STATUS OF MEAT COOKERY RESEARCH

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In an effort to obtain information on research in meat cookery since 1950 (a date arbitrarily selected), as well as to ascertain the current status of meat cookery research, a representative at each of the institutions represented in the American Meat Science Association was contacted by the author. An excellent response resulted, with all but five of the institutions represented answering this inquiry. The survey showed that less than a dozen of the approximately 40 institutions or organizations represented in the Association had done work in the field of meat cookery since 1950. Of the institutions now conducting meat cookery research, only three or four have relatively extensive programs in effect at the present time.

It appears that less research is being done in meat cookery now than in past years. Much of this decrease is undoubtedly due to the retirement of a group of extremely active home economists noted for their excellent investigations in the area of meat cookery. Names such as Dr. Belle Lowe (Iowa), Dr. Sylvia Cover (Texas), Dr. Faith Fenton (Cornell), Dr. Gladys E. Vail (Kansas), Dr. Alice Child (Minnesota), and Dr. Ruth M. Griswold (Chicago) have disappeared from the meat research scene. Probably the most active workers in the field at the present time are Dr. Pauline C. Paul (California), Dr. Isabel T. Noble (Minnesota), Drs. C. Edith Weir and E. H. Dawson (USDA), and Dr. Robert L. Hostetler (Texas).

A number of the respondents to the mail survey indicated areas of meat cookery research which should be explored and expanded. Dr. Weir will refer to some of these in her paper which follows this one.

The literature was reviewed on meat cookery research since 1950. Much of this search of the literature was made by Mr. Dean T. W. Ho, a graduate of the University of California, who just completed his work at the School of Hotel Administration at Cornell University, as part of a seminar course dealing with special problems in foods.

For purposes of discussion, this review of meat cookery research is divided as follows:

I. Nutritive value as affected by cookery, including the use of antibiotics, radioactive materials, etc.

II. Physical and Physiological changes.

III. Organoleptic studies.

I. Nutritive Value

A. Vitamin Retention

A great deal of work has been done on the vitamin retention of meat, as a function of cooking. Naturally, this work has primarily been done on the B-complex vitamins, with scattered work on some of the fat-soluble vitamins and ascorbic acid.

(1) Thiamin

In general the destruction of thiamin continues throughout heat processing. From 75 to 100 per cent of the thiamin present in fresh meat was retained under standard cooking conditions (Lushbough et al.). Thiamin retention was improved when low temperatures, 210°F., were used, as compared with higher temperatures, 450°F. (Cover et al.) In beef, roasting at an oven temperature of 350°F. resulted in a retention ranging from 54 to 63 per cent (Noble and Gomez). This relative range was supported by other workers (Mayfield and Hedrick). Temperature rather than time was more critical in the destruction of thiamin (Noble and Gomez). Method of cooking had an influence on thiamin retention, broiling generally resulting in a higher retention than braising or stewing (Cover and Smith, Wilcox et al.). In lamb, roasting resulted in an average retention of 64 per cent (Noble and Gomez), in pork less than 50 per cent (Erikson and Boyden), and in veal the retention of approximately 33 per cent in braising, as compared with approximately 66 per cent in roasting (Asp et al.). Studies have also been conducted on thiamin retention after cooking variety meats (Noble and Gomez).

(2) Riboflavin

As was indicated with thiamin, riboflavin destruction was lower when low temperatures were used (Cover et al.). Retention studies, as a function of method of cookery, have provided data on the riboflavin content of meat after cooking. In beef, roasting various retail cuts at an oven temperature of 350°F., to an internal temperature of 140°F., resulted in retentions ranging from 81 to 88 per cent. Further cooking did not affect retention (Noble and Gomez). Very similar figures were obtained in roasting lamb (Noble and Gomez). The simmering of beef hearts resulted in a retention of approximately 75 per cent (Noble and Gomez). Slightly higher figures were reported for pork (Erikson and Boyden), with still higher retentions for veal (Asp et al.)

