August 10, 1968

To the Graduate Council:

I am submitting herewith a thesis written by James B. Stansbury entitled "Post-Mortem Processing Treatments on Selected Characteristics of Whole Hog Pork Sausage." 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 Food Technology.

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POST-MORTEM PROCESSING TREATMENTS ON SELECTED CHARACTERISTICS OF WHOLE HOG PORK SAUSAGE

A Thesis

Presented to

the Graduate Council of

The University of Tennessee

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

---

by

James B. Stansbury

August 1968

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ABSTRACT

The processing of pork sausage to a finished form prior to initial chilling has been an area of considerable recent study and experimentation. The conventional technique of production required the porcine materials to be chilled 20-24 hours at 30-34°F and then boned, ground, seasoned and packaged. The completion of all or some of the fabrication steps prior to initial chilling of the pork product was described as "hot processing". This study was undertaken to evaluate scientifically the relative merits of the two techniques of production by calculating yields and costs, and by studying selected quality attributes.

Proximate analyses, physical tests (color, gassiness development, and cooking losses), bacteriological counts, and sensory evaluations were chosen for the study of quality attributes. The moisture, protein (N x 6.25) and NaCl determinations were made. Hydrogen ion concentration (pH) was determined with a Bechman pH Meter. Of the physical tests, color was determined by taking cross-section readings of the packaged pork sausage by the Color Eye Reflectometer and calculating CIE color notations. Gassiness development was determined by observing stored packages of pork sausage and recording the day at which a disagreeable odor was detected. The Analysis of Variance was used for the statistical analysis of the data obtained from the study of quality attributes.

A net yield of only 0.04 percent for the cold process was found in favor of the conventional processing technique. A net advantage of

only 0.4 of a cent per hundred weight of saleable pork sausage for the hot processing technique was found. None of the quality attributes studied showed statistically significant differences.

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CHAPTER I

INTRODUCTION

The processing of pork products to a finished form prior to initial chilling has been an area of considerable recent study and experimentation. Conventional industry methods of production require that pork products remain in the packing house from two days to two weeks, depending on the various steps of fabrication. The completion of all or some of the fabrication steps prior to the initial chilling of the pork product has been described as "Hot Processing," "Pre-Chill Processing," "Processing Prior to Rigor Mortis," and "Accelerated Pork Processing" (15).*

The historical development of "Hot Whole Hog Pork Sausage" is an interesting one. The story told by Dr. William J. Shannon (20), one of the country's leading food technologists in meats, was that

> . . . the accepted backwoods way of preparing pork sausage a hundred years or so ago in Canada was to grind it up hot and place it in a crock jar and pour paraffin on top of the jar to seal it.

Dr. Shannon said that he had watched his grandmother do this when he was a growing boy in Canada. Now there are some companies (8) manufacturing a major portion of their products by "hot processing" techniques.

However, sometime prior to 1964, executives of Bird Provision Company of Pekin, Illinois (11) observed that no one had patented the

---

*Numbers in parentheses correspond to numbers of references in Literature Cited.

process. Neither was there any scientific documentation on the subject prior to 1958. The Patent No. 3,124,462 (28) was granted on March 10, 1964, to Virgil and Paul Vogel of Bird Provision Company (11).

Since that time, much interest has been stimulated among industry leaders as well as academic researchers. Industrial leaders generally favor the "hot processing" technique over the conventional method. Several leaders in the academic profession are not in agreement with the industrial leaders as to the advantages--real and imagined--that the "hot processing" technique has over the conventional method of producing pork sausage.

This study was undertaken to evaluate scientifically the relative merits of the two techniques of production.

The objectives were:

1. To compare by proximate analyses, physical tests (color, cooking losses, and gassiness development), bacteriological examination, and sensory evaluation the various quality attributes of products produced by the two techniques.
2. To compare the actual costs of producing pork sausage by the two techniques.
3. To compare the yields of sausage obtained by the use of the two techniques.

CHAPTER II

REVIEW OF LITERATURE

Manufacture

The Bird Provision Company patent (28) consists essentially of the following steps;

1. Boning a freshly slaughtered carcass, while still hot, into trimmings;
2. Grinding desired carcass trimmings while still warm and fluent;
3. Mixing the ground trimmings while fluent and above approximately 80°F.;
4. Completion of mixing not more than about 3-1/2 hours after the carcass has been bled; and stuffing the warm and fluent mixed trimmings into air impermeable casings.

