December 6, 1960

To the Graduate Council:

I am submitting herewith a thesis written by James W. Bond, III entitled "Palatability of Ham as Affected by Methods of Curing, Curing Time and Aging Temperature." I recommend that it be accepted for nine quarter hours of credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Animal Husbandry.

J. R. Cobb
Major Professor

We have read this thesis
and recommend its acceptance:

Charles S. Hobbs

F. W. Sievers, Jr.

Accepted for the Council:

V. E. Spivey
Acting Dean of the Graduate School

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PALATABILITY OF HAMS AS AFFECTED BY METHODS OF CURING, CURING TIME AND AGING TEMPERATURE

A Thesis

Presented to

the Graduate Council of

The University of Tennessee

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

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by

James W. Bond, III

December 1960

ACKNOWLEDGMENT

The writer wishes to express his sincere appreciation to Professor J. W. Cole for his patient guidance and technical assistance in carrying out the work on which this study is based and for his assistance in preparing the manuscript.

The writer is indebted to Dr. R. J. Cooper for advising on the statistical analysis, Mr. R. N. Terrell for conducting chemical sodium chloride analyses and Mrs. Kathleen McCook for preparing samples for organoleptic tests.

In addition, acknowledgment is made to Dr. C. S. Hobbs, Dr. G. W. Wiegers, and Dr. C. B. Ramsey who have critically read and aided in the revision of parts of this thesis.

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CHAPTER I

INTRODUCTION

An increased demand for country ham in recent years has created a definite interest in the production of dry-cured aged hams. The salty tang and outstanding flavor of aged hams have increased their popularity at a time when mild cured packer style hams have been available at a lower price. Dry-cured aged hams have also gained in popularity during a time when the almost universal availability of refrigerated storage makes the curing of meat for preserving without refrigeration no longer of such prime importance.

Many roadside markets in Tennessee and other southern states are selling dry-cured, aged country hams as a speciality item. The curing of such hams has become so much an art and tradition in some families that recipes for curing have been handed down from generation to generation.

Curing methods now used by different people vary greatly, resulting in a large variation in ham quality. Factual information is needed to develop methods of curing and aging that can be used to produce more uniform high quality aged hams.

The principal object of the process of curing hams is to preserve them by preventing or reducing the action of undesirable microorganisms. However, in addition to this function, the curing agents should contribute to a higher quality meat product as shown by its flavor, juiciness, tenderness, and saltiness. More adequate information is needed on the amounts, application, and role of the curing ingredients.

Stitching, which is the forced introduction of brine into a ham by means of a ham syringe, is used quite often in commercial packing plants. According to Skelley (1960), the primary purpose of stitching hams is to hasten the introduction of curing ingredients into all of the cell tissues to eliminate spoilage, reduce shrinkage, and reduce curing time. Indications are that stitching hams before placing them in dry-cure would hasten the introduction of salt into the center portion. This seems to point out a need for research concerning stitching and its value in curing "farm-style" hams.

The methods for determining ham quality are mostly subjective palatability factors, although saltiness can be determined quite accurately by chemical analysis.

This study was designed primarily to determine:

1. The effect of storage temperature on the palatability of aged hams.

2. The optimum length of time for curing of aged hams.

3. The effects of "stitching" hams before dry curing.

4. The palatability effects of using six pounds of salt as compared to eight pounds of salt per one hundred pounds in curing aged hams.

5. The salt equalization pattern in hams after curing and after thirty days of aging.

CHAPTER II

REVIEW OF LITERATURE

All methods of preserving meat are directed toward keeping away undesirable external factors favoring the development of putrefactive bacteria, according to Edelmann (1939). This is accomplished by physical or chemical agents and methods, or by combinations of these.

Most good meat-curing mixtures should contain salt, sugar, and saltpeter, according to Helser (1929) and Warner (1938). The amount of curing mixture to apply per pound of fresh ham to produce a mild-flavored cured ham, according to Ziegler and Miller (1938), is one to one and one-fourth ounces of a 8:3:3 mixture per pound of ham. This should be applied in three rubbings and the hams left in cure a minimum of seven days per inch of thickness through the aitchbone.

The preservative action of salt forms the basis of one of the oldest methods of preserving meat. Salt is also the most common and the most important of all the ingredients used in curing meat products as described by Tomhave (1925). It shrinks the meat and is also a strong preservative which helps prevent the growth of undesirable bacteria which commonly have access to meat.

Miller and Ziegler (1936) stated that the main function of salt is as a preservative to prevent or reduce the action of microorganisms which might cause spoilage in the meat, but that it also contributes greatly to the palatability of the meat. The amount of salt present should be sufficient to exert the required preserving action but should not be so excessive that it impairs the palatability of the product. Other things being equal, the effectiveness of salt in preventing bacterial action depends largely on the temperature at which the curing process is conducted. It was shown in this study that salt in hams cured by dry-cure or brine-cure did not become well distributed throughout the meat until approximately sixty days after the beginning of the curing period. Salt equalization begins in dry-cured hams as soon as the last portion of curing mixture is applied to the meat. In brine curing, salt equalization is accomplished by absorption of salt from the brine until the meat is removed from it. Thereafter, salt equalization alone takes place. In all curing methods used, the aging of hams for thirty days after their removal from the cure permitted further equalization of the salt and gave a product of more uniform salt content.

Dunker and Hankins (1951) conducted a survey of 1300 farmers and found there were four distinct methods of curing meat: dry-cure with no previous pumping of the

meat, brine-cure with no pumping, brine-cure with previous pumping, and dry-cure with previous pumping. The curing agents used were salt only; a mixture containing various combinations of salt, pepper, and saltpeter; and a commercially prepared mixture. It was found that 80 per cent of the farmers dry-cured meat and about 50 per cent used salt as the only curing ingredient. The average temperature for the different types of curing was between 35° and 41° F.

Ziegler and Miller (1942) reported that sharp frozen hams or hams frozen in freezer lockers at 0° F. to -10° F. and held in storage for one to eight weeks were cured in three days less time per inch of thickness or one-half day less per pound of ham than unfrozen hams. Pumping of the hams reduced the curing time as much as one day per inch. Although freezing after pumping shortened the curing time, it also produced hams that were less tender than hams receiving other treatments. They concluded that the primary purpose of brine-curing was to hasten introduction of salt into the cell tissues and to reduce shrinkage.

It was shown by Miller and Ziegler (1936, 1939) and Ziegler and Miller (1938) that the weight and thickness of the ham are important factors in the length of time necessary for salt equalization. Blumer et al. (1952) found that the rate of salt distribution was affected by the weight of ham, salt absorbed, and the distribution of fat.

The salt absorbed per pound of ham was essentially independent of the size of ham and age of the hog. There was a significant negative correlation, however, between the salt absorbed per pound of ham and fatness of the ham. The rate at which the salt equalized was conditioned by weight of ham, fat content of the ham, and salt absorbed.

According to Miller and Ziegler (1936a) and Ziegler and Miller (1938), the concentration of salt in the outside inch of ham is at least ten times as great as it is in the center at the time they are removed from the cure. They further observed that the temperature at which salt was effective in preventing bacterial action (36° to 40° F.) also permitted rapid uptake of cure. In other work salt did not penetrate regular hams as rapidly as it did skinned hams due to the heavier fat covering on the regular hams. It was found that the major salt movement takes place from the cushion side of the ham.

According to Callow (1947) the absorption of salt into fatty tissue is simple, while absorption into muscle tissue is complex. This is explained by the fact that muscle fibers are filled with fluid immediately after death of an animal, and absorption of salt into these fibers is slow until the glycogen in the fibers is converted to lactic acid causing them to give off fluid.

Moulton (1929) outlined a method for determining salt distribution in hams. According to this method, a one-inch cross-section slice is taken from the hams directly behind the aitchbone, and from the center of this slice a strip extending from the face to the skin and adjacent to the femur is removed and divided into five horizontal sections. Using this method Moulton (1932) presented data indicating the salt distribution in partly cured and fully cured hams before and after smoking. Barnicoat (1929), Miller and Ziegler (1936, 1939), and Ziegler and Miller (1938) used a similar sampling technique.

Beasley and Carroll (1942) reported a considerable amount of variation in salt content between muscle segments in the same slice. They suggested that the failure of salt to penetrate in sufficient quantity into certain muscles in hams may be largely responsible for the development of spoilage in these areas provided the spoilage organisms are present. McBryde (1911) and Beasley and Carroll (1942) agreed that sour and sound hams did not differ in chemical analysis and salt distribution.

Sugar is added to curing mixtures primarily to aid in the development of proper color as shown by Jensen (1935). According to Lewis (1937) and Tomhave (1925), sugar is also added for the purpose of reducing the hardening effect caused by the action of salt, and thus

allowing meat to retain its normal texture. They also stated that sugar does not impart a sweet flavor to cured hams. Moulton (1929) and Warner (1938) stated that a more desirable flavor develops when sugar is added to the curing mixture. Jensen (1942) concluded that the use of sugar in a curing mixture provides a good food for bacteria, limiting the deteriorative action of the bacteria on the meat itself.