(3) Niacin

Niacin retention in beef and pork was higher when these meats were roasted at lower temperatures than at high temperatures (Cover et al.). In beef, broiling resulted in higher retention values than braising, excluding drippings; oven roasting was superior to pot roasting (Cover and Smith). In pork, niacin losses were less than 50 per cent (Erikson and Boyden). A retention of 75 per cent in cooking lamb chops (Lehrer) and from 67 to 69 per cent in pork roasts

(Westerman et al.) was reported, with the use of moist-heat cookery resulting in approximately a 50 per cent retention of niacin (Miyamoto).

(4) Pantothenic Acid, vitamin B_6 and vitamin B_{12}

In dry heat cookery at 325°F. there was a 54 per cent retention of vitamin B_6 (Lushbough et al.). Browning pork for pork stews resulted in a significant reduction in pantothenic acid (Cover and Smith). Cooking beef, lamb, and pork resulted in a 50 to 85 per cent retention of pantothenic acid (Schweigert and Guthneck). Preliminary studies indicated more than a 70 per cent retention of vitamin B_{12} in cooking beef, pork, and lamb (Scheid).

(5) Vitamin A, ascorbic acid and iron

In a study of nutrient retention in beef, calf, lamb, and pork variety meats, cooked liver was found to retain from 90 to 100 per cent of vitamin A and from 63 to 90 per cent of ascorbic acid; cooked brains retaining 87 to 96 per cent of ascorbic acid, with iron retentions ranging from 80 to 100 per cent (Kizlaitis et al.). Presimmering caused significant drip losses of ascorbic acid, resulting in a high degree of variation in total recovery.

(6) Vitamin retention as affected by freezing and storage conditions.

Cooking pork chops from the frozen state resulted in an increased retention of thiamin, 19 per cent, and of riboflavin, 14 per cent. Freezer storage at-15°F. and at 0°F. for six months resulted in a loss of 40 per cent thiamin and 31 per cent riboflavin; interestingly, the niacin content actually increased by freezing, due to the relative shrinkage of tissue (Lehrer).

Storage temperatures, rather than length of time, influenced vitamin retention in pork loin roasts. In general, greater retention was obtained after storage at - 10°F. and at lower temperatures, as compared with storage at 0°F. (Westerman et al.) In liver, retention of thiamin and riboflavin was greater in cooking from the frozen state, with niacin retention smaller (Kotschevar).

(7) Miscellaneous

Grain feeding had no significant advantage over grass feeding in the vitamin retention of beef after cooking (Mayfield and Hedrick). Pasture feeding vs. feedlot feeding resulted in insignificant differences with respect to thiamin and niacin content (Cover and Smith).

In comparing pale, soft, and watery pork muscle, with dark, firm, and dry pork muscle, the former contained twice as much niacin in both the fresh and in the cooked state; however, niacin losses were greater in the former due to the higher drip loss. Dark, firm, and dry pork muscle had a slightly higher riboflavin and thiamin content, with the cooked samples containing more thiamin as well (Meyer et al.)

Electronic and conventional cooking methods showed insignificant differences in thiamin and riboflavin content (Noble and Gomez). A very extensive study of the nutritive value of cooked meat has been reported (Leverton and Odell).

B. Miscellaneous

(1) Protein quality

A study of 18 amino acids in choice and utility grades of beef indicated that amino acids are stable to cooking. Approximately 88 per cent of the total nitrogen was accounted for by the amino acids (Greenwood).

In beef muscle, less than 3 per cent of certain of the amino acids was found in drippings or in non-protein nitrogen (Ginger). In only one of three tests on cooking bacon to the crisp fried (well-done) degree of doneness was a reduction in nutritive value noted (McBride et al.). Little or no change in protein quality was described in standard cooking methods. Only under conditions of severe heat treatment were decreases observed (Siedler). Other studies have indicated that pressure saucepan cookery and braising methods did not reduce the nutritional value of beef significantly (Clark et al.).

