YIELD AND PALATABILITY OF FIVE STYLES OF MILD CURED HAMS IN THE 12 TO 14-POUND WEIGHT RANGE

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By

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INTRODUCTION

Cured ham is a popular and versatile meat item in many food service operations. Choosing wisely among the many available styles of hams is important and difficult for the operator who strives to serve food of the highest quality as economically as possible.

Many styles of ham are currently available and some meat packers are planning to put new styles on the market. The styles differ in the degree of trimming and boning and in the final shapes in which they are packaged. Several styles are available both uncooked and precooked: this increases still further the list from which the operator must make his choice.

In addition to choosing from the available styles of ham, the food service operator must also decide what weight range he should select. Some styles of ham are available in sizes from 6 to over 30 pounds each; other styles are sold in fairly narrow weight ranges.

To choose wisely the style and kind of ham and to estimate the amount of edible ham needed for a specific purpose, the food service operator must learn by trial and error or consult authoritative materials. Presently, little accurate information is available to guide the buyer.

This study is one phase of an extensive project designed to compare the cooking losses, palatability, sliceable portion, edible scrap, and waste from various styles of ham, both cooked and uncooked, which are widely available. The different weight ranges of each style and kind will also be compared and analyzed upon completion of all phases of the total project.

REVIEW OF LITERATURE

During the past fifty years new developments in methods of breeding, feeding, and slaughtering of hogs have resulted in increased yield of lean meat from the carcass and better eating quality of pork cuts (59).

Composition, appearance, flavor, juiciness, and tenderness of pork cuts reflect the effect of the diet of the animal. Hogs fed soybeans when young and fattened on carbohydrate diets have firm fat (59). Peanut fed hogs, commonly raised in the South, produce soft, oily hams from which Smithfield hams are often processed (7, 56, 22).

The effect of feeding of special supplements to meat animals has been extensively explored. The addition of tocopherol to the feed of hogs has been reported to have little antioxidant effect on the fat of the slaughtered animal (56). Hams from animals fed antibiotics, surplus animal fat, or a combination of the two, did not differ significantly from controls in color, moisture, fat, chloride, or thiamine content (20, 22, 34). Jul (31) reported that hogs fed antibiotics produced hams with increased yield and water retention during canning. Feeding antibiotics to meat animals is still considered controversial (3). In another study, hogs fed vitamin B_{12} and blood meal, to supplement their diet of corn, meat, and bone meal, showed increased weight gains (44).

The introduction of more humane methods for the slaughter of hogs has done much to eliminate internal bruises in hams (59), insure more complete bleeding (3), and reduce contamination of the carcass with dirt during the killing and dressing.

Frazier (23) suggested the injection of antibiotics just before slaughter or infusing the carcass or special parts immediately after slaughter. He believes that antibiotics thus used would prolong the keeping quality of carcasses at atmospheric temperatures before they reach the refrigerators. At the present time the use of antibiotics is permitted only on poultry. Ayers (3) stressed that meats infused with antibiotics pose several questions which will need to be answered before the use of antibiotics can be considered safe for carcass use.

Ham Processing

Important as the advances just described have been in their effect on table pork in general, other factors may have made even greater contributions to the improvement of the eating quality of cured hams. Among these are refinements in methods for curing, smoking, processing, and packaging.

Curing ingredients

Federal specifications (54, 55) state that a well-blended mixture of salt, sugar, sodium nitrate and/or sodium nitrite (potassium salts may be used), with or without phosphates and other permissible minor ingredients, with or without water, shall be used to cure hams. Each curing ingredient contributes to the final quality of the ham.

<u>Salt</u>. The primary curing ingredient, salt or sodium chloride, imparts a characteristic flavor to ham. Salt also improves the color, helps preserve ham, and affects tenderness, juiciness, and yield.

The pink color of ham is produced by the action of microorganisms which change the muscle hemoglobin to nitric oxide myoglobin and nitric oxide myochromogen during the curing process (23). Watts (56) reported that in the presence of nitrite, salt accelerated the formation of the pink pigment; in the absence of nitrite, salt aided the formation of a brownish-red color.

Dry salt reduces the water content and can harden and toughen the fibers (7). Thornton (51) describes the drying effect of salt which preserves meat. A dry cured ham loses an average of 5 to 7 percent of the original or green weight (59).

Most mild cured hams are sweet pickle cured with a formula containing less salt than is necessary for dry cured hams (59). Sweet pickle cured hams gain an average of 5 percent in cure (59).

Salt may affect the development of rancidity of the ham fat; the occurrence and/or the degree of rancidity depends on the area of fat with which the salt comes in contact and the state of the salt, in solution or dry (56). Watts (56) points out that since salt is not absorbed at the interface between fat and water, dilute solutions may retard oxidation; however, salt out of solution accelerates rancidity development.

Salt functions as a preservative by preventing or reducing the action of bacteria (59). Jensen (30) stated that lessening the amounts of salt used in food preservation has induced changes in microbiological flora. In addition, he reported that most investigations indicate that salt, in concentrations used in food preservation, is not a bactericide but a preservative which merely inhibits the growth of many species of bacteria. Experiments have shown that salt is the most active preservative used in meat-curing solutions (30). Palatable salt concentrations do not inhibit the food poisoning staphylococci (32).

Sugar. According to Ziegler (59) the flavor of cured ham is enhanced by sugar, which counteracts the astringent quality of the salt. Sugar also affects the color, tenderness, and juiciness, and has a preservative effect on hams. Sugar furnishes material for bacterial reduction of nitrate to nitrous acid which helps fix cured meat color (59). Ziegler (59) reported that curing pickles without sugar had pH values of 7.3 at the end of 40 days as compared to 5.7 for curing pickles with sugar. Color fixation was normal and meat was tender and palatable with the pH between 5 and 6.

Bull (7) reported that sugar counteracts the hardening effect of salt and helps to increase tenderness in hams. Sugar also helps to make the meat juicy (59).

Nitrates and nitrites. Combinations of nitrates and nitrites produce better color stability than either product used alone (59). Sodium or potassium nitrates and nitrites are permitted in curing formulae (54, 55).

Nitrate indirectly fixes the color and increases the permeability of the meat fibers to the water carrying the curing ingredients (59). Frazier (23) reported that nitrates in acid solutions may be bacteriostatic, especially against anaerobes. However, the effect of nitrates on anaerobes is controversial (29, 32).

Nitrites are the source of the real color fixative (23). Hams cured with nitrite alone tend to discolor rapidly when exposed to light and air (30). When nitrite is converted from nitrate, the color is more stable (59). Although nitrite is used primarily to fix the color of cured meat, it also produces a characteristic flavor (37). Nitrite helps inhibit the growth of ham souring organisms (56).

Phosphates. Phosphates increase the water absorption ability of ham (59). Miller (37) listed six phosphates which are permitted in curing formulae.

Ziegler (59) reported less shrinkage in phosphate treated hams than in controls. Wilson (58) did not find that phosphate significantly affected ham yield but reported it did produce firmer hams with less free moisture than the controls. Miller (37) stated that phosphates helped decrease the amount of cooked-out juices. Urbin (53) found that yields of phosphate treated hams, both smoked and unsmoked, were significantly increased.

No significant differences in aroma, flavor, tenderness, or texture were noted between phosphate treated and control hams compared by Urbin (53). Mahon et al (34) reported significantly higher scores for color, aroma, and saltiness in phosphate treated hams than in control hams; however, the authors stated that "differences were so small that not much inference can be drawn from them."

Phosphates may cause precipitates in the pickle and crystal formation on the finished ham (53). Urbin (53) found that crystallization was delayed and less dense on hams cured in pickle containing calcium sulfate and that precipitation was delayed by using highly purified salt and demineralized water in the curing solution.

Minor ingredients. Curing formulae sometimes include sodium ascorbate and ascorbic acid which accelerate color fixing and inhibit fading (46, 27, 56). Zielger (59) reported that adjusting the pickle solution with ascorbic acid to a pH value between 5 and 6 helped fix the color and increase tenderness of hams. With further decrease in pH, the meat became less tender and palatable and color fixation was impossible. With pH values between 7 and 8, the cured pork became soft and gelatinous (59). Watts (56) pointed out that if ascorbic acid was introduced into meat along with a phenolic antioxidant, it would always inhibit oxidation; but when added alone, ascorbic acid may accelerate or may inhibit rancidity.

Smoking

The smoking of foods usually has two main purposes: to add desired flavors and to aid in preservation (23). Smoking may also improve the color, help tenderize, and add to the desirable appearance of hams (23).

The source and concentration of smoke determine the flavor of smoked ham. Hickory is the most popular wood for smoking hams. However, since one particular wood is not generally available in sufficient quantity, sawdust from a variety of hardwoods is usually used (37). Although smoked salt, liquid smoke, chemicals, or smoke substitutes are not allowed to replace smoke in commercial packing houses, there may be some advantages in their use in curing brines (56). Watts (56) believes that artifical smokes incorporated in brines could be dispersed uniformly throughout the meat, thus imparting the smoked flavor to all parts of the ham. Jensen (30) and Frazier (23) stated that liquid smoke and smoked salt have little or no preservative effect on meat.

The preservative effect of woodsmoke is considered to be due to the condensates from volatile compounds: aldehydes, organic acids, alcohols, ketones, phenols (creosotes), and minor constituents (37, 23, 30). Miller (37) stated that since smoking adds chemicals to the meat, new chemical additive legislation will probably bring about an investigation of smoke as an additive. Formaldehyde is one of the most effective bactericidal compounds of smoke; however, some of the others may also be germicidal (23, 30). The rate of germicidal action increases with the smoke concentration and temperatures (23). Various studies have shown that pathogenic bacteria are destroyed in a short time if they are easily reached by smoke; but a coagulated layer, often formed on the surface of the meat, makes smoke penetration difficult (30). Miller (37) found no surviving staphylococcus either in or on inoculated hams after they were smoked to an internal temperature of 137°F.

Color formation and fixing temporarily stops during smoking because reduction of nitrate to nitrite is inhibited (37). The amount of nitrite in the meat at the beginning of the smoking operation is reduced sharply, but the nitrate content does not change. After the meat is smoked, the nitrate produces more nitrite.

Smoking imparts a desirable appearance to the surface of hams through a combination of actions (37). The drying effect and the action of aldehyde-phenol condensed resins on the surface produces a gloss on the ham (37, 30). Watts (56) stated that the phenol constituents of smoke may have an antioxidant effect on the surface of hams, although this is not certain; because of the limited extent of smoke penetration, the possible antioxidant effects would not protect slices of hams from oxidation.

Some tendering results from the effect of heat and salt during smoking (30). Special temperature and humidity conditions increase the tenderness of hams. The tendering process consists of subjecting the hams to relatively high temperatures for extended periods of time which raises the temperature of the pork above 137°F, the level necessary for the destruction of trichinae (37).

Sweet pickled meats lose 2 to 5 percent of their weight during smoking which, Ziegler (59) points out, is approximately the same amount as was gained in curing. Dry cured meats shrink about 2 percent during smoking (59).

Smoking is customarily accomplished in smokehouses in which the humidity is controlled by opening and closing ventilators (59). A smoking process that rapidly and uniformly deposits the smoke particles on the meat is referred to as an electrostatic method (25, 31, 37). The entire smoking process takes place in a matter of minutes, during which the meats pass through an infra-red drying section, the smoking chamber, and then another drying chamber. The smoked meat has satisfactory flavor and shrinkage is low.

Processing methods

Commercial ham processing usually consists of curing by one of four predominant methods (22). Packing companies follow the same general methods for each style of ham but may deviate at different stages of processing to obtain special effects (22).

Types of cure. Fields and Dunker (22) reported that a survey of representative members of the National Independent Meat Packers Association and the American Meat Institute showed that the four principal commercial methods for curing hams are: (1) sweet pickle, quick cured, tendered hams; (2) sweet pickle, quick cured, ready to eat hams; (3) sweet pickle, long cured hams; and (4) the Smithfield type of dry cured hams. For sweet pickling the meat is treated with a salt solution, whereas in the dry curing process the salt is added to the meat in a dry form (37, 51, 59).