Shannon (21) emphasized that the important thing about "Hot Whole Hog Pork Sausage" is that the salt and spices be mixed in with the diced or ground tissue before the temperature of this tissue drops below 90°F. He said that by this technique:

1. The salt would be in contact with the protein materials before rigor set in and before the complicated changes take place in the protein molecules;
2. The hog fat would be warm, being above 90°F., so the essential oils of the spice would be dissolved into the warm fat and

there would be greater retention of the spice flavor in the finished product;

3. The normal bacterial contamination associated with pork would not have had a chance to proliferate on the raw materials.

In work reported by Davidson et al. of the University of Minnesota (7) differences between weeks for various response criteria were often observed. These differences showed significance at the 0.10, 0.05, and 0.01 levels of probability. These workers pointed out that, because of the inherent biological variability of the experimental material and practical limitations of experimental techniques, these differences were expected.

Briskey et al. (5) have indicated that the biochemical aspects of post-mortem changes in protein muscle cannot be adequately resolved without some deference to the physiology of the live animal. The University of Minnesota workers (7) minimized physiological error by using ten littermate pairs in their study.

Color

The color of a meat product is essential to consumer acceptance. The development and retention of meat color is of prime economic importance to the meat processing industry (25,26). The color of meat has been shown to develop through definite changes depending on the status of the pigment myoglobin (9). The bright red pigment of fresh meat was oxymyoglobin and its step-wise conversion to brown metmyoglobin was the

major discoloration problem of fresh meats. The first step in this conversion was found to be the deoxygenation of oxymyoglobin to yield myoglobin. This transformation was readily reversible in an oxygen atmosphere; however, in the interior of meats the respiratory enzymes consume oxygen and tend to deoxygenate oxymyoglobin to myoglobin, which was purple-red. Myoglobin, with iron in its heme moiety in the ferrous state, was very labile to oxidation to the brown ferric compound, metmyoglobin (6). Figure 1 (6) illustrates these reactions. The reversible first step, oxymyoglobin to myoglobin transformation, is not subject to control by antioxidants. The change is oxygenation and not oxidation.

Oxymyoglobin is stable at high oxygen partial pressures; thus, the color retention of prepackaged meat is dependent upon the use of an oxygen permeable film (14). The oxidation of myoglobin to metmyoglobin, however, is amenable to control; reducing compounds afford protection by continuously regenerating myoglobin from metmyoglobin. In the presence of oxygen, the resulting myoglobin is then oxygenated to oxymyoglobin.

Light does not greatly affect the color of fresh meats; however, exposure of prepackaged meats to ultraviolet light should be avoided, since this favors the myoglobin-metmyoglobin transformation. No extensive investigations of the use of reducing compounds incorporated in packaging firms have been reported although the possibility has been mentioned (13).

Also of interest was the metmyoglobin reductase enzyme systems of mammalian muscle and blood (17,30). These enzymes are ill characterized at present, but protection against discoloration of fresh meats

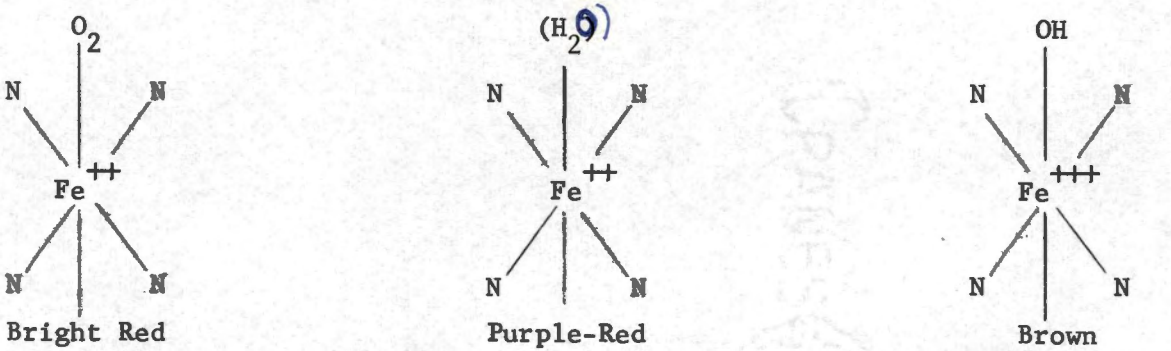

Figure 1. Myoglobin changes in fresh meats (6).

might be afforded by providing the environment and reactants necessary for the proper function of these enzymes. However, it was shown by Florida State University workers (23) that the enzymatic reduction of metmyoglobin to myoglobin did not occur until the oxygen of the raw meat system was practically depleted.

