from the turkeys roasted in this study. Also, significant differences usually were not observed in juiciness of light meat from birds cooked to the four end points. Juiciness of dark meat from birds cooked to all end points and of light meat samples from turkeys roasted to the two lower breast and thigh temperatures was similar; light meat of turkeys cooked to the other two end points was considerably less juicy. These differences in the juiciness of the light meat were reflected in the similar and significant effect that variation of the end point internal temperatures had on press fluid yields.

Total, dripping and volatile cooking losses for turkeys roasted to 90°C. in the pectoralis major or to 95°C. in the thigh were significantly ($P < .05$) higher than those for birds cooked to 85° or to 90°C. in the breast or in the thigh muscles, respectively. Cooking time, in minutes per pound, also was affected significantly ($P < .05$) by varying the end point temperatures. Generally, cooking losses increased as cooking time, in minutes per pound, increased.

Generally, whole unstuffed turkeys roasted to internal end points of 85°C. in the breast or to 90°C. in the thigh, as evaluated by the subjective and objective measurements used in this study, were not optimumly done. Birds roasted to 90°C. in the breast or to 95°C. in the thigh were of optimum doneness in most instances. Pre-carving evaluations, particularly

as based on observations of the thigh area, indicated that turkeys roasted to 95°C. in the thigh were more done than were birds cooked to the 90°C. pectoralis major end point.