(1) Sweet pickle, quick cured, tendered hams require three processing steps: pumping, curing in a cover pickle, and smoking (22). Pumping to an 8 to 10 percent net weight increase is done by either artery or spray methods. Most packers prefer the artery method because it is quicker and assures more uniform distribution of the pickle than the spray method. The pumped hams soak in a cover pickle for 4 to 15 days at 38°F. The washed, drained, and dried hams are smoked from 16 to 18 hours to bring the internal temperature to 142°F. This temperature is maintained for one hour (22, 37, 59). The tenderized hams which are perishable, require storage at 40°F or below and should be cooked before eating (7, 37). The American Meat Institute (2) described hams processed by the above method:

> Cook before eating (uncooked or regular) hams---have been heated, in compliance with government regulations, to an internal temperature of at least 137°F. These hams require thorough cooking before eating (cooked to an internal temperature of 160°F as registered by meat thermometer.)

(2) Sweet pickle, quick cured, ready to eat hams are processed similarly to the tendered hams except that the

smoking temperature increases so that the final internal temperature of the ham is not less than 150°F (22, 55). Final internal temperatures vary from 150 to 165°F (7, 22, 37, 55). These hams bear tags stating that they are safe to eat without further cooking (7). Ziegler stated that ready to eat hams are entirely safe in respect to trichinae (59). Miller (37) stressed the fact that the mild cured products are not protected against spoilage under conditions favorable to bacterial growth. The American Meat Institute (2) described and differentiated between ready to eat and fully cooked hams:

> Ready to eat hams--in compliance with government regulation, have been heated to an internal temperature of at least 137°F and then further processed to make them palatably tender. This processing makes them safe to eat but the texture and flavor are improved by further cooking. These hams require slightly less cooking time per pound than uncooked hams, usually 16-18 minutes per pound for a whole ham (unless label specified otherwise), 20 to 22 minutes per pound for a half ham. "Ready to Eat" ham should be heated to an internal temperature of at least 130° to 140°F.
>
> Fully Cooked or Cooked Hams--have been processed to an internal temperature of 148° to 150°F or above and may be served without further cooking; or they may be reheated before service. Heating to an internal temperature of 125° to 130° F will warm them sufficiently. Some of the "fully cooked" hams are available with jelly glaze.

(3) Sweet pickle, long cured hams receive similar treatment to that given the quick cured, tendered hams, except they are left in the cover pickle longer and are smoked at lower temperatures (22). The hams remain in the cover pickle for 3 to 6 days per pound of meat. Smoking to an internal temperature of about 120°F requires 20 to 26 hours.

(4) Dry cured hams are rubbed with a dry curing mixture and then packed in layers with a layer of the dry mixture between layers of ham. Depending on the weight of the hams the total time in the cure ranges from forty to sixty-five days (37). Two kinds of dry cured hams are processed: Smithfield and Italian. Smithfield hams, sometimes called Virginia hams, are rubbed with black pepper after curing and after smoking (7, 59). The Virginia legislature passed an act which specifies that Smithfield hams must be processed in Smithfield and come from hogs grown in the peanut belt of Virginia and North Carolina. Hams processed by the Smithfield method, but not in Smithfield, may be labeled Smithfield Type ham. The Italian style ham is the only dry cured ham generally produced by meat packers in the United States (37). The Italian ham has the pelvic bone removed before the ham is cured. This makes it possible to press the ham flat to a thickness of about 2 inches.

Miller (37) states that modern methods of curing ham provide very little opportunity for bacterial growth. Dunker, et al (15) also concluded that commercial curing produces hams which are generally wholesome from the bacteriological standpoint. However, ham, particularly tenderized ham, has been found frequently to be a source of food poisoning organisms (18). Lechowich et al (32) found that food-poisoning staphylococci were able to grow vigorously in ground pork muscle containing palatable combinations of permissible curing ingredients. They also reported that staphylococci injected into hams with the pump pickle survived the curing operation but were killed during smoking to 137°F. Ingram (28) noted that pork cured by dry salting or immersion in brine was nearly sterile, whereas hams pumped with brine contained micrococci throughout the tissue. Deskins (13) found that bacterial counts of hams processed by one packer were consistently much higher than those of another packer; all hams examined contained more bacteria per gram in the center slices than in end slices.

Styles of ham. The American Meat Institute (2) classified hams in three styles on the basis of the amount of bone they contain and the completeness of skin and fat trim as described in Federal Specifications. Federal Specifications (54) also described regulations for cured, canned hams.

(1) Regular bone in hams weigh from 8 to 24 pounds. The hams are partially or fully skinned, cooked or uncooked, smoked or unsmoked.

(2) Skinless shankless hams are prepared by removing the shank and skin from regular hams. Skinless shankless hams are trimmed of surface fat in excess of ½ inch in depth. The hams may be cooked or uncooked, smoked or unsmoked.

(3) The bone and skin are removed from cured hams to produce boneless and skinless hams. Whole boneless, skinless hams or major lean muscle portions (not exceeding three pieces) are encased in rolls. The hams may be cooked or uncooked, smoked or unsmoked. If the hams are cooked, they may be placed in the casing before or after cooking.

(4) Canned hams are sweet pickle quick cured, skinned, boned, defatted, and may or may not have been smoked before canning (54). A canned ham is prepared from a whole or from one to three separate portions. Hams are placed with the major fibers running parallel with length of the can and with the butt portion in the wide end of the can. Monosodium glutamate, gelatin, and other preparations may be added to the product. The amount of gelatin permitted is specified as the amount necessary to solidify juices to prevent liquefaction at internal ham temperatures ranging from 30 to 65°F and to give added stability, cohesion, and sliceability to the finished product. Hams ranging from 1½ to 14 pounds may be canned in rectangular, oblong, or pear-shaped cans. Hams which weigh 4 pounds or less may also be packed in cylinderical or semi-cylindrical cans. The sealed cans of ham are processed in hot water to bring the temperature throughout the ham to a minimum temperature of 150°F. Hams weighing less than 3 pounds are vacuumized and processed "at such temperatures and for such period of time as will assure keeping without refrigeration under unusual conditions of storage and transportation" (54).

Jensen (30) stated that, although destruction of the microorganisms present in the cans is the fundamental purpose of canning, certain bacterial spores cannot be destroyed without high temperatures which may ruin the contents of the can. At a symposium on the microbiology of semi-preserved meats (4) temperature resistant curves of bacteria were

discussed; stress was placed on considering the nutritive value, flavor, and water retention of the meat in establishing time-temperature curves for processing. Deibel (12) found that streptoccoccus was isolated with relative frequency from pasteurized, refrigerated canned hams and was often present as virtually a pure culture. Scott (49) stressed the need for facts regarding the water requirement of microorganisms and the effect on it of variables such as temperature, pH, and nutrient supply. Scott (49) showed that the water activity of canned hams was not low enough to prevent growth of staphylococcus or clostridium botulinum. Subjecting ham to pressure while it is in the curing pickle has helped lessen the excess moisture in pasteurized canned ham (4). Schack (48) suggested that in bacteriological studies solid pieces of meat should have 90 percent of the inoculum confined to the surface layers, if the studies are to be applicable to industrial conditions.

Packaging, labeling, display, and storage

The packaging, labeling, display, and storage of cured, processed hams are important in providing the consumer with a high quality product.

Packaging. The main consideration in the packaging of cured meats is the exclusion of oxygen and light (56). Watts (56) stated that any type of packaging which reduces contact with oxygen retards both rancidity and discoloration. She reported that storage of meat in atmospheres containing carbon dioxide retarded bacterial action as well as oxidative changes.

Because fading of cured meats is accelerated by visible light rays, only deeply colored wrappings are very effective in retarding it; these, however, may create sales resistance (52). Erdman and Watts (16) found that light and the type of wrapping material had little effect on -SH losses of cured meats.

The plastics used for packaging material have been investigated to make sure that only those which are safe are used (37). Miller (37) listed various non-toxic plasticizers, antioxidants, and stabilizers which the Federal meat inspection program has approved. Ricket et al (45) concluded that of thirteen packaging materials they tested, three coated cellophane wrappings and a trithene package proved best for wrapping and storing cured pork.

According to Ziegler (59), paraffin dip forms an air-tight coating on hams which prevents shrinkage and mold, but the exclusion of air causes hams to rot. Coating of cooked hams with gelatin is permissable if the coating meets specifications (55). The coating must be edible and must permit handling and slicing of ham with internal temperatures from 30 to 60^{o}F. It may be caramelized, mildly flavored or seasoned with salt, sugar, vinegar, clove, or other conventional ham flavorings.

Ziegler (59) recommended that waxed or greaseproof paper be used for wrapping hams. The Federal specifications also emphasized that the paper should be moisture resistant (55).

According to Jul (31), much work has gone into the development of better and less expensive containers for canned meats. To minimize corrosion problems caused by the extensive use of phosphates, a method for attaching an aluminum electrode in the can has been developed (31). Enamel on the inside of cans keeps hams from sticking to the lining and helps eliminate discoloration (31, 37). Some companies spray the inside of the cans with lard emulsion prior to canning (31).

Labeling. Meat packers who ship meat out of state are inspected continuously by the Meat Inspection Service and must use only those labels and markings that have been previously approved by the Meat Inspection Service (37). Each label is required to contain specific labeling information, cannot contain misleading statements, and must be appropriate for the product for which it is intended.

The label often contains the name of the product, net weight, name and address of packer and distributor, and the U.S.D.A. inspection mark (21, 37). Many hams carry the brand names of the packers which indicate their own grades for the product (7). Bull (7) listed larger meat packers' brands and corresponding grades. Cooking directions and storage instructions are also often found on ham labels. Esselen (18) pointed out the need for cooking instructions which take into consideration the thermal destruction of food-poisoning microorganisms with no reduction in food quality.

Labels on canned products carry much the same information as that found on the other types of hams. The number which indicates the place of inspection is sometimes embossed on the metal container, in which case it may be omitted from the federal inspection stamp (21). Canned hams weighing over 3 pounds must be labeled "PERISHABLE: KEEP UNDER REFRIGERATION" (54).

Display and storage. Erdman and Watts (16) found that the storage temperature and light affected the fading of cured meat. Slight color fading occurring during illumination of display cases was counteracted by color regeneration when the cases were darkened. Ramsbottom (43) stated that under continuous lighting of the intensity frequently observed in display cases and store aisles, nitrite gives only temporary color protection. Although display case lighting does not significantly discolor fresh meats in periods up to three days, the fading of cured, smoked, and table-ready meat is noticeable in an hour under the same conditions (56).

Storage temperatures for hams, other than the canned hams under 3 pounds in weight, are specified in United States government regulations (54, 55). Canned hams should be stored, delivered, and handled under refrigeration of 30 to 50°F; mild-cured hams should not attain a temperature in excess of 40°F. The package for mild-cured ham should be kept dry and free from condensation and contamination. Canned ham should not be frozen at any time; mild-cured hams may be frozen but not for longer than 60 days (2).

Recent developments.

At least three new processing methods, which may apply to ham products, have been developed or are in the developmental stages. They are irradiation, freeze-dehydration and di-electric processing.

Irradiation. Radiation preservation of foods involves subjecting foods to ionizing radiations which render the product sterile without the use of heat. The process is sometimes called cold sterilization. However, adverse flavor, odor, color, and texture changes often occur in the irradiated product. Miller (37) reviewed the studies of the effect of radiation on trichinae; larvae of the parasite may be killed by large irradiation doses or sterilized sexually by fairly low doses. Niven (40) stated that irradiation may, in some instances, prove more economical than conventional methods for guaranteeing trichina-free meat. Erdman and Watts (17) reported off-odors, which were not objectionable, and color fading in cured pork irradiated with various doses. However, when ground pork, mixed with curing salts, sodium ascorbate, and liquid smoke, was given a low dose of irradiation and heated to inactive enzymes, the pork retained good color and odor for 6 months at room temperature (17). Miller (37) stated that irradiation is more likely to be used in pasteurizing doses to prolong the life of refrigerated meats than in sterilizing doses to permit room temperature storage. The microbiological aspects related to radiation preservation research were reported by Miller (37) and Niven (40). Spoilage flora of cured meats were found to be much more radiation-resistant than the flora of fresh meat. Bacterial endospores were highly resistant under all conditions tested, and there appeared to be no reliable method of predicting the radiation resistance of microorganisms.