Brady et al. (1949) reported that sucrose in the curing mixture had no over-all effect on the aged, long-cured country style hams, from either a chemical or a taste standpoint. Sugar, when added to a curing mixture, seems to have its greatest effect at the beginning of the storage period. However, its effects diminish as the aging period progresses. These observations also indicated that the final flavor of sugar is masked by the presence of stronger flavor components.

In the book Pork Operations (1936) it was reported that nitrite and nitrate, although used primarily to fix color, have some effect on flavor. If excessive quantities of nitrate or nitrite are used, the flavor of the product is distinctly impaired.

Jensen (1949) listed several desirable effects which may be obtained from smoking cured meat. Some of these are: (1) drying effect, (2) imparting desirable

organoleptic properties, (3) bringing out the color inside the cured meat, (4) imparting antioxidants to the fat, (5) impregnating the outside portions of the meat with smoke which has antiseptic and germicidal properties, (6) retarding action on microorganisms at temperatures above 120° F., (7) a tenderizing action from increased activity of the autolytic enzymes of the meat and the humidity of the smokehouse, and (8) imparting a desirable gloss to the smoked meat.

Bedenbaugh and Richmond (1951) studied the keeping qualities and flavor of two groups of country dry-cured hams smoked at different temperatures. All hams were smoked for twenty-four to thirty-six hours. The first group was smoked at 110° F. The second group was smoked at 125° F. for the first eight hours, 135° F. for the second eight hours and 150° F. for the third eight hours. Half of these hams were stored at 40° F. while the other half were stored at normal room temperatures. Both groups were aged for 140 days. All hams were sound after the aging period and a taste panel concluded that the hams smoked at temperatures under 110° F. and stored under natural conditions were most desirable.

Moody (1957), studying the effects of not smoking and smoking at different temperatures on the quality of hams, found that higher smoking temperatures increased the

tenderness of hams. He also reported that, after six months aging at 65° F. with a relative humidity of 55 per cent, hams smoked to internal temperatures of 125° F. or above developed green and deteriorated spots. These hams had undesirable light red or pink colored lean and did not have the characteristic "old-ham" odor.

Fields et al. (1955) conducted a study to provide data on the composition, nutritive value, and the effects of storage on hams dry-cured with salt only. The hams were cured, smoked, and stored at 40°, 70°, and 90° F. for periods of six weeks, six months, and twelve months. The data showed that, on storage, loss of moisture due to temperature differences occurred more slowly at 40° F. than at 70° or 90° F. Hams stored at 40° F. aged slightly during twelve months storage. Those stored at 70° F. deteriorated appreciably on storage of six months or longer, while those stored at 90° F. were scored undesirable after six months storage.

In an attempt to find means of controlling conditions responsible for the production of aged hams of superior quality, Hunt et al. (1939) used specially controlled incubators for aging hams. The incubator temperatures ranged from 91° F. to 126° F. Hams aged with the temperature maintained at 108° F. for ten to twelve weeks had less shrinkage and the trimming losses were very slight.

They were of good quality and comparable in chemical composition to hams stored a year or longer at ordinary room temperatures. The salt concentration increased from approximately 6 per cent in dry-cured hams after one month aging to 8 to 10 per cent after one to two years of aging. Brine-cured hams aged for nine weeks at 108° F. had a higher salt content and a drier appearance than did dry-cured hams.

Cecil and Woodroof (1954) conducted a study to compare rates of aging as indicated by weight losses, concentration of salt in the center lean, development of yellow color in the fat and red color in the lean, toughening of the muscle tissues, rancidification of the fat, and development of typical aged flavors. In this study country style hams that had been stored at 0°, 33°, 50°, 68°, and 86° F. were examined at intervals of three months for one year. It was shown that these factors, which are representative of the changes which accompany aging, were proportional to both time and temperature of storage at 50° F. or above. Hams aged at 86° F. were fully aged, and those aged at 50° F. were moderately aged at the end of one year. Hams stored at 33° F. aged slightly during the first six months, remained relatively unchanged during the next three months, and then lost desirable color and flavor during the next or last three months of aging.

Blumer (1954), in a study using dry-cured hams sampled and tested after one, six, and twelve months storage, found that flavor and saltiness as scored by a taste panel increased with each sampling period. Kemp et al. (1957) found that dry-cured hams aged at 70° F. were slightly deteriorated after six months of aging.

Fields and Dunker (1952) conclude that different curing procedures affect the chemical composition of the cured product. Some of these factors are concentration of curing solution, dehydration resulting from high and lengthy smoking temperatures, long aging periods and enzymatic action.

CHAPTER III

PROCEDURE

Seventy-two hams used in this study were obtained from Yorkshire, Duroc, and Hampshire hogs which came from the Swine Testing Station at the University of Tennessee, Blount Farm. These hogs were fed under similar environmental conditions and received the same rations. They were slaughtered when their weights reached 200 ± 5 pounds. After slaughter the carcasses received a twenty-four hour chill in a thermostatically controlled 36° F. cooler before being fabricated into wholesale cuts. One packer style ham and one country style ham were obtained from each carcass. The packer style hams were removed between the second and third sacral vertebra, counting from the lumbo-sacral joint, and at right angles to the leg line. These hams were skinned leaving about three-eighths of an inch of external fat and a collar of skin amounting to 35 per cent of the length of the ham. The country style hams were removed between the last two lumbar vertebra at right angles to the back line. These hams were trimmed but not skinned. The feet were removed from the hams by sawing just below the hock joint without exposing the marrow.

This study used twenty-four packer style hams ranging in weight from 12 to 15 pounds and forty-eight

country style hams ranging in weight from 16 to 19 pounds. A period of seventy-five days was required to secure this group of hams.

After removing each ham from the carcass, it was weighed and numbered. The hams were rubbed with one-third of their respective curing mixture and placed for curing on shelves one layer deep, skin-side down, in a cure room at 40° ± 3° F. Ingredients of the curing mixtures were weighed and thoroughly mixed. They were then applied in three equal applications at five day intervals on the first, fifth, and tenth day of curing.

Half of the hams used in this study were stitched with a brine solution before being placed in the dry-cure,* and half of the hams were dry-cured without brine. The stitched hams received six ounces of an 80 per cent brine solution inserted with a ham syringe in the following locations: (1) center of butt-end parallel to the external surface; (2) at right angle to the surface of the ham through the obturator foramen; and (3) beside the tibia and fibula in the hock.

Both stitched and dry-cured hams were separated into three, four, and five week curing periods, and each curing period was sub-divided so that two curing mixtures could be

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*These hams hereafter will be referred to as stitched.

used. Half of the hams received a curing mixture containing eight pounds of salt, two pounds of brown sugar, 22.6 grams of sodium nitrate and 11.3 grams of sodium nitrite per 100 pounds of hams. The other half of the hams received a curing mixture containing six pounds of salt, two pounds of brown sugar, 22.6 grams of sodium nitrate and 11.3 grams of sodium nitrite per 100 pounds of hams. Each treatment contained two packer style and four country style hams. The treatment diagram is shown in Table I.

At the end of the curing period, the hams were brushed to remove excess salt and then soaked for two hours in a bath of lukewarm water in order to remove the surface salt. The hams were then placed in stockinet and hung hock down in the smoke room to dry for two hours before smoking.

A gas-fired smoker was used which generated the smoke by burning hickory sawdust. The hams were smoked for forty hours at a temperature of 115° F.

Immediately after smoking, the hams were subdivided again. Half of the hams in each treatment were aged in a thermostatically controlled 36° F. cooler, and the other half were aged in a well ventilated room that ranged in temperature from 60° to 90° F. with a relative humidity of 30 to 60 per cent. This room was enclosed

TABLE I

HAM TREATMENT DIAGRAM

Curing method	Pounds of salt per 100 pounds of ham	Weeks in cure		
		3	4	5
		Number of hams		
Stitched[a]	6	6	6	6
	8	6	6	6
Dry-cure alone	6	6	6	6
	8	6	6	6

[a]Stitched - refers to hams stitched with a brine solution before dry-curing.

with screen wire covered with cheese cloth to exclude insects.

Twenty-four of the country style hams were used for salt analyses. These twenty-four hams represented each cure period, cure mixture, type of cure, and aging temperature, as shown in Table II.

The first slice for salt analysis was taken just after the hams were removed from cure and before they were soaked. This one-half inch slice was cut posterior to the aitchbone and at a 90° angle to the femur. A second slice, one inch below the first, was taken thirty days later after the hams had been smoked. It was also one-half inch thick, and was taken one inch from the first one, moving toward the shank. After each slice was removed it was wrapped in freezer paper, numbered, and frozen until all samples were secured.