(2) Protein digestibility

Using conventional and pressure cooking methods to measure differences in digestibility of beef stews showed no significant differences (Freeman). Frying had a greater affect on digestability of pork than other cooking methods (Nozaki and Kato).

(3) Fatty acid content

In all cases studying the loss of fatty acids in pork, lamb, and beef, a loss of the total unsaturated fats was reported. Losses exceeded 2 per cent only in the case of roasted pork loins and legs of lamb which showed considerable peroxidation during cookery (Chang and Watts).

(4) Antibiotics and hormones

The residues of chlortetracycline in ground beef and in frankfurters decreased with increased cooking temperatures; however, heating to temperatures associated with broiling did not completely inactivate the chlortetracycline (Escanilla et al.).

Feeding stilbestrol increased the weight of the semitendinosus, area of muscle fibers, nitrogen content of the lean, and losses during cooking, but did not significantly change the other chemical measures or tenderness of Choice and Good grade beef (Paul).

(5) Radioactive materials

Roasted ham had a higher concentration of radiostrontium than did raw meat or bone (Bartley and Reber). The meat from bone-in beef loin roasts contained more Sr^{89} and Ca^{45} than did meat from boned roasts. Activity varied inversely with the distance from the bone. Drippings from the bone-in roasts also contained more of the two substances (Bell and Buescher). In studying the loss of radioactivity from cooked beef obtained from steers given oral doses of cesium 134, it was observed that such losses were affected by the surface area exposed to liquid and the amount of water used in cooking. Boneless loin roasts retained 81 per cent of the radioactivity. Top round, surface braised with a small amount of liquid, retained 57 per cent. Drippings accounted for 13 per cent of the original activity in roasts, 34 per cent in steaks, and 48 per cent in stews (Forrester and Bell).

(6) Bacterial destruction

Cookery reduced the number of micrococci in ham loaves and in ham croquettes (Deskins and Hussemann). In evaluating the bacteriological safety of beef patties made with whole eggs solids, it was suggested that roasting temperatures should not be terminated until an internal temperature of 165°F. was reached (Moragne et al.).

II. Physical and Physiological Changes

A. Shrinkage, cooking losses, and yield

(1) Beef

Round steaks cooked in a pressure sauce pan to an internal temperature of 176°F. lost less weight during cooking and were more desirable in aroma, flavor, and juiciness, but less tender than those cooked to an internal temperature of 234°F. (Clark et al.). Cooking from the frozen state as opposed to the thawed state gave greater yields of cooked products (Fenton et al.). Using good and standard grades of beef, at the same oven temperature, 300°F., and internal temperature, 170°F., dry-heat cookery resulted in lower cooking losses than foil-wrapped, moist-heat cookery (Hood et al.). In conventional roasting, 350°F., vs. high temperature foil cookery, 500°F., to the same internal temperature, 170°F., weight losses by dry heat methods were less than by moist heat methods (Baker et al.). Similar results have been reported with respect to commercial grade beef (Paul et al.). In cooking standard grade beef rounds at 145°F. for 30 hours and at 155°F. for 18 hours, to the same internal temperature, meat cooked at the lower temperature had lower cooking losses and a higher moisture content (Bramblett et al.). Prebrowning good and choice top rounds on a surface unit, then cooking at 500°F. resulted in lower cooking losses than broiling conventionally (Rodgers et al.).

The electronic cooking of baby beef liver resulted in a higher drip loss than in conventional cooking (Williams et al.). The

electronic and deep fat cooking of the semitendinosus and longissimus dorsi muscles of prime, choice, good and standard grade beef resulted in greater cooking losses than did broiling or oven roasting (Fielder et al.). Using top rounds, it was determined that weight and volume yields were directly related, and, further that yield was a function of evaporation loss with yield decreasing as temperatures and air circulation increased. It was also noted that at low temperatures, from 175°F. to 225°F., with forced air circulation and at the pressure of saturated steam, the yield increased and roasting time decreased. (Schoman and Ball).