Freeze-dehydration. Freeze-dehydrated meat retains its original volume and form without hardening, rehydrates rapidly to the original moisture content, and is almost indistinguishable from fresh meat in its physical characteristics (37). Color and flavor of freeze-dried pork remain similar to those of the fresh product; however, Harper (26) reported that the rehydrated product is generally significantly drier than the fresh material. The major problem in the dehydration of pork is the melting of fat at high drying temperatures and the migration of the fat into the dry porous meat; therefore, the removal of excess fat from pork products may be necessary prior to drying (26). Di-electric heating equipment appears to have potential as a source of heat for quick drying frozen meats (26).

Di-electric heating. In di-electric heating, sometimes called high-frequency cooking, the product to be cooked is placed between two plates or poles which very rapidly alternate electric current and cause the product to heat in every part at the same rate (37). The successful application of the process depends on designing a unit that assures the even penetration of microwaves to all parts of the meat, regardless of uniformity in size and shape (37).

Preparation and Service

The method of cooking, oven temperature, and the final internal temperature play important roles in controlling palatability and yield of cooked hams and the growth of food poisoning bacteria in the cooked product. A comprehensive outline of investigations and recommendations show variations in all three factors (Appendix A.).

Method of cooking

The literature contains reports of hams cooked by moist heat, dry heat, and combinations of moist and dry heat (Appendix A.). Hams were sometimes cooked in covered containers.

Because of the lack of precise methods for cooking hams, a conference was called in 1925 for the purpose of establishing a method of procedure for cooking hams experimentally (47). Results of work by Rountree (47) indicated that hams could be either boiled or roasted successfully without previous soaking. Dawson et al (11) reported edible yields of 55 percent when bone-in hams were simmered and 50 percent when hams were boiled and then baked. The simmered hams received tenderness scores of "slightly tough" and "moderately tender"; juiciness scores were "dry" and "slightly dry". The shrinkage of smoked pork cuts cooked in water may be lessened if the meat is cooled in the cooking water (9). Meat cooked in water below the boiling point is juicier, more tender, and more easily sliced than meat which is boiled (9). The Committee on Preparation Factors, National Cooperative Meat Investigations (9) expressed the need for further studies on the effect of the temperature of the water on the kinds and amounts of cooking losses in meats. Alexander and Hankins (1) reported that simmered dry-cured hams were stringy, water-logged, and tough compared to baked commercially cured hams. The simmered hams were also less juicy than the baked hams.

Rountree (47) recommended roasting ham in a covered roaster to which a cup of water was added. Cooking losses from hams thus cooked varied from 20 to 36 percent of the original weight (47). Staggs (50) concluded that tenderized hams should be baked in their original wrappings. According to Lowe (33), results generally indicate that cooking time is longer, but cooking losses are less, nutritive losses are less, and the meat is more palatable when tender cuts are cooked in uncovered pans than when meat is covered during cooking.

Burgoin (8) seared bone-in hams for thirty minutes in a 150°C oven and then lowered the temperature to 125°C for the remainder of the cooking period. The resulting cooking losses ranged from 25.2 to 29.1 percent. The searing method is no longer recommended for roasting ham.

Staggs (50) and others (9, 33) used metal skewers for decreasing the roasting time in various meats, including ham. The skewers generally shortened cooking time, but also decreased tenderness and attractiveness of the meat.

Standard roasting procedures (9, 33) for ham advocate placing the ham, fat side up, on a rack in an uncovered pan without the addition of water.

<u>Oven temperature</u>

Lowe (33) stated that, in general, low cooking temperatures result in more uniformly cooked meat and in less cooking losses than do high temperatures. Other studies (38, 50) of hams cooked at various oven temperatures verify this statement. Cooking directions for hams usually recommend low to medium oven temperatures (2, 39).

Staggs (50) studied the effect of oven temperature on the palatability and serving value of tenderized and dry-cured hams. She found that the hams baked at 250°F and 300°F were tenderer, had more desirable and intense flavor, and had greater sliceability and serving value than those baked at 375°F; the differences between hams baked at 250°F and 300°F were not significant. Staggs concluded that tenderized hams should be baked at oven temperatures from 250 to 300°F. Another study (38) reported a 30 percent cooking loss for hams cooked at 450°F as compared to losses of 13 percent for hams cooked at 250°F.

The National Livestock and Meat Board (39) recommended cooking hams in 300 to 325°F ovens, stating that there is less crumbling and falling apart of ham cooked at low temperatures as compared to that cooked at high temperatures. The American Meat Institute (2) advocated roasting ham at 325°F.

Internal temperature

Meat is cooked to sterilize it (33). The internal temperature of meat indicates the degree of doneness: various internal temperatures are recommended and/or reported in the literature (Appendix A.).

The most frequently reported temperature in ham studies is 70°C. Rountree (47) was the first to recommend cooking ham to an internal temperature of 70°C. This recommendation resulted after initial studies showed that hams cooked to 76°C were judged overdone by three cooks who evaluated the doneness of hams. Total cooking losses reported for hams baked to 70°C range from 15.1 percent (50) to 29.1 percent (8).

Meat packers specify different end cooking temperatures for hams processed by various methods. The American Meat Institute (2) summarizes the recommendations from packers as follows: heat cook-before-eating hams to 160°F, ready-to-eat hams to 130° to 140°F, and fully cooked and canned hams to 125° to 130°F.

Several brands of meat thermometers were examined and all specified the same end temperatures for baking hams. The designated temperature for tendered hams is 150°F; for cured hams, the end temperature is 170°F.

Alexander and Hankins (1) and Dawson et al (11) cooked hams to internal temperatures of 76°C and 170°F respectively. Edible portion of bone-in hams ranged from 46 to 62 percent (11).

Bacteriological studies include reports of ham and ham products cooked to 77° and 80°C. McDivitt (35) found that 77°C did not kill all micrococci present in hams. Deskins (13) cooked ham loaf to 80°C and the bacteriological analysis revealed that cooking reduced the number but did not destory all of the viable cells. Jensen (29) recommended that hams should be cooked so that the inside of the ham reaches a temperature of at least 72.2°C.

The internal temperature of meat may continue to rise after removal from the oven (33). Temperature rises reported for baked hams ranged from 3 to 6.8°C (Appendix A.). Temperature increases in boiled hams averaged 10°C (1). Staggs (50) found that the increase was directly proportional to increased oven temperatures.

Directions for cooking often state the time of cooking in terms of minutes per pound. Lowe (33) stated that, at best, minutes per pound can serve only as a poor guide, for various reasons including the fact that as the size of a piece of meat increases, its weight increases in greater ratio than its dimensions.

<u>Bacteriological aspects of serving</u>

Temperature control is important in preventing the production of poisonous toxins in food and thus in reducing food poisoning outbreaks. Baughman (5), McDivitt (35), Esselen (18), and Jensen (29,30), and others pointed to the frequency with which ham has been implicated in food poisoning outbreaks. These outbreaks often involve groups who have eaten food from institutional kitchens, commercial restaurants, armed forces units, church suppers, and social gatherings in private homes. Dack (10) reported that although methods involved in heating quick cured hams during manufacture are designed to kill trichinae and staphylococci, the hams can easily become contaminated after leaving the packers. Niven (41) also reported that conventional smoking times and temperatures appear sufficient to assure the absence of living staphylococci in the hams as they leave the smokehouse. The staphylococci produce toxins rapidly at temperatures between 60 and 115°F according to Fraizer (23) and between 50 to 120°F according to Esselen (18).

Since warm temperatures are conducive to microorganism growth and development, adequate refrigeration is a necessary control in preventing food poisoning. Esselen (18) stressed that refrigeration, including freezing, does not rid the product of the organisms but merely represses them while the food is cold. Evans (19) repeated the rule that ham should never remain in the temperature zone of 50 to 120°F for an accumulative period of longer than four hours. Prompt and efficient refrigeration of uncooked and cooked ham was advocated by the work of McDivitt (35), Black (6), and Draim (14). Slow cooling or holding ham at room temperatures allows dangerous incubation; hams cooled at room temperature before refrigerating remained in the danger zone twice as long as those refrigerated immediately after cooking. West and Wood (57) pointed out that food should be so placed in the refrigerator to permit free circulation of cold air throughout the storage unit and that the temperature of the refrigerator should be maintained at 33 to 38°F.

Boning, cutting, and slicing afford chances for contamination of the food by bacteria from the air, utensils, equipment, and personnel (57). Jensen (29) reported that most contamination of cooked ham occurs during the slicing operation and advocated that the safest procedure to follow is one in which the raw ham is sliced and cooked at 8 to 12 pounds pressure for 30 minutes and served immediately.

Jensen (29) stressed that cooked hams be kept at 130°F or above when placed on steam tables and that hams not be held for more than four hours accummulated time, in the incubation range. West and Wood (57) stated that the desirable minimum temperature for holding all heated foods is 150°F and that some investigators favor higher temperatures. The holding time should be as short as possible (29, 57).

The control of staphylococcus food poisoning apparently lies in the education of the public and food handlers (5, 10). Dack (10) stated that one of the difficulties is educating the public that foods containing food poisoning microorganisms do not look, taste, feel, or smell different from safe food. Evans (19) believes that some consumers and retailers still interpret the word "cured" as implying that the ham is a relatively non-perishable product even at room temperature. On the contrary, food-poisoning organisms can grow readily at temperatures above 50°F in cured hams as well as in other foods.

METHOD OF PROCEDURE

For a comparison of yield and palatability, five basic styles of 12 to 14-pound hams, three of them in both uncooked and precooked state, were baked under controlled conditions. The standard procedure for the entire project was based on preliminary investigations in the laboratory and was an adaptation of methods practical for use in food service kitchens.

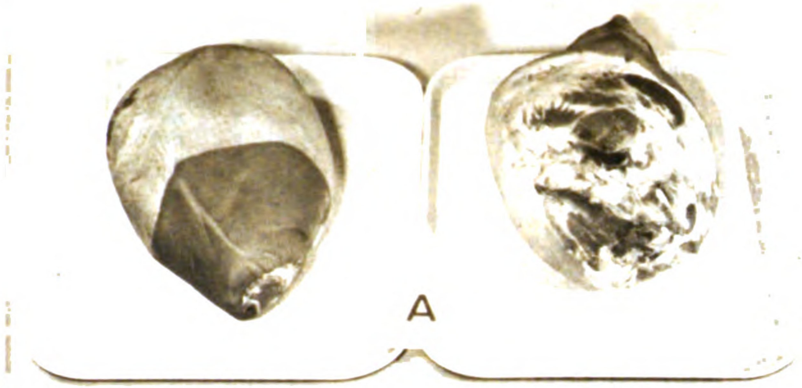
Materials Used

The styles and sources of hams selected for the study were determined through consultation with the manager of the campus food stores and through correspondence with major meat packing companies. Styles of ham widely available to food services were selected, and the major pieces of equipment used in the study were comparable to those generally used in institutional kitchens.

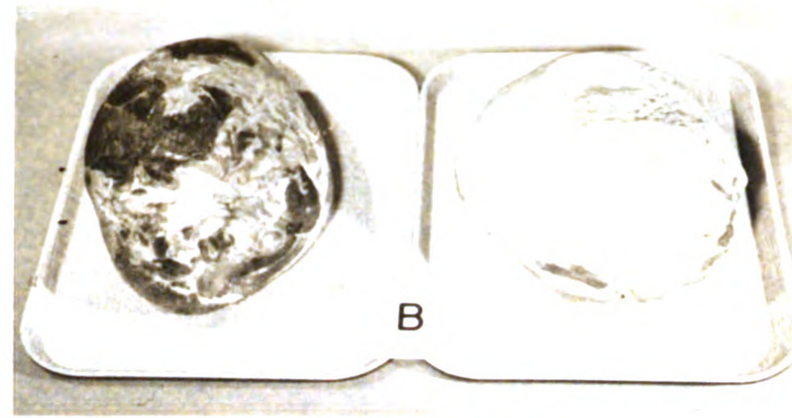
Hams

The five styles of hams selected for the comparison in this investigation were (1) regular bone-in; (2) skinless shankless; (3) boned rolled visking packed; (4) splits, visking packed; and (5) canned pear-shaped (Figure 1). The first three styles were available both uncooked and precooked, making a total of eight different types of ham.