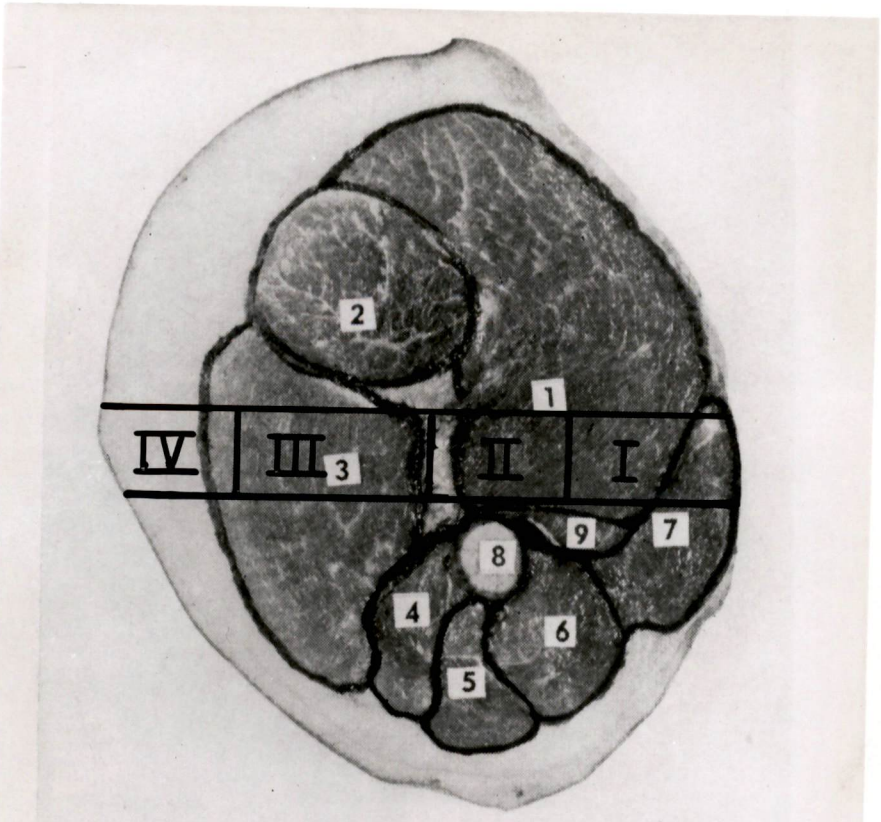
After all samples were secured, each slice was sampled for salt analysis by taking a center strip adjacent to the femur one inch wide and as long as the ham was thick. Each strip was divided into four sections which were numbered one through four from top to bottom, as shown in Figure 1. These sections collectively contained gracilis, semi-membranosus, and biceps femoris muscles and an external fat layer. Two adjacent samples from each section were analyzed according to the A.O.A.C. method

TABLE II

TREATMENT DESIGN FOR SALT ANALYSES

Curing method	Pounds of salt per 100 pounds of ham	Aging temperature	Weeks in cure		
			3	4	5
			Number of hams		
Stitched	6	36° F.	1	1	1
	6	R.T.[a]	1	1	1
	8	36° F.	1	1	1
	8	R.T.	1	1	1
Dry-cure alone	6	36° F.	1	1	1
	6	R.T.	1	1	1
	8	36° F.	1	1	1
	8	R.T.	1	1	1

[a]R.T. - room temperature.



1. semimembranosus
2. semitendinosus
3. biceps femoris
4. vastus lateralis
5. rectus femoris and vastus intermedius
6. vastus medialis
7. gracilis
8. femur
9. adductor

FIGURE 1

CROSS SECTIONAL HAM SLICE DEPICTING MUSCLE NOMENCLATURE AND SAMPLE LOCATIONS USED FOR SALT ANALYSIS

(1955). Each sample was allowed to thaw and reach room temperature before weighing. After weighing the samples were dried in a vacuum oven at 100° C. overnight and re-weighed. A 2.5 to 3-gram sample was then placed in a 300 milliliter flask and moistened with 5 milliliters of 0.5 normal $AgNO_3$. Fifteen milliliters of HNO_3 were then added and the samples were boiled until the meat was digested. Concentrated $KmNO_4$ was then added in small portions, boiling after each addition until the $KmNO_4$ color disappeared and the solutions remained colorless or nearly so. Next, 25 milliliters of water were added and the solution boiled five minutes, cooled, and diluted to approximately 150 milliliters with distilled water after which 25 milliliters of ether were added and the flask shaken. The solution then was titrated with 0.1 normal NH_4SCN until a permanent light brown color appeared. $FeNH_4(SO_4)_2$ was used as the indicator. The NaCl content was determined by subtracting the milliliters of 0.1 normal NH_4SCN used to titrate from the milliliters of 0.5 normal $AgNO_3$ added. The NaCl content was then adjusted for sample size.

A slice from one packer style and one country style dry-cured ham of each treatment was broiled for scoring by a trained taste panel. Plans were made for broiling slices from the stitched hams also, but deteriorated spots in 95 per cent of them at two months of aging prevented the

further use of these hams.

The taste panel was conducted by the Food Research Section of the College of Home Economics. Four one-half inch slices from hams of four different treatments were used for each of the eighteen taste panels.

The slices at two months of aging were taken adjacent and parallel to the long axis of the aitchbone on the shank side. The slices at four and six months of aging were cut at the same angle moving toward the hock. A three-fourths inch slice of deteriorated ham was discarded before taking both the four and six month taste panel slices.

After each slice was obtained, it was numbered and taken to the food research laboratory. In preparation for broiling the temperature of the slices was standardized to 72° F. The external fat was trimmed to a thickness of one-half inch and scored at one-half inch intervals to prevent the slice from curling during broiling. Each slice was placed on a broiling rack and weighed, and a thermometer was inserted in the slice for determining the internal temperature.

The slices were placed in an oven preheated to 425° F. and broiled until the internal temperature reached 138° F. They were then turned and broiled until the internal temperature reached 184° F. After broiling they were

removed from the oven and allowed to cool to 171° F. and then weighed to determine atmospheric and drip losses.

Immediately after broiling, six one-half inch cores were taken from each slice and scored for tenderness on the Warner Bratzler Shear. These cores were numbered from one through six. Cores one and two came from the semimembranosus muscle, core three from the semitendinosus muscle, cores four and five from the biceps femoris muscle and core six from the vastus medialis muscle.

Next the slices were divided by muscles for the six taste panel members, each panel member receiving the same muscle or portion of muscle at each testing. The samples were identified with code numbers and served on plates to the members of the panel. Each panel member was provided with a pencil, water, and a rating sheet for indicating individual preferences.

The four palatability factors of flavor of fat, flavor of lean, tenderness, and juiciness were scored by the tasters on a nine point rating sheet ranging from like extremely to dislike extremely using different adjectives to describe each point.

Analyses of variance as described by Snedecor (1958) were used to determine differences which were significant at the 95 or 99 per cent probability level.

CHAPTER IV

RESULTS AND DISCUSSION

Seventy-two hams used in this study were obtained from swine testing station barrows. The slaughter weight ranged from 195 to 205 pounds. The hogs were of similar type and were raised under quite similar environmental conditions. Eighty per cent of the carcasses graded U.S. No. 1 and 20 per cent U.S. No. 2. Standard slaughter and processing procedures were used.

Half of this group of hams were stitched in three locations with six ounces of an 80 per cent brine solution before being placed in dry-cure. Twelve of these hams were sliced before smoking to secure samples for salt analyses. Slight deterioration was noticed in the muscle seams and areas of needle insertion at the time of slicing. During smoking 60 to 70 per cent of the stitched hams swelled, became soft in the cushion area, and developed undesirable odors. After two months of aging the remaining stitched hams were sliced. At this time 95 per cent of the hams were considered unfit for testing by the taste panel. The hams stored at room temperature had deteriorated more severely than the hams stored at 36° F. No palatability data were collected for stitched hams because of this deterioration.

This discussion is limited to means and interactions that are significantly different at the 95 per cent level or above. Individual mean scores for each factor tested are in the Appendix.

Sodium chloride content at four locations (Figure 1) in the twelve stitched and twelve dry-cured hams was determined after curing and after thirty days of aging. In analyzing this study differences between aging at cooler and room temperature were disregarded. This allowed two hams each treatment in the analysis instead of one. In the discussion of sodium chloride analysis, the terms "sodium chloride" and "salt" are used interchangeably.

Table IV contains saltiness mean squares showing both significant and non-significant treatment effects and treatment interactions.

TABLE III

RELATIONSHIP OF MEAN SALT CONTENT PERCENTAGES TO DAYS OF AGING AND SAMPLE LOCATIONS

Days aging		Location I	II	III	IV	Mean[a]
0		6.77	3.76	2.30	1.62	3.61
30		5.79	5.38	3.67	1.72	4.15
	Mean[b]	6.28	4.57	2.98	1.67	

[a]Differences in aging periods were significant at the 99 per cent level.

[b]Differences in sample locations were significant at the 99 per cent level. The interaction between aging and locations was significant at the 99 per cent level (Table IV).