In a study using U.S. Choice grade, top round roasts, roasted to three internal temperatures (140°F., 158°F., and 176°F.) at three oven temperatures (200°F., 225°F., and 250°F.) it was found that evaporation losses varied with oven temperatures and increased with internal temperature in low-temperature roasting, that drip losses increased with increasing oven temperature and internal temperature, that trim and juice losses decreased as internal temperature increased, that total losses were greatest in the 200°F. oven, and at all oven temperatures there was greater loss at the higher internal temperatures. These studies indicated that length of time and variability in total time appeared to be a major problem in low-temperature roasting, making these temperatures impractical (Marshall et al.). These results substantially supported earlier work reported by the same workers (Marshall et al.), in which roasts of different sizes were used, the 10- and 15-lb. roasts showing significantly lower losses than the 5-lb. roasts at all degrees of doneness except rare. A study of roasting 10-lb. top round roasts at different oven temperatures and to various degrees of doneness, indicated that oven temperature did not significantly affect yield, total losses, and shear values; however, internal temperatures to which the meat was cooked did affect significantly the first two of these factors. Both oven and internal temperatures affected the cooking time per pound (Hunt et al.). In a study of the effect of grade (prime, choice, good, and standard) on the palatability of frozen prefabricated beef, grade had a significant effect on all chemical data (fat, moisture, juice, collagen and elastin); however, when data for prime carcasses were removed, there was no grade effect. Correlations between subjective and objective measurements of palatability varied widely with cooking method and/or cut (Fielder et al.).

(2) Pork

Pork loin roasts cooked at 350°F. to an internal temperature of 170°F. had greater yields than similar roasts cooked to an internal temperature of 185°F. (Weir et al.). Broiling pork chops to internal temperatures of 185°F. resulted in greater losses than braising similar chops to the same internal temperatures (Weir et al.). Studies have been conducted on heat denaturation and its effect on waterbinding capacities at different temperatures and under different influences of additives (Sherman). Studying the relationship of marbling to yield, and using half inch loin chops, braising losses were approximately one third of the raw weight and

drip losses increased in percentage as back fat thickness increased (Murphy and Carlin). In comparing electronic cookery of pork roasts to conventional methods, the former gave greater yield results than the latter method (Apgar et. al.).

(3) Lamb

Electronic cookery of lamb roasts was four times as fast as conventional cookery but gave greater shrinkage losses (Headley and Jacobson).

(4) Miscellaneous

The high correlation between cooking time and cooking losses indicated that one of the major factors affecting cooking losses was the time required to cook meat (Paul and Bratzler). Using a commercial enzymatic tenderizer on beef did not adversely affect shrinkage (Hay et al.). Cooking losses for bone-in and bone-out cuts of beef showed no significant differences (Paul et al.).

B. Collagen changes

The collagen content of commercial grade beef was significantly higher than that of prime grade beef. There was no significant differences between top and bottom round muscles in the same animal. Losses of collagen increased as internal temperature increased. The average collagen loss on all methods of cookery was 61 per cent, collagen losses were higher in meat roasted at 250°F. than at 300°F. or braised by standard methods, and were especially high in meat soaked in vinegar (Griswold).

The collagen nitrogen content was considerably lower in the raw and broiled longissimus dorsi muscle then in the raw or broiled biceps femoris muscle. Losses of about 25 per cent collagen nitrogen during broiling indicated that some of the collagen was converted to gelatin. The data suggested an association between the chemical entity, collagen, as determined by collagen nitrogen, and the ability of judges to score for tenderness or toughness of connective tissue (Irvin and Cover).