Cooking Losses

Weiner (29) found that hams, cut and processed within one hour of bleeding, had significantly lower drip losses and cooking losses than the controls. This agrees with Shannon's (21) statement that getting the salt soluble proteins into solution would improve the binding ability of the protein. Hamm (10) prevented the rapid loss of water-holding capacity after slaughter by salting ground or cut meat during the first hours post mortem. Trautman (27) indicated that salt-soluble protein (myosin) has been shown to be the major emulsifying component in ham muscle and was greatly influenced by time post mortem. The water-soluble proteins and salt insoluble residue possessed very little emulsifying power.

According to Saffle (18), there were two reasons why more soluble protein would be extracted from hot-boned meat than post-rigor meat. The first was that hot-boned meat had a higher pH than post-rigor meat. The pH of a substance or solution denotes its acidity or alkalinity and ranges from 1 (most acidic) to 14 (most alkaline). A solution with a pH of 7 usually was considered neutral. When an animal was first slaughtered the tissue pH would be around 7; but, at the end of rigor, its pH would

be down to 5.6 or 5.7. Therefore, maximum extraction of the salt-soluble protein was possible immediately post slaughter. The second reason for the higher protein yield of hot-boned meat is the presence in pre-rigor meat of two different proteins--myosin and actin--which after rigor form one large protein complex--actomyosin. It is much easier to extract the two proteins separately than to extract the myosin from the actomyosin complex post-rigor.

Sensory Characteristics

The importance of various pork quality factors and their association with sensory characteristics in the processing and merchandising of pork products has been indicated by several workers (29). Wismer et al. (31) found that pork muscle quality improved following various treatments before the onset of rigor mortis. They reported that significantly higher taste panel tenderness scores resulted from infusing sodium hexametaphosphate into hams 15 minutes after porcine animals were bled.

Proximate Analyses

The moisture, protein, ether extract, ash and NaCl contents of sausage from hot and conventionally processed pork sausages were not significantly different in work reported by Davidson et al. (7). Iodine numbers were used to measure the degree of unsaturation of the pork sausage. They did not find differences which were attributable to the method of processing.

Bacteriology

Davidson et al. (7) reported higher mesophilic counts from hot-processed pork sausage than from the conventionally processed product. These findings agree with those reported by Pulliam and Kelly (16) who worked with hams. Davidson further indicated that psychrophilic counts after 15-20 days in storage were significantly greater. Coliforms counts were erratic and generally low in their study which is in agreement with the findings of Barbe et al. (4).

The University of Minnesota workers (7) indicated some reluctance to relate significant differences in bacterial populations of fresh sausage specifically to method of carcass processing. It was pointed out that it was impossible to measure the contribution of environment to contamination of samples on a day-to-day basis. Thus, differences observed may have been due to lack of precision in the technique used rather than to particular treatment effects.

CHAPTER III

MATERIALS AND METHODS

Manufacture

The pork materials for each replication in this study were obtained from the slaughter of two sows weighing between 700 and 1,200 pounds total weight. Figure 2 is a flow diagram of the manufacture of the whole hog sausage, and it also shows the points where samples were drawn for the chemical, physical, bacteriological, and sensory studies. These procedures were performed and all subsequent assessments were made in four replications with a total of eight sows.

Immediately post-slaughter the carcasses were split. One-half of each carcass was chilled for 20-24 hours at about 30°F. The other one-half of each carcass was immediately boned and weights of the useable sausage material, bones, ribs, lard, skins and feet were recorded and boning yield calculated. The dressed weights were not taken due to inaccurate scales. The boner's time and hourly rate was recorded for cost calculations. The same boner was used for each replication and treatment. The boning yields were calculated as the percentage of total boned weight and credits (bones, ribs, feet, lard, and skins). The total yield of useable pork material transferred to the sausage department was calculated as the percent of total split carcass weight for each process treatment.