TABLE IV

ANALYSIS OF VARIANCE FOR VARIOUS TREATMENT EFFECTS ON SODIUM CHLORIDE CONTENT

Source of variation	Degrees of freedom	Mean squares
Total	192	
Aging (0 vs. 30 days)	1	13.56**
Curing (3, 4, 5 weeks)	2	27.66**
Method (Stitching vs. Dry-cure)	1	3.52
Salt (6 vs. 8 pounds per 100 pounds of hams)	1	5.20
Location (Sample I, II, III, IV)	3	190.40**
Aging x Salt	1	19.20**
Aging x Location	3	17.44**
Curing x Method	2	2.82
Curing x Salt	2	4.89*
Curing x Location	6	2.32
Salt x Location	3	2.14
Aging x Curing x Method	2	6.70*
Aging x Salt x Location	3	1.66
Curing x Method x Location	6	3.16*
Aging x Curing x Method x Salt	2	2.76
Aging x Curing x Salt x Location	6	2.44
All other interactions	51	.73
Error	96	1.49

**Denotes significance at 99 per cent level.

*Denotes significance at 95 per cent level.

The total percentage salt varied from 3.61 per cent to 4.15 during the first thirty days of aging (Table III). A significantly higher percentage salt on a dry matter basis at thirty days of aging was attributed to different equalization patterns in the hams.

Ziegler and Miller (1939) found that with hams cured twenty-six to forty-two days an additional aging period of 30 days after curing gave a product in which the salt was well distributed. The data from our study show that more equalization had taken place at thirty days of aging than at the end of the curing period, however, maximum salt equalization had not been reached at thirty days. Apparently the highly significant interaction between aging and location was caused by more complete salt equalization in the hams after aging thirty days (Table III).

TABLE V

RELATIONSHIP OF MEAN SALT CONTENT PERCENTAGES TO POUNDS OF SALT AND WEEKS IN CURE

Pounds of salt per 100 pounds of hams	Weeks in cure			
	3	4	5	Mean[a]
6	3.17	3.68	4.29	3.71
8	3.77	3.37	4.98	4.04
Mean[b]	3.47	3.52	4.63	

[a]Differences in six and eight pounds of salt were not significant at the 95 per cent level.

[b]Differences in weeks in cure were significant at the 99 per cent level. The interaction between pounds of salt and weeks in cure was significant at the 95 per cent level (Table IV).

As shown in Table V, there is a trend for an increase in percentage salt in hams as weeks in cure increase. Also, a higher but non-significant percentage of salt is present in hams receiving eight pounds of salt than hams receiving six pounds of salt in the cure mixture. A deviation in the trend is shown by 3.37 per cent salt at four weeks in cure using eight pounds of salt in the mixture. This deviation, possibly caused by sampling procedure, is primarily responsible for the significant interaction between curing time and pounds of salt. Differences between salt contents at three and four weeks in cure were small, however, differences between salt contents at four and five weeks in cure were much higher.

At the end of each of the three curing periods, hams cured with six pounds of salt per 100 pounds of hams contained an average of 3.13 per cent salt, while hams cured with eight pounds of salt per 100 pounds of hams contained an average of 4.09 per cent salt. After thirty days of aging the hams receiving six pounds of salt in the mixture contained an average of 4.29 per cent as compared to an average of 4.00 per cent for hams receiving eight pounds of salt in the mixture. In this case the interaction was obviously brought about by an increase in salt content during aging of hams receiving six pounds of salt compared to no increase in the hams receiving eight

pounds of salt. This probably was affected by sampling procedure.

No significant difference in salt content was found between stitched and dry-cured hams (Table IV). The average percentage salt for stitched hams was 3.74 as compared to 4.01 for dry-cured hams.

TABLE VI

RELATIONSHIP OF MEAN SALT CONTENT PERCENTAGES TO DAYS OF AGING, METHOD OF CURING, AND WEEKS IN CURE[a]

Weeks in cure	Zero days aging		Thirty days aging	
	Stitched	Dry-cure	Stitched	Dry-cure
3	2.40	3.84	3.90	3.75
4	3.26	3.15	3.44	4.24
5	4.65	4.26	4.79	4.73

[a]The interaction between days of aging, method of curing, and weeks in cure was significant at the 95 per cent level (Table IV).

Stitched hams remaining in cure for three weeks contained an average of 2.40 per cent salt, and dry-cured hams remaining in cure for four weeks contained an average of 3.15 per cent salt at the beginning of the aging period. These low salt percentages along with other variations in trends as shown in Table VI cause a significant interaction among aging time, curing method and curing time.

TABLE VII

RELATIONSHIP OF MEAN SALT CONTENT PERCENTAGES TO WEEKS IN CURE, METHOD OF CURING, AND SAMPLE LOCATION[a]

Weeks in cure	Method used	Location			
		I	II	III	IV
3	Dry-cure	6.30	4.21	3.28	1.40
	Stitched	4.96	3.83	2.41	1.39
4	Dry-cure	6.25	4.57	2.44	1.50
	Stitched	6.64	3.38	2.16	1.23
5	Dry-cure	6.03	5.51	3.85	2.78
	Stitched	7.48	5.91	3.78	1.73

[a]The interaction between weeks in cure, method of curing, and sample location was significant at the 95 per cent level (Table IV).

The significant interaction between curing time, curing method, and sample location probably was brought about by different penetration patterns and their effects on per cent salt in various sample locations (Table VII). No particular trend was noticed in this three way interaction.

Taste panels were conducted at two, four, and six months of aging on the two dry-cured hams from each treatment. Each ham slice was trimmed to a standard fat thickness before broiling. Evaporation, dripping, and total cooking losses were obtained.

According to Table VIII, highly significant

TABLE VIII

ANALYSIS OF VARIANCE FOR EVAPORATION LOSSES DURING BROILING

Source of variation	Degrees of freedom	Mean squares
Total	72	
Temperature (Room vs. 36° F.)	1	82.77**
Salt (6 vs. 8 pounds per 100 pounds hams)	1	.32
Curing (3, 4, or 5 weeks)	2	.63
Temperature x salt	1	5.73
Temperature x curing	2	.02
Salt x curing	2	13.44
Temperature x salt x curing	2	1.12
Error A	12	4.76
Aging (2, 4, or 6 months)	2	170.95**
Aging x temperature	2	9.39
Aging x salt	2	1.94
Aging x curing	4	2.97
Aging x temperature x salt	2	.39
Aging x temperature x curing	4	4.38
Aging x salt x curing	4	.19
Aging x temperature x salt x curing	4	1.91
Error B	24	4.37

differences were present between aging temperature and months of aging and the interaction between these two was approaching significance at the 95 per cent level.

TABLE IX

RELATIONSHIP OF MEAN EVAPORATION LOSS PERCENTAGES TO MONTHS OF AGING AND AGING TEMPERATURE

Aging temperature	Two months aging	Four months aging	Six months aging	Mean[a]
Room temperature	10.00	5.20	3.80	6.33
36° F.	10.70	8.10	6.70	8.60
Mean[b]	10.35	6.65	5.25	

[a]Differences in aging temperatures were significant at the 99 per cent level.

Differences in months of aging were significant at the 99 per cent level (Table VIII).

Hams aged at room temperature apparently dehydrated more during aging than hams aged at 36° F. as evidenced by lower evaporation losses during cooking (Table IX). All hams had dehydrated less at two months of aging than at four or six months, respectively. Hams aged at room temperature lost moisture more rapidly between two and six months of aging than hams aged at 36° F. Two, four and six month samples were removed from these hams in May, July, and

September. The higher room temperatures during these months help to explain the greater evaporation losses in these hams.

Table XI containing dripping loss mean squares shows similar treatment differences as evaporation losses (Table VIII)

TABLE X

RELATIONSHIP OF MEAN DRIPPING LOSS PERCENTAGES TO MONTHS OF AGING AND AGING TEMPERATURE

Aging temperature	Two months aging	Four months aging	Six months aging	Mean[a]
Room temperature	9.40	7.00	8.40	8.26
36° F.	6.00	5.40	6.80	6.07
Mean[b]	7.70	6.20	7.60	

[a]Differences in aging temperatures were significant at the 99 per cent level.

[b]Differences in aging periods were significant at the 95 per cent level (Table XI).

Hams aged four months had the lowest average dripping losses (Table X). Since it is assumed that dripping losses are primarily fat, it is probable that variations in fat in the slices helped to prevent definite trends. With dripping losses expressed as percentages, more dehydrated hams can have higher percentage losses without increasing the

TABLE XI

ANALYSIS OF VARIANCE FOR DRIPPING LOSSES DURING BROILING

Source of variation	Degrees of freedom	Mean squares
Total	72	
Temperature (Room vs. 36° F.)	1	86.46**
Salt (6 vs. 8 pounds per 100 pounds of hams)	1	1.83
Curing (3, 4, or 5 weeks)	2	5.72
Temperature x salt	1	5.07
Temperature x curing	2	.94
Salt x curing	2	4.96
Temperature x salt x curing	2	.09
Error A	12	5.05
Aging (2, 4, or 6 months)	2	16.17*
Aging x temperature	2	6.39
Aging x salt	2	.23
Aging x curing	4	4.28
Aging x temperature x salt	2	.13
Aging x temperature x curing	4	6.03
Aging x salt x curing	4	.59
Aging x temperature x salt x curing	4	3.24
Error B	24	3.40

volume of drippings per slice. These data show a significantly greater dripping loss in hams aged at room temperature which probably resulted from these hams being lighter due to greater dehydration as compared to hams stored at 36° F.