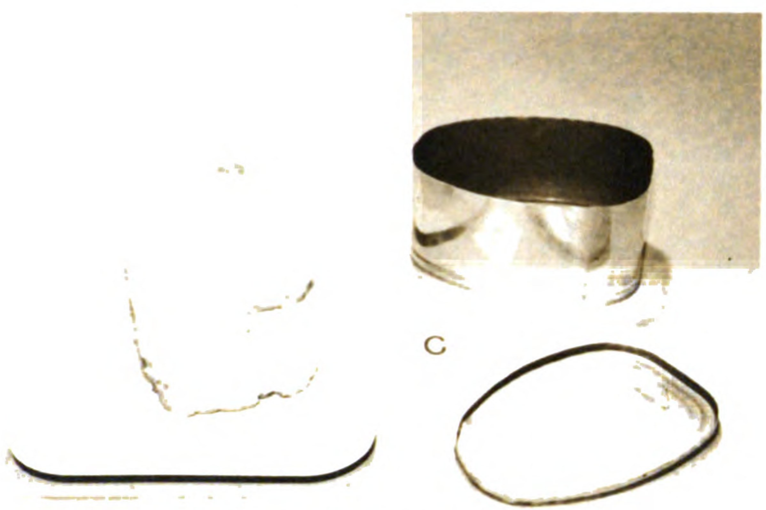
Styles. Regular bone-in hams contained the leg bone, shank bone, and aitch bone. The shank end of the ham was covered



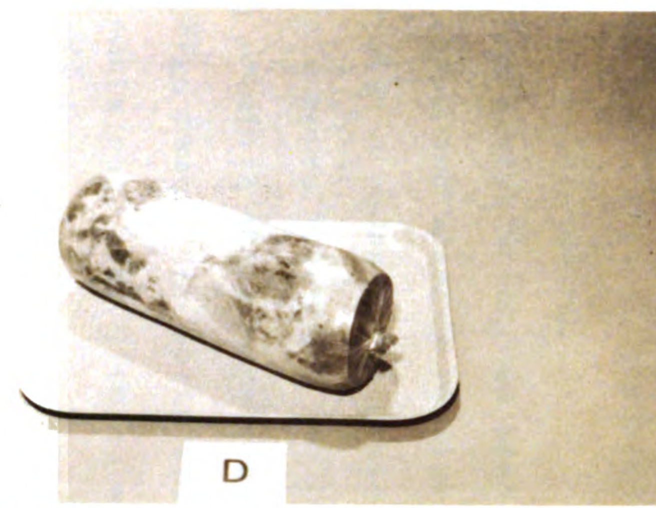
Regular bone-in



Skinless shankless



Canned pear-shaped



Visking-packed: boned rolled and splits

Figure 1. Styles of hams studied in this investigation.

with skin. As the name implies, the skinless shankless hams had the shank and all of the skin removed.

Boned rolled hams were whole hams which had been boned and rolled into a cylindrical shape and wrapped in visking. Each end of the ham was capped with a round metal plate over which the visking was drawn and clamped together.

The shape and packaging of split style hams closely resembled that of the boned rolled hams. The split style, however, did not consist of a whole ham. The visking was filled with two or more pieces of small to medium hams or with one piece from a large ham.

Canned hams were boned and trimmed hams which were forced into metal containers and processed. Only hams canned in pear-shaped containers were used in this study: pullman-shaped canned hams were not available in 12 to 14-pound size.

Kinds: uncooked and precooked. Three styles of hams, including regular bone-in, skinless shankless, and boned rolled, were purchased both uncooked and precooked. Only precooked splits were available. The canned hams were also precooked.

Throughout the report of this investigation, the term uncooked is used to designate hams heated to an internal temperature of 137°F during the processing. The term precooked is used to refer to all hams heated to a minimum of 150°F during processing, as prescribed by Federal Specifications. The exact internal temperature for hams of the precooked type from each company was not known.

Ten hams of each style were cooked, including ten uncooked and ten precooked for styles in which both kinds were available. During each baking period six hams were cooked simultaneously. As far as possible, styles in each cooking period were selected according to a randomized arrangement of styles and kinds of hams from three purveyors. Cooking periods were scheduled twice weekly, and yield and panel evaluations of the baked hams were conducted on the day following the baking day.

Equipment

Standard institutional equipment was used when possible in this study. To facilitate accurate data collection, however, some of the equipment was built or altered to fit special specifications.

Weighing and Measuring. A 4.5-kilogram capacity torsion balance was used to weigh the hams, pans, racks, and drippings to the nearest gram. A 2-kilogram capacity torsion balance was used to weigh the fat samples to the nearest 0.1 gram for specific gravity calculations.

A device was designed for measuring the length, width and depth of each ham. It consisted of two vertical 18-inch rulers which were numbered from the bottom to the top. Connecting the two vertical rulers was a horizontal 24-inch ruler with numbers reading from left to right. The left vertical ruler was secured on a metal foot and could stand alone. The horizontal ruler could be moved up and down. The right vertical ruler could be moved toward or away from the left ruler. Each ham was placed fat side up, between the vertical rulers which were adjusted so that the rulers touched both sides of the ham at its widest point for measuring the width. The rulers touched the ham on both ends at the longest point for determining the length. To measure the thickness of the ham, the horizontal ruler was lowered until it touched the highest portion of the ham and adjusted until it met both vertical rulers at the same inch marking.

Internal ham temperatures were measured by precision laboratory thermometers which were calibrated in 1°C intervals. Two thermometers were used in each ham: a 6-inch complete immersion thermometer with a temperature range of 0 to 105°C, and a 12-inch partial immersion thermometer with a -20°C to +110°C temperature range.

Baking. Each ham was baked in a standard aluminum baking pan, 18.75 inches long by 12.50 inches wide by 3.75 inches deep. A 10.5-inch square wire rack, which stood on one-half inch legs, was placed in each pan. Each pan and rack was coded with metal rings strung on metal pins which were fastened to the pan handle and the matching rack. The weight of each coded pan and rack set was recorded.

A 2-deck Hotpoint roasting and baking oven, Model No. HJ 225, with an air cushion bottom was used throughout the study. Special fabrication in each deck included interior lighting and two single-pane glass windows which facilitated reading thermometers without opening the oven doors.

Boning and slicing. Hams were boned with a professional boning knife with a 5.5-inch blade. Taste panel slices were cut 1/8-inch thick on a manually operated General slicing machine, Model No. 225.

Preliminary Investigations

Six regular bone-in style hams, three uncooked and three precooked, were baked and evaluated before the actual study was started. The preliminary investigations served to establish the final internal temperatures and to develop boning and separation techniques to be used throughout the study. The taste panel was trained, using samples from the hams baked during preliminary investigations.

Baking

Each oven was preheated to 325°F with upper and lower grids on medium and the air vent closed. Because the permanent pan codes were not visible through the windows of the oven, aluminum foil strips were marked with red wax pencil and folded over the edge of each pan so that code numbers were easily visible.

Each ham was placed fat side up on the rack in the baking pan. Thermometers were placed so that the bulbs were in the center of the thickest portion of each ham. Three hams were baked in each oven.

Determining final internal temperatures

Due to conflicting instructions on ham labels and the lack of specific processing temperatures, it was necessary to establish a standard to use as the final internal temperature to which to heat the hams for this study. A bacteriologist was consulted regarding the minimum internal temperatures for safely cooking hams. As a result of this consultation the uncooked hams in the preliminary investigation were cooked to 79°C internal temperature and the precooked hams to 66°C.

Because a preference for samples from hams heated to 79°C was indicated by the scores in the preliminary tests, this was selected as the internal temperature for cooking all hams in the study. Although in several earlier investigations (Appendix A.) 70°C was used as the endpoint of cooking, selection on the basis of panel preference in the preliminary tests was deemed equally valid.

Boning

A member of the meat division of the Michigan State University Food Stores demonstrated the technique used to bone hams for the campus food services (Figure 2). The chilled hams from the preliminary bakings were then boned under the supervision of the demonstrator. A diagram of the bone structure and placement in a ham helped to clarify the boning process (Figure 3).

Removing aitch bone. Surplus exterior fat was trimmed away and the ham was placed on the cutting board with the fat side down. The fat and lean which covered the aitch bone were removed so that the bone was exposed. The knife was

Removing aitch bone

Removing under portion of ham

Removing shank

Removing leg bone

Figure 2. Procedure used for boning hams.

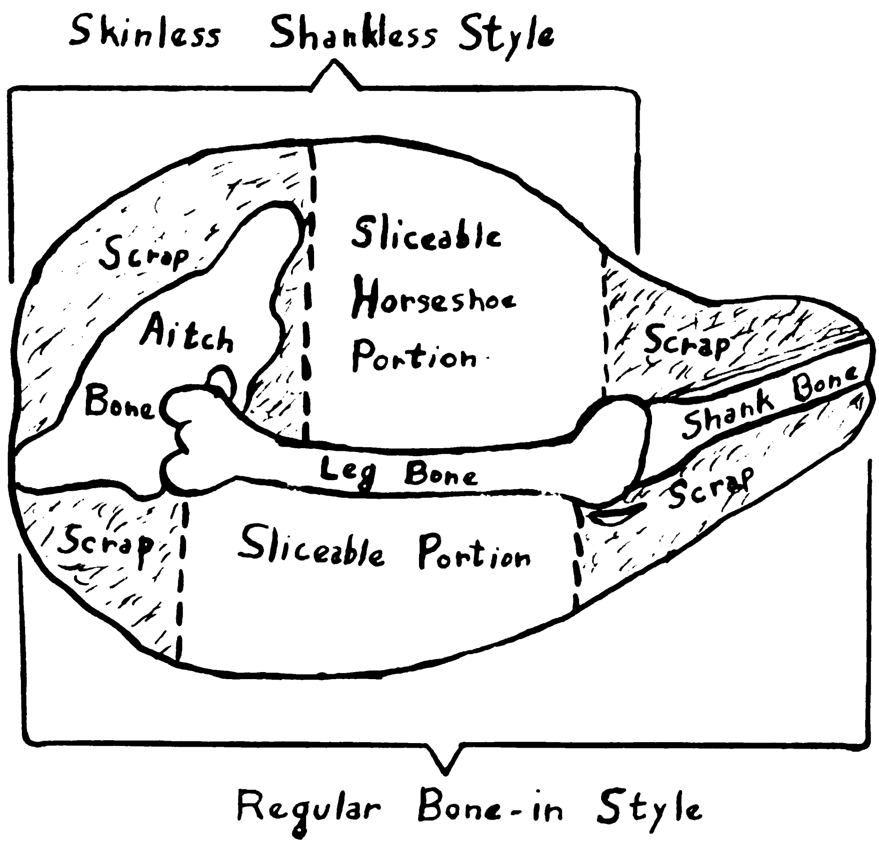


Figure 3. A diagram of bone structure, sliceable portions, and scrap portions of bone-in style hams.

slipped under the edge of this broad flat bone found near the surface on the butt end of the ham and worked carefully around the bone, freeing it from the meat beneath. The free end of the aitch bone was lifted to expose the joint between the aitch bone and the leg bone. This joint was disengaged with the knife point, and the aitch bone was removed.

Removing the shanks. The shank was grasped in one hand and moved back and forth until the shank bone and leg bone joint was loosened. If the shank was not easily freed from the ham, the knife tip was inserted into the joint to sever the connection and the shank was cut from the ham.

Removing the leg bone. Removal of the aitch bone and the shank bone exposed both ends of the leg bone. The next step was the removal of the meat from below the leg bone by placing the knife blade flat against the bone and cutting along the full length of the bone. The portion of ham thus removed was trimmed and the ends squared for slicing.