Supporting evidence in the comparison of the biceps femoris muscles with the longissimus dorsi muscles with respect to collagen nitrogen has been reported elsewhere (Ritchey et al.). The conversion rates of collagen to nitrogen were similar in both muscles. Higher levels of collagen were found in dairy-type cow beef than in beef-type cow beef (Paul et al.).

Collagen losses were greater from braising than from broiling for biceps femoris and longissimus dorsi steaks cooked to well-done stages (Cover and Smith).

Data not in agreement with these results has been provided by other workers (Skelton et al.). Using longissimus dorsi and semimembranosus muscles from beef roasts of good grade to internal temperatures of 131°F., 158°F., and 185°F. indicated that collagen nitrogen was greater in the cooked samples than in their raw counterparts. The degree of doneness did not seem to affect collagen nitrogen values. The amount of collagen

nitrogen was greater in the semimembranosus than in the longissimus dorsi muscles.

A study of the physical changes in the connective tissues of beef during heating shows that collagenous tissue softened, lost weight, shortened in length, decreased in width and increased in thickness, the degree of change increasing with increased temperature. Little or no change resulted when these tissues were heated in distilled water at 140°F., even after heating for 64 minutes (Winegarden et al.). Collagen shrinkage was completed during the heating of the semitendinosus muscle from 140°F. to 148°F. for from 30 to 60 minutes. (Machlik and Draudt). Cooking beef decreased the solid or fibrous collagen, but the total area of collagen increased through the formation of granulated tissue, this granulation being greater in steaks cooked by braising than in those cooked by dry heat (Paul et al.).

Losses of collagen nitrogen were much greater in well-done steaks than in rare biceps femoris and in longissimus dorsi beef steaks (Ritchey and Cover).

During heating, beef fat disperses along the path of hydrolyzed collagen, resulting in fat droplets thoroughly mingled with degraded collagen, thus forming a new entity (Wang et al.).

Connective tissue decreased the rate of heat transfer in suet (Seimers). Studies have also been conducted on a comparison of various methods for determining collagen content in raw and cooked meat (Griswood and Leffler).

Electronic and deep fat cookery of steaks of various grades decreased the collagen content significantly more than oven roasting and broiling methods (Fielder et al.).

C. Fat

The release of fat, not released in a continuous liquid state, but dispersed along the path of degraded collagen interpreted as the process of emulisification, and referred to above, indicated the possible relationship of this phenomenon to the known effects of cooking on meat palatability. (Wang). An increase in the ether extract of beef during heating would indicate some infiltration of fat into the meat (Paul).

D. Protein

Changes in hydration solubility and in muscle protein during heating have been reported (Hamm and Deatherage). Heat penetration on beef aged from 0 to 53 hours after slaughter showed that slow heat penetration during roasting induced rigor. Rapid penetration, as experienced in deep fat cooking, coagulated the muscle substance before rigor could take place (Paul et al.).

E. Color

The reflectance spectra of slices of fresh pork, ham, beef steak, and leg of lamb cooked to an internal temperature of 158°F. have been

reported (Tarladgis). Color was dependent upon temperature rather than on time of cooking (Tuomy et al.). The effect of cooking on the color of cured meat has been reported (Tyszkiewicz and Stanislaw). The effect of streptomycin and subtilin on the red discoloration of cooked meat has also been studied (Hugli and Prudent). A relationship between the degree of browning resulting from deep fat cookery and by evaporation to dryness in a 212°F. oven indicated that the amount of brown color was related to the level of reducing sugars in fresh pork tissue. The degree of brownness developed was measured spectrophotometrically. (Pearson et al.).

F. Flavor

Flavor components, as affected by cooking, have been isolated, identified, and studied (Yueh and Strong, Kramlich and Pearson, Hornstein and Crowe, Hornstein et al.).