TABLE XII

RELATIONSHIP OF MEAN TOTAL COOKING LOSS PERCENTAGES TO MONTHS OF AGING AND AGING TEMPERATURE

Aging temperature	Two months aging	Four months aging	Six months aging	Mean
Room temperature	19.40	12.20	12.20	14.61
36° F.	16.70	13.50	13.50	15.55
Mean	18.05	12.85	12.85	

Hams aged at room temperature and 36° F. had approximately the same cooking losses during broiling with slightly greater losses for hams aged at 36° F. (Table XII). At two months of aging all hams had high evaporation and dripping losses which brought about a greater total loss at this time than at four or six months.

Immediately after broiling, six one-half inch cores were taken from four muscles in each slice and used in determining tenderness on the Warner Bratzler Shear. These six values were averaged to give a tenderness score for each slice. Analysis of variance (Table XIII) was then used to determine significant differences in tenderness.

TABLE XIII

ANALYSIS OF VARIANCE (WARNER BRATZLER SHEAR) TENDERNESS SCORES

Sources of variation	Degrees of freedom	Mean squares
Total	72	
Temperature (Room vs. 36° F.)	1	13,108.50**
Salt (6 vs. 8 pounds per 100 pounds of hams)	1	102.48
Curing (3, 4, or 5 weeks)	2	1,174.87
Temperature x salt	1	415.21
Temperature x curing	2	229.92
Salt x curing	2	80.69
Temperature x salt x curing	2	174.72
Error A	12	655.40
Aging (2, 4, or 6 months)	2	4,379.43**
Aging x temperature	2	4,859.07**
Aging x salt	2	50.02
Aging x curing	4	818.25
Aging x temperature x salt	2	.62
Aging x temperature x curing	4	851.75
Aging x salt x curing	4	35.29
Aging x temperature x salt x curing	4	84.99
Error B	24	324.25

Each palatability factor scored by the taste panel was analyzed separately. An average of six taste panel members' scores was used for analyzing each of the four palatability factors. Taste panel members used a scale of from one to nine, with nine being most desirable. Table XV contains taste panel tenderness mean squares showing both significant and non-significant treatment effects and treatment interactions.

TABLE XIV

RELATIONSHIP OF MEAN WARNER BRATZLER SHEAR AND TASTE PANEL TENDERNESS SCORES TO MONTHS OF AGING AND AGING TEMPERATURE

Aging temperature	Two months aging	Four months aging	Six months aging	Mean[a]
Warner Bratzler Shear				
Room temperature	5.08	6.14	13.52	8.24
36° F.	4.24	3.34	3.67	3.75
Mean[b]	4.66	4.74	8.59	
Taste Panel				
Room temperature	7.28	7.42	5.17	6.62
36° F.	7.32	7.92	7.39	7.54
Mean[b]	7.30	7.67	6.28	

[a]Difference in aging temperatures were significant at the 99 per cent level.

[b]Differences in months of aging were significant at the 99 per cent level. The interactions between months of aging and aging temperatures were significant at the 99 per cent level (Tables XIII and XV).

TABLE XV

ANALYSIS OF VARIANCE (TASTE PANEL) TENDERNESS SCORES

Source of variation	Degrees of freedom	Mean squares
Total	72	
Temperature (Room vs. 36° F.)	1	550.0**
Salt (6 vs. 8 pounds per 100 pounds of hams)	1	0.0
Curing (3, 4, or 5 weeks)	2	81.0
Temperature x salt	1	26.0
Temperature x curing	2	22.5
Salt x curing	2	.5
Temperature x salt x curing	2	26.5
Error	12	21.2
Aging (2, 4, or 6 months)	2	447.5**
Aging x temperature	2	285.5**
Aging x salt	2	3.5
Aging x curing	4	14.0
Aging x temperature x salt	2	5.5
Aging x temperature x curing	4	4.8
Aging x salt x curing	4	3.0
Aging x temperature x salt x curing	4	1.2
Error B	24	5.2

Aging time and aging temperature caused similar tenderness trends when tested by the Warner Bratzler Shear and taste panel members (Table XIV). Hams aged at room temperature scored less tender on both the shear and panel than hams aged at 36° F. The hams aged at room temperature became fairly tough after six months of aging as evidenced by shear and panel scores. A highly significant interaction between months of aging and aging temperature was affected by room temperature hams becoming less tender as they aged while 36° F. hams increased in tenderness up to four months and then remained approximately the same tenderness at six months of aging. Only one slight deviation was present in score trends between taste panel and shear scores. Panel members scored hams aged four months at room temperature more tender than hams aged two months at room temperature. Shear scores indicated opposite results on these same hams, however, these differences were small.

The average shear scores for hams cured three, four, and five weeks were 4.60, 5.92, and 7.47, respectively. These differences were not significant at the 95 per cent level, but compare very favorably with taste panel tenderness scores. The panel members' average scores for three, four, and five weeks of curing were 7.34, 7.16, and 6.74, respectively, with higher scores being more tender. Both

methods of measuring tenderness produced evidence that hams become less tender as the curing period was extended.

Results of analysis of variance for juiciness scores are given in Table XVII.

TABLE XVI

RELATIONSHIP OF MEAN JUICINESS SCORES TO MONTHS OF AGING AND AGING TEMPERATURES

Aging temperature	Two months aging	Four months aging	Six months aging	Mean[a]
Room temperature	7.17	7.14	6.26	6.86
36° F.	7.19	7.18	7.08	7.15
Mean[b]	7.18	7.16	6.67	

[a]Differences in aging temperatures were significant at the 99 per cent level.

[b]Differences in months of aging were significant at the 99 per cent level. The interaction between months of aging and aging temperature was significant at the 99 per cent level (Table XVII).

Hams aged at 36° F. were juicier than hams aged at room temperature (Table XVI), and this difference was highly significant. Juiciness scores decreased as hams aged, although the major decrease came after four months of aging. A sharp decrease was seen in room temperature hams at six months of aging. This rapid decrease effected an interaction between aging and temperature since hams aged at 36° F. did not decrease in juiciness as rapidly.

TABLE XVII

ANALYSIS OF VARIANCE
JUICINESS SCORES

Source of variation	Degrees of freedom	Mean squares
Total	72	
Temperature (Room vs. 36° F.)	1	57.0**
Salt (6 vs. 8 pounds per 100 pounds of ham)	1	5.0
Curing (3, 4, or 5 weeks)	2	22.5
Temperature x salt	1	14.0
Temperature x curing	2	39.0*
Salt x curing	2	22.5
Temperature x salt x curing	2	6.0
Error A	12	6.0
Aging (2, 4, or 6 months)	2	71.0**
Aging x temperature	2	44.5**
Aging x salt	2	3.0
Aging x curing	4	7.2
Aging x temperature x salt	2	5.5
Aging x temperature x curing	4	7.2
Aging x salt x curing	4	5.2
Aging x temperature x salt x curing	4	0.0
Error B	24	3.4

Means (Table XVIII) show that hams cured four weeks were jucier at both room and cooler temperature than hams cured for three or five weeks at these temperatures. Juiciness scores were lowest on room temperature hams cured five weeks while they were lowest on cooler hams cured three weeks. These unexplained trends caused a significant interaction between weeks in cure and aging temperature.

TABLE XVIII

RELATIONSHIP OF MEAN JUICINESS SCORES TO WEEKS IN CURE AND AGING TEMPERATURE[a]

Aging temperature	Three weeks in cure	Four weeks in cure	Five weeks in cure
Room temperature	7.00	7.06	6.51
36° F.	6.89	7.32	7.25
Mean	6.94	7.19	6.88

[a]The interaction between weeks in cure and aging temperature was significant at the 95 per cent level (Table XVII).

Tablex XIX and XX contain mean squares showing significant treatment differences and treatment interactions for flavor of lean and flavor of fat.