The knife tip was carefully worked along the bone to cut connective tissues. When possible, the bone was encircled with the fingers to help loosen it from the meat. The horseshoe portion, which remained after the leg bone was removed, was trimmed and squared for slicing samples for panel members to judge. The samples were sliced from the butt end of the ham.

Preliminary Taste Panel. Slices from three uncooked and three precooked hams were presented to a panel of seven judges. Score sheets were discussed (a copy of the score sheet is in the Appendix).

The judges were asked to cut a 0.50 to 0.75-inch square sample from the same muscle of each slice and to chew each sample until it was completely masticated. They recorded the number of chews for each sample and also assigned it a numerical tenderness score. A tenderness table for each judge was compiled on the basis of the scores and number of chews recorded for these samples. The individual tenderness range cards were used by each judge for scoring samples for tenderness throughout this investigation. The judges also evaluated the aroma, flavor of lean, flavor of fat, color, tenderness, texture, and juiciness of each sample.

Prebaking Preparation

Each ham was assigned a 5-digit number, from a table of randomly assorted digits. After coding, hams were weighed, measured, and described prior to baking.

Weight data

The billed weight, initial weight, and the trimmed weight of each ham were recorded. The weight of the ham was recorded in pounds and ounces as it appeared on the label. Some hams lacked billed weights.

The initial weights for the various styles of hams were determined by a method appropriate for the type of packaging. The wrapper was removed before a bone-in ham was weighed. The weight of the visking-packed ham in its covering was recorded. The visking and metal plates were removed after the ham was baked, and the weight deducted from the previously recorded weight to determine the initial weight. Unopened canned ham was weighed, the ham was removed from the can, and the can was washed, dried, and weighed. The weight of the ham in the can minus the weight of the empty can equaled the initial weight.

The trimmed weight determination also varied with the styles. The skin on the bone-in ham was slit with a sharp knife and pulled from the ham. The weight of the skin was recorded as trimmings, and was deducted from the initial bone-in ham weight to give the amount of trimmed ham. The initial and trimmed weights of visking packed ham were identical. Three slits were made in the visking on the top side to prevent irregular breaking during baking. The gelatin and/or packing fat were scraped from canned ham with a rubber scraper; the remaining ham weight was the trimmed weight. The difference between the initial weight and the trimmed weight was recorded as trimmings.

Measurement data

The circumference, width, and thickness of each ham was measured. When possible, the fat depth was also measured. The circumference of each ham was determined by a string which was drawn around the broadest portion of the ham and measured to the nearest 1/8-inch. The length, width, and thickness of each ham was measured to the nearest 1/8-inch with the device described in the equipment section. The depth of the fat was measured on bone-in and canned hams. A metal skewer, inserted through the fat layer, was used to measure the fat to the nearest 1/8-inch in five places on the fat side of the ham: collar, center, left center, right center, and top.

Descriptive data

Notes were made about the general shape and any peculiarities of each ham. Sometimes rough sketches were drawn. The shank length of the regular bone-in style of ham was measured. The degree of trim was also observed.

Thermometer placement

A 6-inch thermometer was inserted vertically from the fat side of the ham into the thickest portion of the ham so that the thermometer bulb was as near the center of the ham as possible. Because the short thermometers could not be read until the internal temperature had risen considerably, a 12-inch partial immersion thermometer, which was too long to stand vertically in the oven, was inserted diagonally into each ham so that the bulbs of the two thermometers touched. This arrangement facilitated the recording of internal temperatures throughout the entire baking period. If there was a discrepancy between the two temperatures, the short thermometer reading was preferred.

Baking Process

The internal temperatures of the hams were recorded at the time they were placed in the 325°F ovens and at 20-minute intervals until the internal temperatures approached 70°C. The temperatures were then checked every five minutes until the internal temperatures reached 79°C. The ham was removed from the oven and allowed to remain in the baking pan at room temperature for 30 minutes. The temperature of the ham at the end of the 30-minute cooling period was recorded and the thermometers were removed.

Handling the Baked Ham

Part of the yield data was collected before the cooked hams were refrigerated. The major portion of the data was collected on the following day.

Treatment of ham before chilling

After essential data collection, the hot hams were placed on coded aluminum trays and refrigerated overnight. Bone-in and canned hams required slightly different treatment than that given visking-packed hams. Ham drippings were collected and saved for future examination.

The baking pan containing a cooked bone-in or canned ham, rack, and drippings was weighed. The hot ham was carefully lifted from the baking pan, placed fat side up on the tray, and refrigerated.

The total weight of each cooked visking-packed ham, rack, and drippings was recorded. With the ham remaining on the rack in the baking pan, the metal end plates were cut loose and removed. The visking was slit from one end of the ham to the other and carefully peeled away from the ham, using a sharp knife to help free the visking. The ham was allowed to remain on the rack so that the drippings could fall into the pan. After the dripping ceased, the ham was placed on a tray. Any ham which remained on the metal plates and visking was removed and added to the tray and the tray of ham and scrap meat was refrigerated. The weight of the visking and plates was recorded.

The baking pan, the rack, and ham drippings were weighed. By deducting the pan and rack weight from the total weight, the weight of the drippings was determined.

Any material remaining on the rack was scraped into the pan and the rack was removed. The drippings were poured into graduated cylinders and the pan scraped clean with a rubber scraper. The cylinders were covered with saran and saved until the following day when additional drippings from the refrigerated hams were added.

Treatment of chilled ham

The amount of sliceable ham, the edible fat and lean scrap, and the inedible portion from each ham was determined the day after the hams were baked. Total cooking losses were calculated and recorded. Slices from each ham were evaluated by the taste panel.

Dividing the ham into portions. Each ham was lifted from the cooling tray and any solidified fat drippings or congealed nonfat drippings which adhered to the bottom of the ham were scraped into the tray and added to the drippings previously collected. The ham was then weighed and placed on a cutting board. Procedures differed for dividing the various styles of hams into sliceable, edible lean scrap, edible fat scrap, and inedible portions.

Bone-in hams were boned according to the method described under Preliminary Investigations and then were divided into portions. The horseshoe portion and the portion from below the leg bone were squared, trimmed, and counted as sliceable ham. The bones were cleaned and weighed. The meat removed from bones was placed with the edible scrap; pieces of gristle were counted as inedible scrap. The edible scrap was divided into fat and lean, by tearing each piece of scrap apart so that visible sections of fat could be separated from lean. One-eighth-inch slices were taken from the butt end of the horseshoe portion for the panel to evaluate.

Visking-packed and canned hams were each cut crosswise into thirds. Both ends of the center section were examined to locate the muscle structure which most nearly resembled those in the panel slices from the bone-in hams. The slices for the taste panel were taken from the selected end. The remainder of the ham was sliced and the slices were sorted into those which were servable and those which were not suitable for sliced portions. The combined weight of the servable slices and the panel slices was designated as the sliceable ham portion. The remaining parts, unsuitable for sliced servings, were divided into edible fat, edible lean, or inedible scrap.

The tray containing the drippings from the cooled ham was weighed and the weight of the empty tray was deducted. The resulting weight plus the weight of the drippings collected on the cooking day were combined to obtain the total weight of drippings for each ham. The tray was placed in a warm oven until the drippings could be easily poured and scraped into the cylinder containing the original drippings. If there was not a clear fat and nonfat separation, the cylinders of drippings were placed in hot water until the division was evident. The total milliliters of drippings and the separate amounts of fat and nonfat drippings were recorded. The color, odor, and clarity of the drippings were observed.

Separate weights were determined for the fat drip and nonfat drip from each ham. About 50 ml. of fat drippings from each cylinder were poured into a 120 ml. graduated cylinder. The small cylinder of fat was weighed and the weight of the empty cylinder subtracted. The resulting weight was divided by the number of milliliters in the sample of fat to determine the weight of one milliliter of fat. By multiplying the weight of one milliliter of fat by the total milliliters of the fat, the total weight of fat was determined. The difference between the weights of the total drippings and the weight of the fat drippings provided the weight of the nonfat drippings.

Evaluation of Hams

The hams were evaluated subjectively by a taste panel. The panel scores and yield data for the types of hams were analyzed statistically.

Subjective testing

One slice from each of the six hams was placed on a coded plate on a tray and presented to each of seven judges. Each judge received the slice cut from the same relative position in each ham. Glasses of water at room temperature were supplied along with the ham samples. Seats were assigned to provide an arrangement that discouraged the panelists from interchanging remarks or facial expressions.

The judges scored each sample for odor, flavor of lean, flavor of fat, color, tenderness, texture, and juiciness. The scores were based on a scale ranging from 1 to 7. A score of 7 indicated excellent quality; a score of 1 represented unacceptable quality. Descriptive terms for each factor were listed on the score card so that the judges could check the reasons for the numerical ratings, especially for low ratings.

Statistical Analysis

Analyses of variance were used in evaluating the data. The yield data and the taste panel scores were analyzed according to procedures recommended by the statistician of the Agricultural Experiment Station.

The weights of sliceable ham, lean scrap, fat scrap, bone, inedible scrap, total cooking losses, volatile losses, nonfat drippings and fat drippings for each ham were converted into percentages based on the raw trimmed weight of the ham. The variations in percentages within the ten replications and among the eight types of hams were analyzed for each yield factor. If the differences were significant, the Studentized range table was used to determine which hams yielded significantly more or less than other hams.

The analyses of variance for aroma, flavor of lean, flavor of fat, color, tenderness, texture and juiciness were based on the average taste panel scores. Because all panel scores for each palatability factor for each ham were averaged, judges were not included as a source of variance in the analyses.

RESULTS AND DISCUSSION

Yield, cooking loss, and palatability data were collected and analyzed statistically to determine whether differences among eight types of ham were significant. Statistical results were examined for patterns in differences among the five basic styles of ham: regular bone-in, skinless shankless, boned rolled, splits, and canned pear-shaped. Differences between results for uncooked and precooked hams were also studied. Percentages, statistical analyses, and subjective evaluations were considered in the interpretation of results for each type of ham. Cooking time and temperature data from all types of hams were compared.

Yield and Cooking Losses

Sliceable portion, lean scrap, fat scrap, inedible scrap, bone, skin, fat drip, non fat drip, volatile loss, and total cooking losses were converted from weights to percentages (Table 1). Analysis of variance revealed highly significant differences among types of ham for all yield and cooking loss data except inedible scrap, bone, and skin (Table 2). Some comparisons in these analyses which did not show highly significant differences did show differences at the 5 percent level of significance. Differences in bone losses were significant at the 5 percent level; inedible scrap and skin analyses showed no significant differences. Graphical presentation (Figure 4) agreed with the statistical

Table I. Mean percentages of yield and cooking losses of eight types of ham (based on the trimmed weight before cooking).

	Regular bone-in		Skinless shankless	
	A_1 uncooked	A_2 precooked	B_1 uncooked	B_2 precooked
Sliceable Portion	40.52	46.28	44.23	44.47
Lean Scrap	15.07	12.08	14.70	16.82
Fat Scrap	11.81	10.56	6.84	6.57
Inedible Scrap	1.19	0.85	1.10	1.24
Bone	7.45	8.13	7.34	7.16
Skin*	2.24	2.06	----	----
Gelatin and Fat*	----	----	----	----
Fat Drip	7.35	6.09	5.39	3.72
Nonfat Drip	5.23	4.43	4.15	4.39
Volatile Loss	11.35	11.55	16.23	15.61
Total Cooking Losses	23.93	22.07	25.77	23.72

*percentage of initial ham weight

Table I. (continued)

Boned rolled		Split	Canned
C_1	C_2	D	E
uncooked	precooked	precooked	pearshape
58.06	61.66	55.59	70.83
14.48	10.07	12.83	3.86
5.10	4.07	4.47	2.17
----	----	----	----
----	----	----	----
----	----	----	----
----	----	----	10.48
3.20	2.17	4.05	3.53
6.61	7.60	7.49	3.81
12.53	14.40	15.54	15.78
22.34	24.17	27.08	23.12

Table 2. Mean squares and significant differences for yield and cooking losses of eight types of ham*.