III. Organoleptic Studies

A. Beef

(1) Tenderness

Traditionally braising produced a more tender beef round (both top and bottom) than did pressure braising, regardless of the grade of beef (Griswold). In a study of oven braising and pressure braising of frozen and thawed beef of various grades, it was found that frozen meat of the higher grades scored more tender; however, shear values did not support these scores (Fenton et al.). Standard braising and pressure braising methods by comparison were judged less important to tenderness scores than were the internal temperatures to which beef was cooked (Clark et al.). In this study, those steaks cooked to an internal temperature of 160°F., by either method, were less tender than those cooked to an internal temperature of 234°F. Extensive studies have indicated that tenderness seemingly is dependent upon a complex combination of factors and that different muscles differ markedly in their tenderness response to various cooking conditions. Shear values indicated that the longissimus dorsi was most tender braised to an internal temperature of 212°F. and held at that temperature for 25 minutes. Low oven temperatures, 250°F., resulted in lower shear values than higher temperatures, 300°F. (Cover et al.). In studying the braising and broiling methods, it was found that well-done biceps femoris steaks were more tender braised than broiled, while well-done longissimus dorsi steaks showed minor differences (Cover and Smith). In cooking commercial cow beef, dry heat was a superior method than moist heat, insofar as tenderness was concerned, when the meat was cooked to the same internal temperature (Paul et al.). Comparisons in this study were made on the basis of common end-point temperatures. In a comparison of dry and moist heat cookery methods with low grades of beef round steaks, tenderness scores indicated insignificant differences; however, thick steaks, 3 inches, were more tender than thin steaks, $1\frac{1}{2}$ inches (Hood et al.). Differences were observed in tenderness for high and low grades of beef cooked by moist and dry heat cookery, these differences not

necessarily falling in line with level of tenderness or grade response (Cover and Shrode). In an extensive report on palatability, vitamin content and yield of cooked beef, based on a review of the literature, it was concluded that good grade and below cuts were generally satisfactory for eating, even when cooked by dry heat methods. Palatability scores were usually in favor of dry heat methods when meat was cooked to a common end-point temperature (Dawson et al.). Deep fat cookery at 212°F. produced roasts that were less tender than those cooked at 230°F. and at oven roasting temperatures. Shear values indicated that the most tender products were produced in the oven (Visser et al.).

Numerous studies have been conducted on tenderness as a function of grade, muscle or location within a muscle, method of cookery, etc. (Machlik and Draudt, Tuomy et al, Sanderson and Vail, Aldrich and Lowe, Ginger and Weir, Paul and Bratzler, Bramblett et al, Cover et al. Ritchey et al.).

In an investigation of the variability in chemical composition, cooking losses,and tenderness of roasts from beef cattle or similar breeding and management, it was found that a considerable degree of uncontrolled variation existed between animals. Significant differences were more numerous in raw meat than in cooked meat (Paul). Mechanical devices have been compared with the taste-panel evaluation for measuring tenderness (Burrill et al.). The influence of methods of cooking on meat tenderness have been very effectively reviewed by several workers (Cover and Hostetler; Paul).

(2) Palatability

Palatability, in general, was not effected in defrosting frozen meat (Lowe et al.). Additional cold storage and freezing after three days of aging increased the tenderness of the longissimus dorsi muscle when it was subsequently cooked in deep fat. Cold storage was nearly as effective as freezing and thawing is increasing tenderness. Frozen steaks cooked without thawing were less tender than steaks thawed before cooking (Paul and Bratzler).

The irradiation of baby beef liver resulted in reduced tenderness. The cooking of these livers by conventional or electronic cookery failed to show significant differences in tenderness (Williams et al). Irradiated beef cooked at lower temperatures were generally more palatable than those cooked at higher temperatures (Gernon and Seaton).

Studies have also been conducted on enzymatic tenderizers and their effect on palatability (Hay et al., Odintsov, Weir et al.).