TABLE XIX

ANALYSIS OF VARIANCE
FLAVOR OF LEAN

Source of variation	Degrees of freedom	Mean squares
Total	72	
Temperature (Room vs. 36° F.)	1	57.0
Salt (6 vs. 8 pounds per 100 pounds of hams)	1	7.0
Curing (3, 4, or 5 weeks)	2	61.0
Temperature x salt	1	38.0
Temperature x curing	2	6.0
Salt x curing	2	8.5
Temperature x salt x curing	2	12.5
Error A	12	34.58
Aging (2, 4, or 6 months)	2	332.0**
Aging x temperature	2	70.5*
Aging x salt	2	33.5
Aging x curing	4	38.5
Aging x temperature x salt	2	17.0
Aging x temperature x curing	4	24.5
Aging x salt x curing	4	3.7
Aging x temperature x salt x curing	4	11.8
Error B	24	19.04

TABLE XX

ANALYSIS OF VARIANCE
FLAVOR OF FAT

Source of variation	Degrees of freedom	Mean squares
Total	72	
Temperature (Room vs. 36° F.)	1	238.0**
Salt (6 vs. 8 pounds per 100 pounds of hams)	1	28.0
Curing (3, 4, or 5 weeks)	2	63.5*
Temperature x salt	1	15.0
Temperature x curing	2	10.5
Salt x curing	2	4.5
Temperature x salt x curing	2	19.0
Error A	12	9.83
Aging (2, 4, or 6 months)	2	151.5**
Aging x temperature	2	28.5*
Aging x salt	2	24.0
Aging x curing	4	42.7*
Aging x temperature x salt	2	3.0
Aging x temperature x curing	4	32.0*
Aging x salt x curing	4	5.5
Aging x temperature x salt x curing	4	18.0
Error B	24	8.20

TABLE XXI

RELATIONSHIP OF MEAN FLAVOR OF LEAN AND FAT SCORES TO MONTHS OF AGING AND AGING TEMPERATURE

Aging temperature	Two months aging	Four months aging	Six months aging	Mean[a]
Lean				
Room temperature	7.10	7.32	5.68	6.70
36° F.	7.32	7.08	6.58	6.99
Mean[b]	7.21	7.20	6.13	
Fat				
Room temperature	6.99	7.36	6.19	6.85
36° F.	7.58	7.61	7.17	7.45
Mean[b]	7.28	7.48	6.68	

[a]Differences in the aging temperature were significant at the 99 per cent level for flavor of fat only.

Differences in months of aging were significant at the 99 per cent level. The interactions between months of aging and aging temperature were significant at the 95 per cent level (Tables IX and XX).

Flavor of lean and fat scores were highest for hams aged at room temperature at four months of aging (Table XXI). After six months of aging at room temperature, flavor of both fat and lean had decreased greatly corresponding to tenderness and juiciness scores. Hams aged at 36° F. decreased in flavor of lean as they aged, however, they did not decrease in flavor of fat until after four months of aging. In comparing flavor of fat and lean, aging seemed to affect flavor of lean more severely than flavor of fat.

TABLE XXII

RELATIONSHIP OF MEAN FLAVOR OF FAT SCORES TO WEEKS IN CURE AND MONTHS OF AGING[a]

Months aging	Three weeks cure	Four weeks cure	Five weeks cure
2	7.46	7.23	7.17
4	7.20	7.75	7.50
6	6.06	7.35	6.62
Mean	6.91	7.44	7.10

[a]The interaction between weeks of cure and months of aging was significant at the 95 per cent level (Table XX).

Comparing four and five weeks of curing, hams cured four weeks averaged higher on flavor of fat scores than hams cured five weeks (Table XXII). Hams cured for three weeks averaged highest only at two months of aging. This rapid decrease in flavor most likely brought about the significant curing times aging interaction. Flavor of lean mean scores for hams cured three, four, and five weeks were 6.54, 7.02, and 6.98, respectively. These scores were lower in all cases than flavor of fat scores. No significant difference, at the 95 per cent level, was found in flavor of lean or flavor of fat when comparing hams cured three, four, and five weeks.

TABLE XXIII

RELATIONSHIP OF MEAN FLAVOR OF FAT SCORES TO AGING TEMPERATURE, WEEKS IN CURE, AND AGING TIME

Months aging	Room temperature aging			36° F. aging		
	Weeks curing			Weeks curing		
	3	4	5	3	4	5
2	7.21	7.04	6.71	7.71	7.42	7.63
4	7.38	7.62	7.08	7.04	7.88	7.92
6	5.13	7.12	6.33	7.00	7.58	6.92

[a]The interaction between aging temperature, weeks in cure, and months of aging was significant at the 95 per cent level (Table XX).

A low score on flavor of fat of 5.13 (Table XXIII) was present for hams cured three weeks and aged at room temperature for six months. This score exhibits some evidence that hams cured for three weeks were becoming rancid after six months of aging at room temperature. An average of fat flavor scores at six months of aging showed a decline from scores at four months of aging.

Although there was no clear-cut linear trend in flavor of fat scores, the fact still remains that all scores are acceptable. Fat was not rancid enough for panel members to score below an average of five which was termed fair.

CHAPTER V

SUMMARY AND CONCLUSIONS

Seventy-two hams were used in studying the effects of method of curing, length of curing period, pounds of salt per 100 pounds of hams, aging time, and aging temperature on palatability factors. Thirty-six of these hams were stitched before dry-curing and thirty-six were dry-cured only. These two groups were divided equally into three, four, and five week curing periods and each curing period was further divided, allowing half of the hams to receive six pounds of salt per 100 pounds of hams and half of the hams to receive eight pounds of salt. At the end of the curing period, each treatment was divided again for aging at 36° F. and room temperature. This last division allowed three hams for each treatment.

Twenty-four hams, or one ham from each treatment, were used for studying salt equalization. Salt concentrations were found to be more equalized in hams after thirty days of aging than at the end of the curing period. This difference was significant at the 95 per cent level. No significant difference at the 95 per cent level was found between the salt content of stitched and dry-cured hams when analyzed on a dry-matter basis. Hams cured for three, four and five weeks contained an average of 3.47, 3.52, and

4.63 per cent salt, respectively. All of these levels of salt seemed to be acceptable when scored by a trained taste panel. The mean salt content of hams cured with six pounds of salt per 100 pounds of hams was 3.71 per cent while the mean salt content of hams cured with eight pounds of salt was 4.04 per cent. This difference, however, was not great enough to be significant at the 95 per cent level. Taste panel data revealed no significant difference at the 95 per cent level between using six and eight pounds of salt per 100 pounds of hams.

Under the conditions of this experiment, 95 per cent of the stitched hams were judged unfit for taste panel use at two months of aging because of deterioration. These data indicate that, under average farm conditions of curing and aging, stitching of hams would not be advisable.

Palatability data obtained on the remaining two dry-cured hams of each treatment at two, four, and six months of aging revealed that flavor of fat scored higher and decreased in desirability less rapidly than flavor of lean. The average flavor score for lean, however, still remained in the acceptable range.

Evaporation losses during broiling decreased as the hams aged. Hams aged at room temperature had smaller evaporation losses than hams aged at 36° F. These results indicated that more dehydration occurred during aging at

room temperature which may account for the lower tenderness values as the hams aged.

The Warner Bratzler shear as well as the trained taste panel found hams cured three weeks to be more tender than hams cured four or five weeks. On the other hand, hams cured four weeks had higher average scores on juiciness, flavor of fat and flavor of lean. None of these differences were significant at the 95 per cent level.

BIBLIOGRAPHY

BIBLIOGRAPHY

Association of Official Agricultural Chemists, 1955. Methods of Analysis. Washington, D. C.

Barnicoat, C. R. 1929. Comparative analysis of cured pork products. New Zealand J. Sci. and Tech. 11:245.

Beasley, A. K. and F. Carrol. 1942. An improved method for determining the distribution of salt and water in cured hams. J. of Agri. Res. 64:293.

Bedenbaugh, P. G. and W. L. Richmond. 1951. Test methods of curing and storing hams. Mississippi Farm Res. 14:7.

Blumer, T. N., F. H. Smith, H. S. Lucas, and W. E. Tyler. 1952. The influence of age of hogs on the ham curing process. J. Animal Sci. 11:749.

Blumer, T. N. 1954. Chemical compounds associated with aged ham flavor. Ph.D. thesis, Michigan State University.

Brady, D. E., F. H. Smith, T. N. Tucker, and T. N. Blumer. 1949. Characteristics of country-style hams as related to sugar content of curing mixture. Food Res. 14:303.

Callow, E. H. 1947. The action of salts and other substances used in the curing of bacon and ham. British J. Nutr. 1:269.

Cecil, S. R. and J. G. Woodroof. 1954. Effect of storage temperatures on the aging of country-style hams. Food Tech. 8:216.

Dunker, C. F. and O. G. Hankins. 1951. Survey of Farm Meat-Curing Methods. U. S. D. A. Circular 894.

Edelmann, Richard, J. R. Mohler, and Adolph Eichhorn. 1939. Meat Hygiene (7th ed.). Lea and Febiger, Philadelphia, Penn.

Fields, M. D. and C. F. Dunker. 1952. Quality and nutritive properties of different types of commercially cured hams. Food Tech. 6:329.

Fields, M. D., C. F. Dunker, and C. E. Swift. 1955. The effect of storage on the composition and nutritive properties of farm-style hams. Food Tech. 9:491.

Helser, M. D. 1929. Farm Meats. Macmillan Publ. Co., New York, New York.

Hunt, W. E., W. C. Supplee, D. Meade, and B. E. Carmichael. 1939. Qualities of hams and rapidity of aging as affected by curing and aging conditions and processes. Maryland Agri. Exp. Sta. Bul. 428:31.

Institute of American Meat Packers. 1936. Pork Operations (4th ed.). University of Chicago, Chicago, Ill.

Jensen, L. B. 1935. Meat Treating Methods. United States Patent 2,002,142.