Source of Variance	D.F.	Mean Square	Significant Differences# 1% level	5% level only
Sliceable	7	1,107.51	$E > C_2\ C_1\ D\ A_2\ B_2\ B_1\ A_1$ $C_2 > D > A_2\ B_2\ B_1\ A_1$ $C_1 D > A_2\ B_2\ B_1\ A_1$ $A_2 >$ AI	None
Lean Scrap	7	164.11	$B_2 > D\ A_2\ C_2 > E$ $B_2\ A_1\ B_1\ C_1\ D\ A_2$ $A_1\ B_1\ C_1 > C_2 > E$ $D\ A_2\ C_2 > E$	$A_1 > A_2$ $D > C_2$
Fat Scrap	7	107.90	$A_1 > A_2 > B_1\ B_2\ C_1\ D\ C_2 > E$ $B_1 > D\ C_2 > E$ $B_2 > C_2 > E$ $C_1\ D\ C_2 > E$	$B_1 > C_1$ $B_2 > C_1 D$
Inedible Scrap	3	.296	None	None
Bone	3	1.80	None	$A_2 > B_1\ B_2$ $A_2\ A_1\ B_1\ B_2$
Skin	1	.14	None	None
Fat Drip	7	28.95	$A_1 > B_1\ D\ B_2\ E\ C_1\ C_2$ $A_1\ A_2\ B_1$ $A_2 > D\ B_2\ E\ C_1\ C_2$ $B_1 > E\ C_1\ C_2$ $D > C_2$	$A_1 > A_2$ $B_1 > D\ B_2$ $B_2 E > C_2$

Table 2. (Continued)

Source of Variance	D.F.	Mean Square	Significant Differences# 1 % level	5% level only
Nonfat Drip	7	23.87	C_2 D > A_1 A_2 B_2 B_1 E C_2 D C_1 A_1 A_2 B_2 C_1 > B_1 E	C_1 > A_2 B_2
Volatile Loss	7	40.57	B_1 E B_2 D > C_1 A_2 A_1 B_1 E B_2 D C_2 C_1 C_2 > A_2 A_1	None
Total Cooking Losses	7	28.59	D > E C_1 A_2 D B_1 C_2 A_1 B_2 E C_1 A_2	D > C_2 A_1 B_2 B_1 > C_1 A_2

> = Significantly greater than those that follow. Ham types are listed in order of descending averages. Underlining denotes no significant difference.

* KEY:
- A_1 Regular, bone-in, uncooked
- A_2 Regular bone-in, precooked
- B_1 Skinless shankless, uncooked
- B_2 Skinless shankless, precooked
- C_1 Boned rolled, uncooked
- C_2 Boned rolled, precooked
- D Splits, precooked
- E Canned, pear-shaped

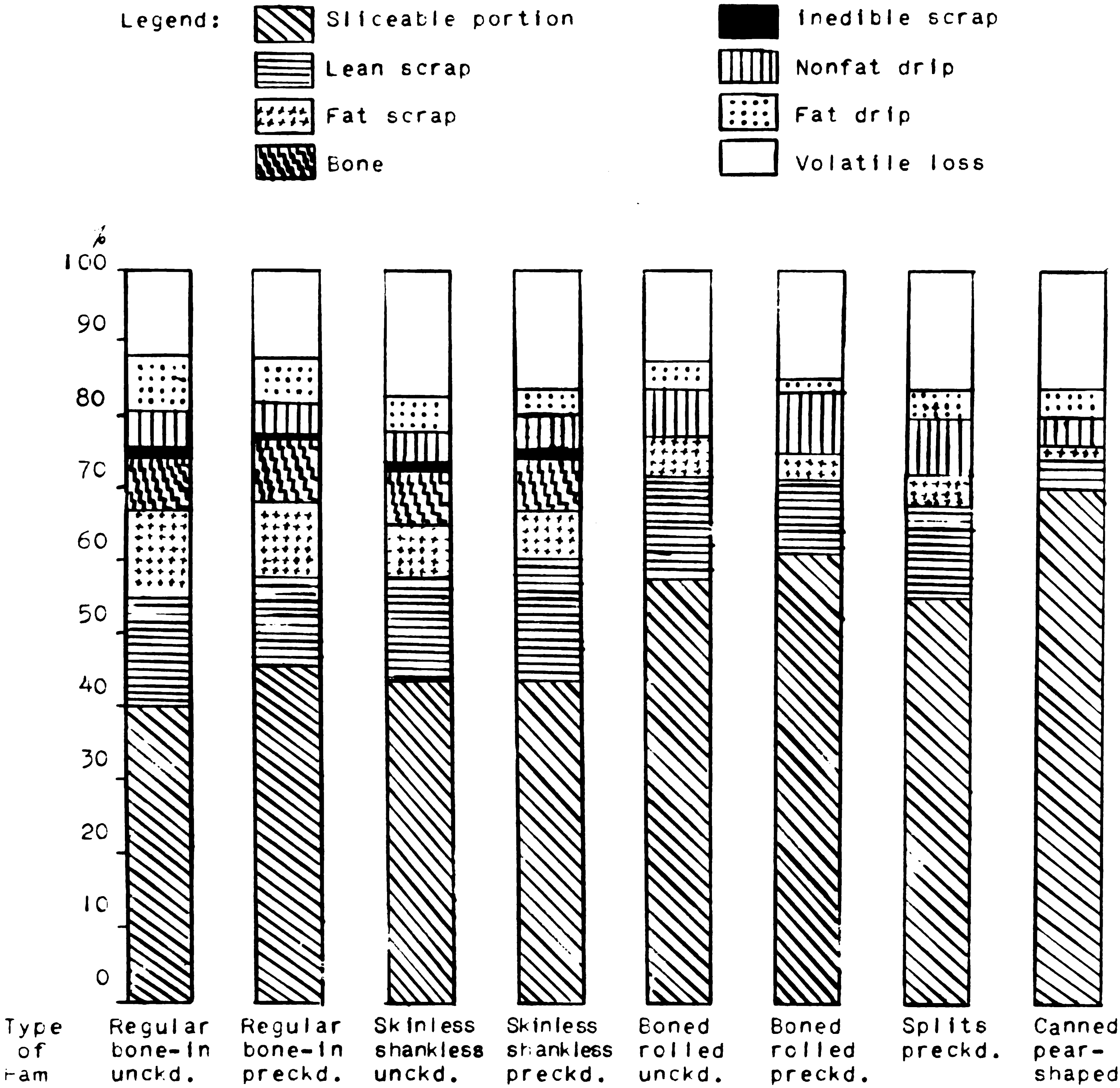


Figure 4. Yield and cooking losses of eight types of ham: percentages based on trimmed weight of ham prior to cooking.

results, which showed no common patterns of yield or cooking losses among the five styles of ham or between uncooked and precooked hams within a particular style.

Sliceable portion

Differences in the amount of sliceable meat were all significant at the 1 percent level and placed the styles of ham in three distinct catagories: canned, visking packed, and bone-in hams. Canned pear-shaped hams yielded more sliceable portion than visking packed and bone-in hams. Visking packed, boned rolled, and split style hams yielded significantly more sliceable ham than regular bone-in and skinless shankless hams.

In all cases precooked hams yielded higher percentages of sliceable meat than uncooked hams of the same style; however, in only one case was this difference significant. Percentages of sliceable portions in regular bone-in precooked and uncooked hams differed significantly at the 1 percent level.

Lean scrap

Statistical differences in the lean scrap among styles of ham did not follow an apparent pattern. Canned pear-shaped ham yielded less lean scrap, at the 1 percent level of significance, than all other hams. The amount of lean scrap, from precooked skinless shankless ham was significantly greater than the percentage of lean scrap from splits, precooked regular bone-in, precooked boned rolled, and canned pear-shaped hams. Differences in the amount of lean scrap from precooked skinless shankless and the three styles of uncooked ham were not significant.

The three uncooked types of ham did not yield statistically different amounts of lean scrap; nor did three of the four precooked types differ at the 1 percent level of significance. At the 5 percent level, however, the amount of lean scrap from cooked split ham was greater than that from precooked boned rolled hams.

Differences between lean scrap from uncooked and precooked hams of the same style were significant in two instances. The amount of lean scrap from uncooked regular bone-in ham was significantly greater, at the 5 percent level than lean scrap from precooked regular bone-in ham; at the 1 percent level, precooked boned rolled ham yielded significantly more lean scrap than uncooked boned rolled ham. The amounts of lean scrap from skinless shankless uncooked and precooked hams did not differ statistically.

<u>Fat scrap</u>

Percentages of fat scrap placed the hams in three catagories: bone-in styles, visking-packed styles, and canned style. Differences in fat scrap among catagories, however, were not all significant at the same level. Canned pear-shaped hams produced less fat scrap, significant at the 1 percent level, than all other hams. Percentages of fat scrap from regular bone-in uncooked and precooked ham were significantly greater at the 1 percent level than fat scrap from all other types of hams. At the 5 percent level of significance skinless shankless hams yielded more fat scrap than visking-packed hams. Differences in fat scrap yields among visking-packed hams were not significant.

Uncooked hams yielded higher percentages of fat scrap than did precooked hams of the same style. However, the only significant difference in fat scrap within a style was found between uncooked and precooked regular bone-in hams.

Bone

The weights of ham bones differed at the 5 percent level of significance. Precooked regular bone-in hams contained significantly more bone than both uncooked and precooked skinless shankless hams. Uncooked regular bone-in hams and skinless shankless hams did not yield significantly different amounts of bone. No significant differences were found between precooked and uncooked hams of the same style. Reasons for the significant differences between the weights of bones from precooked regular bone-in hams and skinless shankless hams were not readily apparent.

Fat drip

Regular bone-in hams produced the largest amount of fat drip; boned rolled hams produced the least amount of fat drip. Significant differences in the amount of fat drip revealed no divisions according to styles or kinds of ham. In a few instances the ranking and significant differences in fat drip resembled those found in the analysis of fat scrap.

Uncooked regular bone-in hams produced more fat drip, at the 1 percent level of significance, than did all other hams except precooked regular bone-in ham. The difference between the fat drip from uncooked and precooked regular bone-in hams was significant only at the 5 percent level. Precooked regular bone-in ham drip contained significantly more fat at the 1 percent level than did drip from visking-packed, precooked skinless shankless and canned pear-shaped hams. A similarity was noted between these statistical results and those from the analysis of fat scrap: in both instances regular bone-in styles were significantly fatter than all other styles.

Uncooked skinless shankless ham drip contained significantly more fat, at the 1 percent level, than the drip from canned pear-shaped and boned rolled hams. At the 5 percent level of significance, fat drip from uncooked skinless shankless were also greater than those from split and precooked skinless shankless hams.

Precooked skinless shankless and canned pear-shaped hams produced significantly more fat drip at the 5 percent level than the fat drip from precooked boned rolled hams. The difference between fat drip from split style hams and precooked boned rolled hams was highly significant. The least amount of fat drip from all hams came from the precooked boned rolled hams.

Precooked hams produced more fat drip than uncooked hams of the same style. A similar pattern was found in the analysis of fat scrap. Differences in fat drip between uncooked and precooked regular bone-in hams and between skinless shankless uncooked and precooked hams were significant at the 5 percent level. Uncooked and precooked boned rolled hams did not produce significantly different amounts of fat drip.

Nonfat drip

Percentages of nonfat drip fell into three divisions: visking packed hams produced the largest amount, bone-in styles followed, and canned hams yielded the smallest amount of nonfat drip. No pattern of differences in the amount of nonfat drip from uncooked and precooked hams was evident.

Nonfat drip did not differ significantly among visking packed hams. Precooked boned rolled and split hams produced more nonfat drip than was produced by bone-in or canned pear-shaped hams, significant at the 1 percent level. Uncooked boned rolled hams yielded greater amounts of nonfat drip, at the 1 percent level of significance, than did uncooked skinless shankless or canned pear-shaped hams. Uncooked boned rolled hams produced significantly more nonfat drip, at the 5 percent level only, than the precooked bone-in styles of ham.

Significant differences in the amount of nonfat drip did not exist between groups of uncooked and precooked hams or between uncooked or precooked hams of the same style.