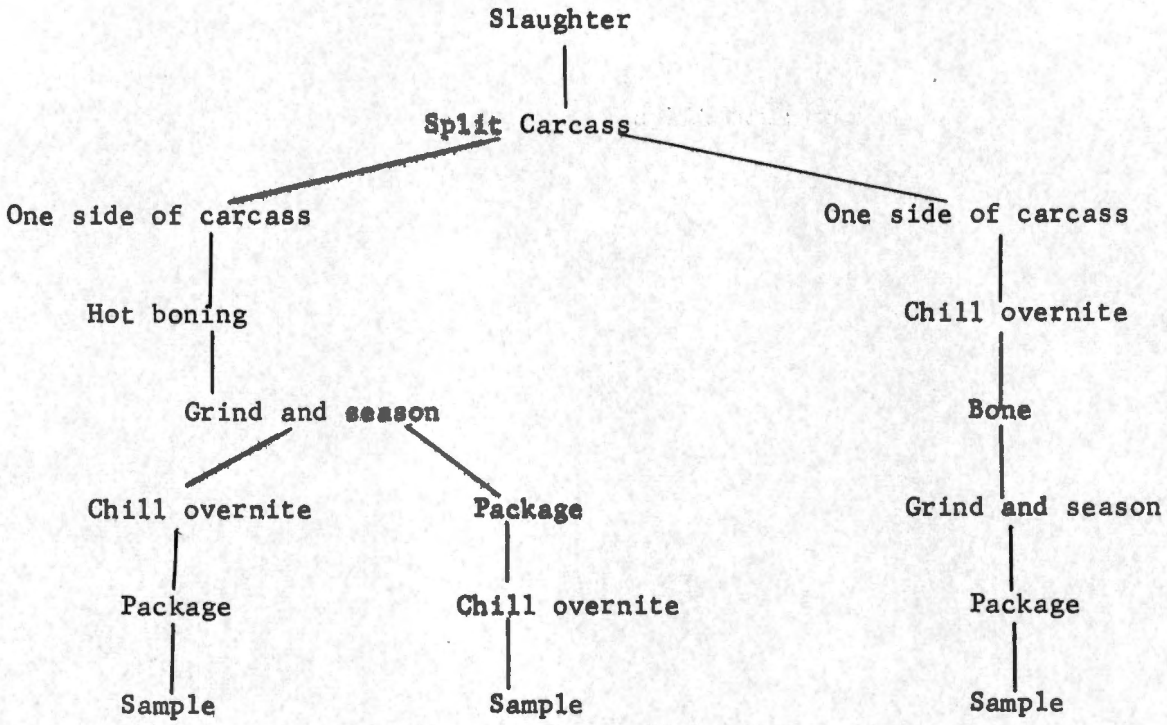

Figure 2. Flow diagram of the manufacture of whole hog pork sausage.

The warm fluent pork material then was ground and mixed with salt and spices. This was completed with the packaging of 12 one pound packages before the mixture cooled below 80°F. The remainder of the sausage was cooled 24 hours at 30°F. then packaged. The time and hourly rates of the workers were recorded for cost calculations. The packaging yields were calculated as the percent of saleable pounds of sausage from the starting raw material which was transferred to the sausage department.

The remaining sides after the 24-hour chill were boned and weights of the useable sausage material, bones, ribs, lard and skins, and feet were recorded and boning yields were calculated. The boner's time and hourly rate was recorded for cost calculations.

The pork material then was ground, mixed with salt and spices, and packaged at the conventional temperature of 30-34°F. The time and hourly rates of the workers were recorded for the cost calculations. The yields were calculated exactly as the hot process calculations. The amounts of ingredients and packaging materials were recorded for both techniques of processing for cost calculations.

Proximate Analyses

Moisture, protein (N x 6.25), and NaCl determinations were made according to "Methods of Analysis of the Association of Official Agricultural Chemists" (1). Hydrogen ion concentration (pH) was determined with a Bechman pH meter in accordance with the method described by the American Meat Institute Foundation (3).

Fat determinations were made according to the method described by Salwin *et al.* (19) as follows:

> The sample should be at or near room temperature. Pass it rapidly through a food chopper three times and mix thoroughly after each grinding. Alternatively, comminute the sample in a food blender. Avoid prolonged blending, which causes overheating of the sample.
>
> Weigh 9.00 grams of the prepared sample into a tared Paley-type Babcock bottle of either 20 or 50 percent size, depending upon the fat content of the sample. Use a 20 percent bottle when the fat content is not more than 15 percent; otherwise, use a 50 percent bottle. If the fat content is more than 45 percent, or if it is desired to have the time required for digestion, use 4.50 grams of sample and multiply the final reading by 2. Add 30 ml. of the perchloric acid-acetic acid mixture, stopper the Paley bottle, and swirl it to mix the contents. Immerse the bottle in a boiling water bath and agitate occasionally during the heating period until the sample is completely digested. Approximately 12 minutes are required to digest 9 grams of material. A metal bath, such as a stainless steel breaker, should be used.
>
> Remove the bottle from the bath as soon as digestion is complete and add more acid mixture until the fat column rises into the calibrated neck of the bottle. Centrifuge the bottle, after careful balancing, for 2 minutes at recommended Babcock speed (875 r.p.m. at 15-inch diameter). If, after centrifuging, the fat column extends below the zero mark in the calibrated neck of the bottle, add more of the acid mixture and centrifuge again for 1 minute.
>
> With the aid of a pair of dividers, measure the length of the fat column as quickly as possible after centrifugation is completed. When using the 20 percent bottle, if the reading is greater than 11.0, add 1 drop of colored glymol from a medicine dropper before making the final measurement. With the 50 percent bottle, always add 3 drops of glymol before measuring the fat column. Add the glymol so that it flows gently down the inside wall of the neck. Fat columns without glymol should be measured from the lowest to the highest point (including meniscus). Fat columns with glymol should be measured from the lowest point to the level interface between the fat and colored glymol. The final reading represents the percentage of fat when a 9-gram sample is used.