Jensen, L. B. 1942. Microbiology of Meats (3rd ed.). The Garrard Press, Champaign, Ill.

Jensen, L. B. 1949. Meat and Meat Foods. The Ronald Press Co., New York, New York.

Kemp, J. D., H. C. McCampbell, and R. B. Grainger. 1957. Procedure for sampling and laboratory rendering of ham fat and characteristics of hams and fat during aging. Food Tech. 11:321.

Lewis, W. L. 1937. The role of sugar in curing meat. Proceedings Operating and Chemical Sect., Institute American Meat Packers.

McBryde, C. N. 1911. A bacteriological study of ham souring. U. S. D. A. Bur. Anim. Indus. Bul. 132.

Miller, R. C. and P. T. Ziegler. 1936. How aging affects the distribution of salt in cured hams. Food Indus. 8:121.

Miller, R. C. and P. T. Ziegler. 1936a. Process of the distribution of salt in hams during the curing process. J. Agri. Res. 52:225.

Miller, R. C. and P. T. Ziegler. 1939. Salt content of cured hams. Food Res. 4:55.

Moody, W. G. 1957. The effect of not smoking and smoking at different temperatures on the shrinkage, rancidity development, and palatability of dry-cured hams. M.S. thesis, University of Kentucky.

Moulton, C. R. 1929. Meat Through The Microscope (2nd ed.). Institute of Meat Packing, University of Chicago, Chicago, Ill.

Moulton, C. R. 1932. Meat and Meat Products. Allen's Commercial Organic Analysis (5th ed.). Philadelphia, Penn.

Skelley, George C. Jr. 1960. The effects of partial pumping on the shrinkage, rancidity development, and palatability of aged hams. M. S. thesis, University of Kentucky.

Snedecor, G. W. 1958. Statistical Methods (5th ed.). Iowa State College Press, Ames, Iowa.

Tomhave, W. H. 1925. Meats and Meat Products. J. B. Lippincott Company. Philadelphia, Penn.

Warner, K. F. 1938. Pork on the Farm: Killing, Curing, and Canning. U. S. D. A. Farmers Bul. 1186.

Ziegler, P. T. and R. C. Miller. 1938. Rate of salt absorption in curing pork. Penn. Agri. Exp. Sta. Bul. 355.

Ziegler, P. T. and R. C. Miller. 1942. Methods of hastening absorption of salt in farm-cured hams. Penn. Agri. Exp. Stat. Bul. 427:1.

APPENDIX

TABLE XXIV

INDIVIDUAL SALT PERCENTAGES OF DRY-CURED HAMS

Weeks in cure	Lbs. salt per 100 lbs. hams	Ham No.	0 days aging Location I	II	III	IV	30 days aging Location I	II	III	IV
3	6	10X	7.01	1.29	1.01	1.70	4.45	5.32	3.71	1.41
		24	6.12	3.76	1.95	1.52	5.78	4.56	3.64	1.25
		Mean	6.56	2.52	1.48	1.61	5.11	4.94	3.67	1.33
	8	8X	9.64	7.46	7.48	1.50	4.23	4.74	3.07	.94
		26	6.31	1.78	1.39	1.56	6.85	4.80	3.99	1.29
		Mean	7.97	4.62	4.43	1.53	5.54	4.77	3.53	1.12
4	6	6X	6.90	2.02	1.63	1.26	6.50	5.54	3.83	1.04
		10	6.18	3.48	1.79	1.02	7.15	8.46	4.02	3.34
		Mean	6.54	2.75	1.71	1.14	6.83	7.00	3.92	2.19
	8	4X	8.44	2.94	.97	1.27	4.50	4.91	2.97	1.62
		14	6.21	3.69	1.23	1.32	4.17	5.55	3.08	1.17
		Mean	7.32	3.31	1.10	1.29	4.33	5.23	3.02	1.39
5	6	11X	6.87	2.53	1.81	4.85	4.86	6.23	6.01	3.17
		2	6.72	5.40	2.48	1.72	5.44	5.88	3.59	2.25
		Mean	6.79	3.96	2.14	3.28	5.15	6.05	4.80	2.71
	8	12X	6.58	4.90	2.07	3.43	6.57	7.41	7.18	2.56
		8	5.81	8.02	4.87	1.73	5.41	3.73	2.82	2.56
		Mean	6.19	6.46	3.47	2.58	5.99	5.57	5.00	2.56

TABLE XXV

INDIVIDUAL SALT PERCENTAGES OF STITCHED HAMS

Weeks in cure	Lbs. salt per 100 lbs. hams	Ham No.	0 days aging Location I	II	III	IV	30 days aging Location I	II	III	IV
3	6	82	2.90	2.58	1.29	.41	5.04	4.50	2.87	.77
		84	4.49	1.77	1.21	.59	6.01	3.83	3.18	5.81
		Mean	3.69	2.17	1.25	.50	5.52	4.16	3.03	3.29
	8	86	5.57	3.20	1.69	.72	5.16	4.69	3.13	1.24
		88	4.86	4.26	1.99	.80	5.64	5.78	3.91	.98
		Mean	5.21	3.73	1.84	.76	5.40	5.23	3.52	1.11
4	6	90	7.02	2.62	1.58	1.38	7.00	3.81	2.68	1.02
		92	7.04	2.45	1.29	2.12	5.41	3.85	3.04	1.19
		Mean	7.03	2.53	1.43	1.75	6.20	3.83	2.86	1.10
	8	94	7.11	3.32	1.53	1.28	5.84	3.75	2.04	.52
		96	8.24	2.11	1.49	1.64	5.50	5.14	3.62	.67
		Mean	7.67	2.71	1.51	1.46	5.67	4.45	2.83	.59
5	6	100X	8.23	4.51	2.37	.74	6.09	7.16	4.39	1.70
		98	8.45	1.97	1.30	1.92	7.19	8.46	2.96	.93
		Mean	7.84	3.24	1.83	1.33	6.64	7.81	3.17	1.31
	8	2X	7.10	7.42	6.85	2.09	7.30	4.65	3.16	2.22
		IX	9.58	6.65	3.93	2.38	6.92	6.43	5.26	1.89
		Mean	8.34	7.03	5.39	2.23	7.11	5.54	4.21	2.05

TABLE XXVI

INDIVIDUAL EVAPORATION LOSS PERCENTAGES

Weeks in cure	Lbs. salt per 100 lbs. hams	Ham No.	Room temperature			36° F.		
			2 mo.	4 mo.	6 mo.	2 mo.	4 mo.	6 mo.
3	6	21	8.5	6.1	6.0			
		22	13.1	4.4	5.0			
		23				9.0	8.0	7.5
		9X				16.1	9.2	5.9
		Mean	10.8	5.3	5.5	12.5	8.6	6.7
	8	31	5.7	4.0	3.5			
		32	9.5	5.5	6.2			
		25				9.3	6.5	5.3
		7X				12.9	6.8	7.7
		Mean	7.6	4.8	4.8	11.1	6.6	6.5
4	6	11	7.3	5.8	4.2			
		12	16.8	5.4	3.7			
		9				9.1	7.3	6.1
		5X				12.1	8.0	7.1
		Mean	12.0	5.6	3.9	10.6	7.6	6.6
	8	15	6.9	5.0	2.9			
		16	12.2	3.5	3.3			
		13				8.1	8.7	6.7
		3X				13.3	7.1	8.0
		Mean	9.5	4.3	3.1	10.7	7.9	7.3
5	6	3	9.0	4.5	1.6			
		4	10.4	5.9	2.8			
		1				8.3	7.8	6.4
		18				9.8	5.8	5.4
		Mean	9.7	5.2	2.2	9.0	6.8	5.9
	8	5	8.3	5.4	3.3			
		6	12.9	6.6	3.4			
		7				9.7	11.2	7.3
		28				11.3	10.4	6.6
		Mean	10.6	6.0	3.3	10.5	10.8	6.9

TABLE XXVII

INDIVIDUAL DRIPPING LOSS PERCENTAGES

Weeks in cure	Lbs. salt per 100 lbs. hams	Ham No.	Room temperature			36° F.		
			2 mo.	4 mo.	6 mo.	2 mo.	4 mo.	6 mo.
3	6	21	6.8	7.1	5.6			
		22	9.6	5.9	9.9			
		23				3.8	5.4	5.4
		9X				7.9	7.4	7.0
		Mean	8.2	6.5	7.7	5.8	6.4	6.2
	8	31	7.0	6.7	5.7			
		32	10.4	6.4	8.5			
		25				4.9	5.1	5.9
		7X				6.3	4.5	5.2
		Mean	8.7	6.6	7.1	5.6	4.8	5.6
4	6	11	6.8	6.2	10.0			
		12	9.9	8.7	12.2			
		9				6.0	5.4	9.5
		5X				9.5	7.3	5.5
		Mean	8.4	7.5	11.1	7.7	6.3	7.5
	8	15	5.4	5.9	8.3			
		16	11.8	7.8	11.5			
		13				3.9	4.5	7.7
		3X				6.0	4.4	5.8
		Mean	8.6	6.9	9.9	4.9	4.4	6.8
5	6	3	13.8	6.2	3.8			
		4	9.3	7.8	7.1			
		1				5.6	4.6	5.0
		18				5.3	5.4	10.8
		Mean	11.6	7.0	5.5	5.4	5.0	7.9
	8	5	8.7	8.6	10.2			
		6	12.8	7.0	7.8			
		7				6.2	6.0	6.5
		28				6.3	4.8	7.5
		Mean	10.8	7.8	9.0	6.2	5.4	7.0