Percentages of nonfat drip were greater for precooked boned rolled and precooked skinless shankless hams than for corresponding uncooked hams. The reverse was found for nonfat drip from regular bone-in hams: precooked hams produced less nonfat drip than did uncooked hams.

Volatile loss

All volatile losses showed significant differences at the 1 percent level. A pattern of losses among styles or between uncooked and precooked hams was not found. The greatest average amount of volatile loss was from uncooked skinless shankless hams and the least amount was from uncooked regular bone-in hams. Volatile losses from skinless shankless, canned pear-shaped, and split style hams did not differ statistically from each other or from precooked boned rolled hams, but were statistically greater than volatile losses from uncooked boned rolled and from both types of regular bone-in hams. Volatile loss from precooked boned rolled ham were significantly greater than those from regular bone-in hams.

Differences in the amount of volatile loss between groups of uncooked and precooked hams or within styles were not significant. Uncooked skinless shankless hams produced higher percentages of volatile loss than did precooked skinless shankless hams. Volatile losses were greater for precooked boned rolled and regular bone-in hams than for uncooked hams of the same style.

Total cooking losses

Percentages of fat drip, nonfat drip, and volatile loss for each ham were combined and the total cooking losses subjected to an analysis of variance. The results of the analysis of total cooking losses showed fewer statistical differences among styles than were found in analyses of individual loss factors. No pattern of losses was revealed among styles or between uncooked and precooked kinds of ham.

Precooked split style hams produced the greatest amount of total cooking loss, which was statistically greater than losses from any other ham except uncooked skinless shankless hams. Total cooking losses from split style hams were greater at the 1 percent level than losses from canned pear-shaped, uncooked boned rolled, and precooked regular bone-in hams. Differences in total cooking losses from split hams and losses from precooked boned rolled, uncooked regular bone-in, and precooked skinless shankless hams were significant only at the 5 percent level.

Total cooking losses did not differ significantly at the 1 percent level among regular bone-in, skinless shankless, boned rolled, and canned pear-shaped hams. Total cooking losses from uncooked skinless shankless hams, however, were significantly greater, at the 5 percent level, than losses from uncooked boned rolled and precooked regular bone-in hams.

Types of ham

The yield of each type of ham was considered in relation to the yield of corresponding uncooked and precooked ham of the same style and in relation to yields of other styles of ham. Discussion of individual types of ham was aided by supplementing the tables of yield percentages (Table I) and analyses results (Table 2) with a table of statistical comparisons between all possible pairs of the eight types of ham in this study (Table 3).

Regular bone-in hams. Uncooked and precooked regular bone-in hams differed significantly from each other in four yield factors. Precooked regular bone-in hams produced significantly more sliceable meat than was removed from uncooked regular bone-in hams. Uncooked regular bone-in hams yielded significantly greater amounts of lean scrap, fat scrap, and fat drip than precooked regular bone-in hams yielded.

Uncooked regular bone-in hams produced the least amount of sliceable meat, the most fat scrap and fat drip, next to the highest percentage of lean scrap, and compared favorably with six other types of ham in the amount of total cooking losses. The average percentage of sliceable meat, 40.52, in uncooked regular bone-in hams was significantly lower than the amount of sliceable meat from all types of ham except the skinless shankless hams. The amount of lean scrap from uncooked regular bone-in hams was significantly more than the percentages of lean scrap from precooked boned rolled hams and from canned pear-shaped hams. Total cooking losses from uncooked regular bone-in hams, 23.93 percent were not

Table 3. Comparisons of yield and cooking losses between types of hams. (Blank spaces indicate insignificant differences)

Types Compared	Sliceable	Lean Scrap	Fat Scrap	Bone	Fat Drip	Nonfat Drip	Volatile Loss	Total Cooking Losses
A_1 & A_2	A_2**	A_1*	A_1**		A_1*			
A_1 & B_1			A_1**		A_1**		B_1**	
A_1 & B_2			A_1**		A_1**		B_2**	
A_1 & C_1	C_1**		A_1**		A_1**			
A_1 & C_2	C_2**	A_1**	A_1**		A_1**	C_2**	C_2**	
A_1 & D	D**		A_1**		A_1**	D**	D**	D*
A_1 & E	E**	A_1**	A_1**		A_1**		E**	
A_2 & B_1			A_2**	A_2*			B_1**	B_1*
A_2 & B_2		B_2**	A_2**	A_2*	A_2**		B_2**	
A_2 & C_1	C_1**		A_2**		A_2**	C_1*		
A_2 & C_2	C_2**		A_2**		A_2**	C_2**	C_2**	
A_2 & D	D**		A_2**		A_2**	D**	D**	D**
A_2 & E	E**	A_2**	A_2**		A_2**		E**	

B_1 & B_2				B_1*			
B_1 & C_1	C_1**		B_1*	B_1**	C_1**	B_1**	B_1*
B_1 & C_2	C_2**	B_1**	B_1**	B_1**	C_2**	C_2**	
B_1 & D	D**		B_1**	B_1*	D**		
B_1 & E	E**	B_1**	B_1**	B_1**			
B_2 & C_1	C_1**		B_2*		C_1*	B_2**	
B_2 & C_2	C_2**	B_2**	B_2**	B_2*	C_2**		
B_2 & D	D**	B_2**	B_2*		D**		D*
B_2 & E	E**	B_2**	B_2**				
C_1 & C_2		C_1**					
C_1 & D						D**	D**
C_1 & E	E**	C_1**	C_1**		C_1**	C_1**	
C_2 & D	C_2**	D*		D**			D*
C_2 & E	E**	C_2**	C_2**	E*	C_2**		
D & E	E**	D**	D**		D**		D**

KEY:
- A_1 Regular bone-in, uncooked
- A_2 Regular bone-in, precooked
- B_1 Skinless shankless, uncooked
- B_2 Skinless shankless, precooked
- C_1 Boned rolled tied, uncooked
- C_2 Boned rolled tied, precooked
- D Splits, precooked
- E Canned, pear-shaped

**Significantly higher at the 1% level of probability
*Significantly higher at the 5% level of probability

significantly different from total cooking losses from other hams.

Precooked regular bone-in hams yielded more sliceable meat than other bone-in types, the third least amount of lean scrap, next to the most fat drip and fat scrap, and the lowest percentage of total cooking losses. Although precooked regular bone-in hams produced a higher average percentage of sliceable meat, 46.28, than other bone-in types of ham, the amount was significantly less than sliceable meat from visking-packed and canned hams. The amount of lean scrap which was separated from precooked regular bone-in hams was significantly greater than that from canned pear-shaped ham and significantly less than the amount of lean scrap from precooked skinless shankless hams. The amounts of fat scrap and fat drip from precooked regular bone-in hams were exceeded only by fat scrap and fat drip from uncooked regular bone-in hams. The percentage of total cooking losses from precooked regular bone-in hams, 22.07, was the lowest in the study; the amount was significantly different, however, only from the split style hams.

Skinless shankless hams. Only one significant difference in average yield and cooking losses was found between uncooked and precooked skinless shankless hams. Uncooked skinless shankless hams produced significantly more fat drip than did precooked skinless shankless hams.

Uncooked skinless shankless hams yielded next to the lowest amount of sliceable ham, third largest amount of lean scrap, fat scrap, and fat drip, and next to the highest percentage of total cooking losses. The average 44.23 percent sliceable portion from uncooked skinless shankless hams was significantly less than the amount of sliceable portion from visking-packed and canned pear-shaped hams, but did not differ significantly from the other bone-in types of ham. The percentage of lean scrap was significantly greater for uncooked skinless shankless hams than from precooked boned rolled hams and canned pear-shaped hams. Average total cooking losses of 25.77 percent from uncooked skinless shankless hams were not statistically different from other total cooking losses.

Precooked skinless shankless hams yielded third from the lowest amount of sliceable meat, the most lean scrap, and the fourth least amount of total cooking losses. The percentage of sliceable meat from precooked skinless shankless hams, 44.47, was significantly less than that from all but bone-in type hams. The amount of lean scrap from uncooked skinless shankless hams was significantly greater than that from splits, precooked regular bone-in, precooked boned rolled, and pear-shaped hams. Total cooking losses from uncooked skinless shankless hams, 23.72 percent, were not significantly different from total cooking losses from other hams.

Boned rolled hams. The only significant difference found in yield and cooking losses between uncooked and precooked boned rolled hams was the amount of lean scrap. Uncooked boned rolled hams produced more lean scrap than did precooked boned rolled hams.

Uncooked boned rolled hams contained the third highest percentage of sliceable meat, fourth largest amount of lean scrap, and yielded next to the least amount of total cooking losses. The 58.06 percent of sliceable meat from uncooked boned rolled hams was significantly greater than sliceable meat from bone-in styles and significantly less than sliceable ham from canned pear-shaped ham. The amount of lean scrap taken from uncooked boned rolled hams was significantly more than lean scrap from precooked boned rolled and from canned pear-shaped hams. Total cooking losses from uncooked boned rolled hams was 22.34 percent which was significantly less than those from split style hams.

Precooked boned rolled hams contained next to the highest percentage of sliceable ham and lean scrap and yielded the third highest percentage of total cooking losses. Precooked boned rolled hams yielded 61.66 percent sliceable portion, which was significantly less than that from canned pear-shaped and significantly more than the sliceable meat from split and bone-in style hams. The amount of lean scrap from precooked boned rolled hams was significantly greater than the amount of lean scrap from canned pear-shaped hams and was significantly less than that from precooked skinless shankless hams. The percentage of total cooking losses from precooked boned rolled hams, 24.17, did not differ significantly from other percentages of total cooking losses.

Split hams. Only precooked split style hams were available in the 12 to 14-pound weight range. Split hams yielded the fourth largest percentage of sliceable meat, the fourth lowest percentage of lean scrap, and the greatest amount of total cooking losses. Sliceable ham from split hams was 55.59 percent, which was significantly less than percentages of sliceable meat from canned pear-shaped and from precooked boned rolled hams, and was significantly greater than sliceable yields from bone-in style hams. The percentage of lean scrap from split hams was significantly more than that from canned pear-shaped hams and was significantly less than the amount of lean scrap from precooked skinless shankless hams. Total cooking losses of 27.08 percent were significantly greater than total cooking losses from all other hams in this study.

Canned pear-shaped hams. Canned pear-shaped hams contained significantly more sliceable meat and significantly less lean and fat scrap than other hams and yielded the third least amount of total cooking losses. The highest percentage of sliceable portion, 70.83, and the lowest percentage of lean scrap and fat scrap indicate that canned pear-shaped hams yielded more edible meat than any of the other seven types of ham. Because these percentages were based on trimmed weight, they do not take into consideration the amount of packing gelatin and fat which is purchased with canned pear-shaped hams. An average of at least one pound of gelatin and fat was removed from each canned pear-shaped ham prior to baking. The percentage of total cooking losses from canned pear-shaped hams was 23.12, which was significantly less than total cooking losses from split hams.

Palatability

No statistical differences existed among averages for taste panel evaluations of five styles of ham. Aroma, flavor of lean, flavor of fat, color, tenderness, texture, and juiciness were scored according to a scale of 1 to 7, or unacceptable to excellent (Table 4). Average scores of "fair" were given to all types of ham for aroma, tenderness, juiciness. Scores ranging from "poor" to "fair" described the panel's evaluation of the flavor of lean and fat, color, and texture. Panel members checked descriptive terms which indicated that, although similar scores were given for hams of all styles, in some instances the reasons for the scores varied among styles.

Aroma

Although panel members checked all descriptive terms on the score sheet for the odor of each type of ham, mildness was the most frequently observed characteristic for each type of ham. The odors of several regular bone-in and precooked boned rolled hams were defined as sharp. Strong and foreign odors were detected more often in regular bone-in hams than in other hams. Uncooked boned rolled and canned pear-shaped hams were occasionally faint in odor.

Table 4. Average taste panel scores for 12-14 pound hams.