(3) Juiciness

In studying commercial grades of cow beef, it was found that as cooking losses increased, juiciness scores decreased; that tenderness and juiciness failed to bear any relationship; and that objective measurements of moisture in beef and juiciness scores were not

well correlated (Paul et al.). Moist-heat cookery methods and their influence on juiciness have been studied by a number of workers. It was noted that round steaks cooked to 176°F. by either pressure cookery or braising were superior in juiciness to those cooked to an internal temperature of 234°F. (Clark et al.). Insignificant differences in juiciness were noted in comparing pressure cooking of thawed vs. frozen meat (Fenton et al.). Pressure braising to 176°F. resulted in less juiciness in beef than when oven braising was employed to the same temperature (Dawson et al.). Other workers reported similar results (Griswold). It was concluded that internal temperature was more significant than method of cookery for juiciness levels (Dawson et al.). Dry heat vs. moist heat cookery, as they affect juiciness, have been studied. Braised steaks were less juicy then broiled steaks. (Cover and Smith). A relationship between juiciness and fatness was observed; the juiciness scores were more closely correlated with fatness in broiled steaks than in either braised loin steaks or broiled or braised bottom round. These correlations however, were not high (Cover et al.). Well-done broiled steaks were more juicy than braised steaks, but well-done oven roasts were little if any juicier than pot roasts (Cover and Shrode). Dry heat cookery produced juicier beef than moist-heat foil cookery, the meat being cooked at 300°F. to an internal temperature of 170°F. (Hood et al.). Within dry heat cookery temperatures and methods, it was found that beef round roasted at 250°F.was less juicy than beef roasted at 300°F., little difference being noted among the various muscles (Griswold). Other studies on the effect of cooking methods and times have reported rather similar results (Aldrich and Lowe, Visser et al., Bramblett et al.). Juiciness scores were higher in untreated meat as compared to meat treated with enzymatic tenderizers; however, press fluid values did not differ (Hay et al.). Using tandrin (salt, glucose, and papain), it was claimed that the tenderizer produced a more juiciness product in low grades of beef (Odintsov). Irradiated baby beef liver showed a lower juiciness score than untreated baby beef liver. The comparison of electronic and conventional oven cookery resulted in a slightly lower juiciness score for the electronically cooked product (Williams et al.).

(4) Flavor

Cooking, prior to the extraction of flavor constituents, increased the flavor threshold of meat, indicating that full flavor development may be due to heating juices and fibers together. Leaching the samples with water resulted in a complete loss of flavor for both raw and cooked meat. Neither fat nor fat-free dry matter were responsible for the flavor differences (Kramlich and Pearson). Internal temperature and resulting cooking losses influenced flavor more than did intramuscular fat, which was not a reliable index of flavor (Dawson et al.). Other studies have compared braising and pressure cooking (Clark et al.), and braising with conventional methods of cookery (Griswold), indicating that the flavor is more desirable when meat is cooked at lower internal temperatures. Pressure braising frozen vs. thawed meat, in general, indicated that cooking from the frozen state resulted in

higher flavor and aroma scores and that frozen meat of lower grades was superior to those of higher grades in flavor (Fenton et al.). Dry-heat cookery produced a more flavorful product than foil-wrapped roasting (Hood). It was also noted that there was an absence of "steamed flavor" in the dry-heat cooked product (Blaker et al.).

A lack of significant difference in flavor scores of beef rounds cooked at very low temperatures, 145°F. and 155°F., with dry heat was noted (Bramblett et al.). An additional hour of cooking after the beef roast had reached an internal temperature of 194°F., reduced flavor scores (Aldrich and Lowe). Storing beef beyond seven days did not improve the palatability of low-grade cow beef (Paul et al.). Irradiated baby beef liver had lower odor and flavor scores than non-irradiated samples. Subsequent cooking, in conventional electric ovens, failed to produce significant differences in flavor and odor (Williams et al.). Other workers reported an impairment of beef flavor subsequent to irradiation (Pearson et al.). The effect on flavor of enzymatic tenderizers is conflicting. Some workers (Odintsov) indicate an improvement in flavor, while other workers showed no significant differences in aroma and flavor resulting from such tenderization (Hay et al.).