TABLE XXVIII

INDIVIDUAL WARNER BRATZLER SHEAR TENDERNESS SCORES

Weeks in cure	Lbs. salt per 100 lbs. hams	Ham No.	Room temperature			36° F.		
			2 mo.	4 mo.	6 mo.	2 mo.	4 mo.	6 mo.
3	6	21	6.6	9.0	15.0			
		22	6.3	5.1	2.2			
		23				2.9	3.2	5.6
		9X				0.8	0.4	0.6
		Mean	6.4	7.0	8.6	2.8	1.8	3.1
	8	31	5.2	4.5	9.8			
		32	3.5	3.1	6.6			
		25				4.6	5.3	5.9
		7X				2.3	0.8	1.5
		Mean	4.4	3.8	8.2	3.6	3.0	3.7
4	6	11	6.3	4.1	14.9			
		12	3.1	7.5	11.0			
		9				5.4	5.6	5.6
		5X				3.4	1.7	1.1
		Mean	4.7	5.8	13.0	4.4	3.6	3.4
	8	15	7.1	5.1	15.8			
		16	4.1	7.7	9.8			
		13				7.2	2.8	3.4
		3X				3.9	3.1	2.4
		Mean	5.6	6.4	12.8	5.6	3.0	2.9
5	6	3	2.3	12.6	29.3			
		4	7.7	2.6	13.5			
		1				5.4	6.3	3.9
		18				4.7	2.4	5.1
		Mean	5.0	7.7	21.4	5.0	4.4	4.5
	8	5	5.7	7.8	19.4			
		6	2.8	4.7	15.0			
		7				6.4	5.9	5.1
		28				4.0	2.7	4.1
		Mean	4.2	6.2	17.2	5.2	4.3	4.6

TABLE XXIX

INDIVIDUAL TASTE PANEL TENDERNESS SCORES

Weeks in cure	Lbs. salt per 100 lbs.	Ham No.	Room Temperature			36° F.		
			2 mo.	4 mo.	6 mo.	2 mo.	4 mo.	6 mo.
3	6	21	7.33	7.00	4.83			
		22	7.66	7.66	6.50			
		23				7.66	8.00	6.66
		9X				8.00	8.16	8.50
		Mean	7.50	7.33	5.66	7.83	8.08	7.58
	8	31	7.33	7.50	5.83			
		32	8.50	7.83	6.33			
		25				7.00	7.83	7.16
		7X				7.66	7.50	7.66
		Mean	7.92	7.66	6.08	7.33	7.66	7.42
4	6	11	7.83	7.33	5.00			
		12	7.83	7.66	5.14			
		9				6.00	7.50	7.66
		5X				7.33	8.16	7.16
		Mean	7.83	7.50	5.08	7.16	7.83	7.42
	8	15	6.50	7.66	5.33			
		16	7.66	7.33	5.33			
		13				6.00	8.16	7.83
		3X				7.66	8.00	7.66
		Mean	7.08	7.50	5.33	7.33	8.08	7.75
5	6	3	6.00	6.33	3.33			
		4	7.17	8.00	4.66			
		1				7.33	7.66	5.83
		18				7.50	8.50	7.83
		Mean	6.58	7.16	4.00	7.42	8.08	7.33
	8	5	6.66	7.17	4.33			
		6	6.83	7.50	5.33			
		7				6.83	7.66	6.66
		28				6.83	7.83	7.00
		Mean	6.75	7.34	4.83	6.83	7.74	6.83

TABLE XXX

INDIVIDUAL JUICINESS SCORES

Weeks in cure	Lbs. salt per 100 lbs. hams	Ham No.	Room temperature 2 mo.	Room temperature 4 mo.	Room temperature 6 mo.	36° F. 2 mo.	36° F. 4 mo.	36° F. 6 mo.
3	6	21	7.16	6.83	5.50			
		22	7.33	6.83	6.33			
		23				7.83	7.66	7.00
		9X				7.16	7.50	7.16
		Mean	7.24	6.83	5.92	7.00	6.58	7.08
	8	31	7.83	7.50	6.66			
		32	8.00	7.50	6.50			
		25				6.83	7.33	7.16
		7X				7.33	7.00	7.00
		Mean	7.92	7.50	6.58	7.06	7.18	7.08
4	6	11	7.83	7.33	6.16			
		12	7.66	7.16	6.83			
		9				7.33	7.83	7.83
		5X				7.50	6.83	7.00
		Mean	7.74	7.24	6.50	7.42	7.33	7.42
	8	15	7.16	7.33	6.33			
		16	7.16	7.16	6.50			
		13				7.16	7.83	7.00
		3X				7.33	7.16	7.00
		Mean	7.16	7.24	6.42	7.24	7.50	7.00
5	6	3	6.50	6.33	5.33			
		4	6.66	7.33	6.16			
		1				7.83	7.66	7.00
		18				7.16	7.50	7.16
		Mean	6.58	6.83	5.75	7.50	7.58	7.08
	8	5	6.33	7.16	6.00			
		6	6.33	7.16	6.83			
		7				6.83	7.33	7.16
		28				7.33	7.00	7.00
		Mean	6.33	7.16	6.42	7.08	7.16	7.08

TABLE XXXI

INDIVIDUAL FLAVOR OF LEAN SCORES

Weeks in cure	Lbs. salt per 100 lbs. hams	Ham No.	Room temperature			36° F.		
			2 mo.	4 mo.	6 mo.	2 mo.	4 mo.	6 mo.
3	6	21	7.33	7.83	5.66			
		22	7.00	6.33	2.00			
		23				7.83	7.16	6.66
		9X				6.66	6.50	6.16
		Mean	7.17	7.08	3.83	7.25	6.83	6.42
	8	31	7.50	7.16	7.00			
		32	7.33	7.50	4.00			
		25				8.00	7.16	5.83
		7X				6.50	5.66	6.16
		Mean	7.42	7.33	5.50	7.25	6.42	6.00
4	6	11	7.66	7.16	6.16			
		12	7.50	7.50	6.33			
		9				7.33	7.83	6.50
		5X				6.66	7.00	7.33
		Mean	7.58	7.33	6.25	7.00	7.42	6.92
	8	15	6.66	7.66	6.16			
		16	6.66	7.50	6.50			
		13				6.83	6.66	6.66
		3X				7.33	7.00	7.83
		Mean	6.66	7.58	6.33	7.08	6.83	7.25
5	6	3	7.00	6.83	6.83			
		4	7.00	7.00	4.33			
		1				8.00	7.83	7.33
		18				7.83	7.50	5.00
		Mean	7.00	6.92	5.58	7.92	7.67	6.17
	8	5	6.83	7.66	6.33			
		6	6.66	7.66	6.83			
		7				7.00	7.66	7.00
		28				7.83	7.00	6.50
		Mean	6.75	7.66	6.58	7.42	7.33	6.75

TABLE XXXII

INDIVIDUAL FLAVOR OF FAT SCORES

Weeks in cure	Lbs. salt per 100 lbs. hams	Ham No.	Room temperature			36° F.		
			2 mo.	4 mo.	6 mo.	2 mo.	4 mo.	6 mo.
3	6	21	7.33	7.33	5.50			
		22	7.00	7.33	3.16			
		23				7.50	6.33	7.16
		9X				8.00	7.16	6.83
		Mean	7.17	7.33	4.33	7.75	6.75	7.00
	8	31	7.50	7.00	6.00			
		32	7.00	7.83	5.83			
		25				7.83	7.16	7.16
		7X				7.50	7.50	6.83
		Mean	7.25	7.42	5.92	7.66	7.33	7.00
4	6	11	6.83	7.50	7.33			
		12	7.33	7.50	7.16			
		9				7.33	8.33	7.16
		5X				7.00	7.50	7.50
		Mean	7.08	7.50	7.25	7.17	7.92	7.33
	8	15	6.83	7.50	7.33			
		16	7.16	8.00	7.66			
		13				7.16	7.66	7.66
		3X				8.16	8.00	8.00
		Mean	7.00	7.75	7.49	7.67	7.83	7.83
5	6	3	6.66	7.33	6.00			
		4	6.83	6.33	5.50			
		1				7.83	8.16	7.50
		18				8.00	8.50	5.83
		Mean	6.75	6.83	5.75	7.92	8.33	6.66
	8	5	6.66	7.50	6.83			
		6	6.66	7.16	7.00			
		7				7.16	7.83	7.00
		28				7.50	7.16	7.33
		Mean	6.66	7.33	6.92	7.33	7.50	7.17