Factor	Regular bone-in		Skinless shankless		Boned rolled		Split	Canned
	A_1 uncooked	A_2 precooked	B_1 uncooked	B_2 precooked	C_1 uncooked	C_2 precooked	D precooked	E pearshaped
Aroma	4.59	4.50	4.78	4.58	4.54	4.27	4.49	4.27
Lean Flavor	4.39	4.29	4.31	4.06	3.99	3.97	4.13	4.30
Fat Flavor	3.94	3.91	4.16	3.94	4.04	3.71	4.00	3.92
Color	4.36	4.29	4.09	3.89	3.99	4.10	4.23	4.07
Tenderness	4.83	4.60	4.67	4.83	4.29	4.46	4.64	4.30
Texture	4.26	4.37	4.16	3.97	4.01	3.90	4.13	3.90
Juiciness	4.46	4.47	4.07	4.00	3.96	4.01	4.26	4.10

Key to scores:
1 Unacceptable
2 Very poor
3 Poor
4 Fair
5 Good
6 Very good
7 Excellent

Flavor of lean

The flavor of lean ham from five types of ham was predominately salty, according to taste panel evaluations; the other three types of ham were mainly mild or typical in flavor. Precooked regular bone-in and skinless shankless hams, uncooked and precooked boned rolled hams, and canned pear-shaped hams often contained salty-flavored lean. The lean flavor of uncooked regular bone-in hams and uncooked skinless shankless hams was described frequently as typical, and occasionally as mild or salty. Split style hams often contained mild-flavored lean; however, salty flavors were frequently noted.

Flavor of fat

The flavor of fat in six types of ham often tasted typical to panel members; fat from the other two types of ham was often described as salty for one type and rancid for the other. Uncooked and precooked regular bone-in, uncooked skinless shankless, uncooked and precooked boned rolled, and canned pear-shaped hams contained typically-flavored fat. Fat from precooked skinless shankless hams was frequently salty. Split hams often contained rancid fat. Rancidity was also noted several times in fat from regular bone-in, skinless shankless, precooked boned rolled, and canned pear-shaped hams.

Color

The color of all types of ham was frequently mottled and/or irridescent. Mottling was noted more often in bone-in and canned hams than in visking-packed hams. Irridescence, which is caused by refraction of light from fat on the cut surface of the meat (29), was most frequently observed in skinless shankless hams, and was also frequently found in regular bone-in, precooked boned rolled, and split style hams. Hams were generally light to medium pink color.

Tenderness

Tenderness scores for the five styles of ham were based primarily on the number of chews required to completely masticate a standard size sample. Various remarks from the taste panel helped to describe reasons for the scores. Few comments about the tenderness of regular bone-in styles were recorded. Skinless shankless hams were reported as being rubbery, flakey, and gristly. In some instances boned rolled hams were mushy, powdery or rubbery. Rubberiness was the most common description for the tenderness of split hams. Canned pear-shaped hams were often flakey.

Texture

Descriptions of the texture varied considerably among hams within types. Terms used to describe texture included spongy, coarse, stringy, fine, and separation of fiber. Large pockets and/or streaks of fat were found in samples from all types of ham. Slices of visking-packed and canned pear-shaped hams often contained portions which were cut parallel with the muscle fibers.

Juiciness

Taste panel members occasionally remarked that ham samples were either too dry to too wet. Samples from all types of ham were described at least once as being too dry. Slices of visking-packed and canned hams frequently appeared wet and felt slippery to panel members.

Cooking Time and Temperatures

The time required to cook five styles of 12 to 14-pound hams to an internal temperature of 79°C varied considerably among and within types of ham. The internal temperature of the hams continued to rise after removal of the hams from the oven.

The number of minutes per pound required to cook each ham was calculated. Broad ranges in minutes per pound resulted within and among types of ham. The variations substantiate the use of thermometers to determine the doneness of meat. In the interpretation of data from the overall ham project, an attempt will be made to correlate the measurements and cooking times and perhaps a pattern for a new method of predicting cooking time may be developed.

Although all hams remained in the oven until internal ham temperatures were 79°C, temperatures taken one-half hour after removal of the hams from the ovens were higher than 79°C. Final internal temperatures ranged from 80 to 87°C. Internal temperature rises after removing hams from the oven were also reported by previous investigators (1, 8, 36, 47, 50).

SUMMARY

The yield and palatability of five styles of 12 to 14-pound hams were evaluated in this initial phase of a project in which hams in 2-pound weight ranges, from 6 to 22 pounds, will be investigated. Regular bone-in, skinless shankless, boned rolled, splits, and canned pear-shaped hams were prepared and cooked according to a standard procedure. Both uncooked and precooked regular bone-in hams, skinless shankless hams, and boned rolled hams were included, making a total of eight types of hams studied in this phase of the project.

Hams were baked in 325°F ovens to 79°C internal temperature. On the day following the cooking of the hams, sliceable portion, lean scrap, fat scrap, bone, and inedible scrap weights were determined. Fat drippings, nonfat drippings, and volatile losses were also recorded. Seven taste panel members scored slices from each ham for aroma, flavor of lean, flavor of fat, color, tenderness, texture, and juiciness.

Statistical analyses disclosed differences which were attributable to variances among the eight types of ham. Highly significant differences were found for all yield and cooking loss factors except bone, inedible scrap, and skin. Differences in bone weights were significant only at the 5 percent level. Significant differences in the percentages of sliceable meat placed the hams into groupings according to styles of ham. Canned pear-shaped hams produced more sliceable meat, 70.83 percent of the uncooked trimmed ham, than all other hams.

Visking-packed boned rolled and split style hams yielded significantly greater amounts of sliceable meat than did regular bone-in or skinless shankless hams. The least average amount of sliceable ham, 40.52 percent, was from uncooked regular bone-in hams. Precooked hams yielded higher averages of sliceable meat than uncooked hams of the same styles; however, the only significant difference between the amount of sliceable meat from precooked and uncooked hams was in regular bone-in style hams.

Canned pear-shaped hams yielded significantly less lean and fat scrap, 3.88 percent and 2.17 percent, than all other hams; otherwise significant differences in scrap meat did not form clear-cut patterns according to styles or between uncooked and precooked hams. Uncooked skinless shankless hams yielded the highest percentage, 16.82, of lean scrap. Uncooked regular bone-in hams yielded 11.81 percent of fat scrap, which was significantly higher than fat scrap from any other type of ham.

Analyses of individual cooking loss factors showed several highly significant differences among styles of ham. The analysis of combined cooking losses, however, revealed only one highly significant difference. Total cooking losses from split style hams were 27.08 percent, and were statistically greater than cooking losses from other hams, except uncooked skinless shankless hams. The least amount of total cooking losses, 22.07 percent, came from precooked regular bone-in hams.

Taste panel scores did not differ significantly among types of ham for any palatability factor. Scores for color, texture, and for the flavor of lean and fat averaged fair to poor. Average scores of fair were given for aroma, tenderness, and juiciness.

Cooking time and temperature data were collected but were not statistically analyzed for this portion of the project. Examination of the data showed that the time required to cook 12 to 14-pound hams to 79°C internal temperature and the rise in temperature after the hams were removed from the oven varied greatly among and within types of ham.

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APPENDIX

Appendix A. Studies on cooking methods, temperatures, and yields of hams.

Year and Investigator	Weight lbs.	Cure	Style	Cooking Method	Cooking Medium °F
1925 Rountree (47)	12-13	dry	bone-in	Roasted (covered, 1 cup water) boiled, then roasted	350 195 250
1926 Purdy (42)	-	dry	bone-in	boiled	180
1927 McElhinney (36)	16-20	dry	bone-in	seared 30 min. then roasted	300 257
1928 Gillaspie (24)	-	dry	-	boiled	180
1929 Burgoin (8)	14-16	dry	bone-in	seared 30 min., then roasted (1 cup water)	300* 257*
	16-18	dry	bone-in	"	257*
	18-20	dry	bone-in	"	257*
1939 Staggs (50)	14 ave.	tenderized	bone-in	roasted	250
	14 ave.		bone-in	roasted	300
	14 ave.	"	bone-in	roasted	375
1946 Nat'l. Livestock & Meat Board (38)	-	-	bone-in	roasted	250
	-	-	bone-in	roasted	450
1952 Alexander and Hankins (1)	12.5	dry	bone-in	roasted	257
	10.7	dry	bone-in	boiled	-
	11.4	commercial	bone-in	roasted	257
	11.1	tendered	bone-in	roasted	257
1958 Dawson et al (11)	31 total	commercial	BRT	roasted	325-350
	4 "	"	bone-in	roasted	325
	25 "	"	bone-in	simmered	-
	733 "	"	bone-in	parboiled, boiled, then baked	- - 350

*Temperatures were reported in degrees Centrigrade
**Temperatures were reported in degrees Fahrenheit

Appendix A. (continued)

Internal Temperature °C	Post-cooking Temperature rise °C	Minutes per lb.	Total Cooking Loss %	Edible Total %	Yield Sliceable %
--	--	--	--	--	--
70	5	--	20-36	--	--
--	--	30	--	--	--
70	--	--	--	--	--
70	--	--	--	--	--
--	--	--	--	--	--
70	7	13.7	26.5	--	48.5
70	--	--	--	--	--
--	--	--	--	--	--
70	4.9	18.9	25.2	--	51.0
70	5.5	18.1	23.9	--	47.8
70	5.6	16.6	29.1	--	46.7
70	3.2	23.7	15.1	--	--
70	5.0	17.5	21.1	--	65.8
70	6.8	14.7	27.7	--	--
66**	--	--	13	--	--
66**	--	--	30	--	--
76	3	26	26	--	--
76	10	22	32	--	--
76	3	39	22.35	--	--
76	3	32	21.36	--	--
77**	--	--	--	62	--
--	--	--	--	46	--
--	--	--	--	55	--
--	--	--	--	--	--
--	--	--	--	--	--
--	--	--	--	50	--

APPENDIX B. Sample score card.

SCORE CARD FOR HAM

Sample No. ______

Judge ______
Date ______

FACTOR	7 Excellent	6 Very Good	5 Good	4 Fair	3 Poor	2 Very Poor	1 Unacceptable	CHECK MOST DESCRIPTIVE
AROMA								___ mild ___ sharp ___ strong ___ faint ___ foreign
FLAVOR (lean)								___ mild ___ salty ___ typical ___ "old" ___ foreign ___ strong Other ______
FLAVOR (fat)								___ mild ___ salty ___ typical ___ rancid Other ___ ___ foreign
COLOR (lean)								___ light pink ___ medium pink ___ dark ___ mottled ___ irridescent
TENDERNESS								___ cut with fork ___ connective tissue ___ chewy Number of chews ___
TEXTURE								___ spongy ___ coarse & stringy ___ fine ___ separation of fiber
JUICINESS								

REMARKS

YIELD AND PALATABILITY OF FIVE STYLES OF MILD CURED HAMS IN THE 12 to 14-POUND WEIGHT RANGE

By

Doris M. Downs

AN ABSTRACT

Submitted to the Dean of the College of Home Economics
of Michigan State University of Agriculture and
Applied Science in partial fulfillment of
the requirements for the degree of

MASTER OF SCIENCE

Department of Institution Administration

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Approved by Pearl J. Aldrich

ABSTRACT

The yield and palatability of five styles of mild cured hams were investigated as the initial phase of a larger project. Regular bone-in, skinless shankless, boned rolled, splits, and canned pear-shaped hams were baked in 325°F ovens to internal temperatures of 79°C. All styles of hams except splits and canned pear-shaped hams were available in both precooked and uncooked states, making a total of eight types of ham in the study.

Highly significant differences were found among types of ham for percentages of sliceable portion, lean scrap, fat scrap, fat drip, nonfat drip, volatile loss, and total cooking losses. Percentages of bones from regular bone-in and skinless shankless styles differed at the 5 percent level of significance. Inedible scrap and skin weights were not significantly different. Canned pear-shaped hams yielded the most sliceable portion and the least scrap meat; bone-in styles yielded the least sliceable portions and relatively high percentages of scrap meat.

Taste panel evaluations indicated that the palatability of hams was not significantly influenced by ham styles. Average scores for aroma, flavor of fat, flavor of lean, color, texture, tenderness, and juiciness were fair to poor.

Considerable variation was noted in the cooking periods and internal temperature rise after the baked hams were removed from the ovens.