(5) Pork

It was observed that pork chop characteristics, as tested by shear and press tests, differ not only due to variations among animals, but also to the position of the chops in the loin (Mackey and Oliver). This variation within a muscle has been reported by other workers (Batcher and Dawson). In cooking pork loins at temperatures ranging from 140°F. to 210°F., it was found that the initial effect of heat was a toughening one, that increased as the temperature was increased.

At 150°F. and above, after the initial toughening, the pork became tender to a degree dependent upon both time and temperature. There were considerable differences in tenderness of individual pieces of pork cooked under the same conditions (Tuomy and Lechnir). The effect of cooking pork showing various degrees of marbling and back fat thickness has been studied (Murphy and Carlin). Marbling was a better criterion for tenderness and juiciness than back fat thickness. On the other hand, it has been reported that in only a few cases were tenderness and juiciness related to the marbling score. Back fat, had little influence on the quality characters of fresh pork from the ham, loin, and shoulder (Batcher et al.). The fat content of cooked ham was not related to tenderness or juiciness in three out of four cases (Batcher and Dawson). Relating fatness to panel scores on the cooked longissismus dorsi muscle, significant correlations were found on marbling, and low but insignificant correlations with specific gravity, ether extract, and muscle fiber extensibility. Low, but significant correlations were found between muscle fiber extensibility and marbling (Saffle and Bratzler).

Tenderness scores decreased as internal temperature increased in the cooking of pork loin roasts. Cooking these roasts to the same internal temperature, 185°F., at oven temperatures ranging from 300°F. to 400°F. resulted in more tender roasts at 350°F. than at 300°F, 325°F. or 400°F. Juiciness was unaffected by variations in oven temperature (Webb et al.). Muscle fiber extensibility values were inversely related to tenderness scores (Weir et al.).

Broiling pork chops to an internal temperature of 185°F. resulted in lower juiciness scores for thick chops than for thin chops. The opposite was true for thin chops, which were more tender and juicy when broiled, but had less flavor when braised. With the thicker chops, tenderness and flavor were apparently not affected by the cooking method. Braising pork chops beyond 185°F. did not have any significant improvement on palatability (Weir et al.). The irradiation of frozen ground pork resulted in significantly lower aroma, juiciness, flavor, and palatability scores. Cooking pork electronically resulted in higher juiciness scores and lower aroma and flavor scores (Lim et al.). The electronic cooking of pork chops and roasts resulted in superior products to those cooked conventionally. The use of the browning unit increased the acceptability of the products (Apgar et al.).

(6) Lamb

Tenderness appeared to be unrelated to age or weight and cooking losses did not vary to a significant degree in lamb. Roasts from lambs older than six months were scored "milder" than those from young animals. Meat from the youngest lambs scored lowest most frequently. Meat from animals older than six months of age was found most often to have a "natural" lamb flavor (Weller et al.).

Meat cooking losses of roasts legs of lamb, trimmed and boned before cooking and cooked at 325°F. to an internal temperature of 180°F., ranged from 28.9 to 35.9 per cent (Schuck et al.). In cooking lamb electronically, it was found that although cooking was four times faster than conventional cooking a less juicy product resulted (Hedley and Jacobson).

A selected bibliography of meat cookery research follows.

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DR. WANDERSTOCK: I would like to at this time introduce Dr. Edith Weir. Edith, a native of Canada, did her undergraduate work in Canada and came to work at the University of Rochester, and received her PhD degree at the University of Massachusetts in Food Technology. Since that time she has worked for Heinz and Company, at Beltsville with our good friends Dick Hiner and the late O. G. Hankins. She then became Chief of the Division of Home Economics of the American Meat Institute Foundation, and is currently with the Human Nutrition Research Division of the United States Department of Agriculture. Dr. Weir will talk this morning on "Trends and Needs in Meat Cookery Research". Dr. Weir.

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