Physical Tests

Readings were taken by the (x,X,Y,Z) filters of the Color Eye reflectometer from which Commission Internationale de l'Éclairage color calculations were made (12). These were obtained by taking surface and cross-section readings against the white standard. Two surface readings and likewise cross-section readings were made of each of the four replications of the three treatments.

Cooking losses were determined by cooking one pound of each replication of the three treatments made up into patties of approximately one-half inch thickness and the diameter of the entire pound of pork sausage. These patties were fried at about 300°F., to the same observed degree of doneness for each treatment. The weights of the fresh sausage, cooked sausage, and drip were taken. The difference between the weight of the cooked and fresh sausage was the total cooking loss. The drip loss was calculated by weight, and the difference between that and the total loss was the evaporation loss.

Gassiness development was determined by storage of each replication of the three treatments at normal refrigeration temperatures of 36-40°F. and making daily sensory examinations and recording the day at which a gassy odor was detected.

Bacteriological Counts

Total plate counts and coliform counts were made at three and seven days of storage of the packaged product. These counts were made in accordance with methodology as described in the "Recommended Methods

for the Microbiological Examination of Foods" (21). The sampling and preparation of the sample was done as follows.

Interior samples were taken from sausages by scoring the surface with a knife, breaking the sausage by hand, and removing core samples with a sterile knife or scalpel. An 11 gram sample was taken and then emulsified in 99 ml. of a sterile diluent in a sterile, mechanical blender cup. The samples were blended for not more than 3 minutes in order to avoid overheating of the sample. Shaking was accomplished by hand.

The procedure for total plate counts was completed by transferring appropriate dilutions to petri plates, in duplicate, pouring with total plate count agar. The total plate count agar consisted of: trystone--5 grams; yeast extract--2.5 grams; glucose--1.0 grams; agar--15.0 grams; distilled water--1.0 liters. These ingredients were dissolved in water by bringing to a boil, and then were dispensed into flasks and autoclaved 15 minutes at 121°C. (15 lb. pressure). After pouring and solidification of the agar, the plates were inverted and incubated at 32°C., for 2 days. The viable colonies were then counted and reported as total bacteria per gram of product.

The procedure for enumeration of the coliform group was to prepare the sample as in the total plate count procedure and then transferring 1 ml. portions of appropriate dilutions to duplicate petri plates and pouring with violet red bile agar. The violet red bile agar consisted of: yeast extract--3.0 grams; peptone--7.0 grams; bile salts--1.5 grams; lactose--10.0 grams; sodium chloride--5.0 grams; neutral red--0.03 grams; crystal violet--0.002 grams; agar--15.0 grams; distilled water--1.0

liters. This material was suspended in water and allowed to stand for a few minutes. It was then heated with agitation and boiled for two minutes and then cooled to about 42°C. and used as a plating medium.

The medium and inoculum were mixed thoroughly and allowed to solidify. An additional four to five milliliters of medium was distributed over the surface of the agar to inhibit surface and spreader-type growth. As soon as the agar was solidified, the plates were inverted and incubated for 18-24 hours at 35°C. The dark red colonies 1-2 mm. in diameter, being surrounded with a reddish zone of precipitated bile, were reported as the average number of coliform colonies per gram.

Sensory Evaluation

Taste panel evaluations were made three days post-packaging for the samples packaged cold and four days for the samples packaged hot and then chilled. Therefore, both samples were aged four days post-mortem. A panel consisting of 13 people scored samples from the three treatments for color, texture and flavor. The results were calculated by giving three points for a first place, two points for a second place, and one point for a third place. This gave a total score for each attribute of 78 points to be divided according to preference in each of the four taste panels.

Statistical Analysis

The Analysis of Variance was used for the statistical analysis of the data obtained from the chemical, physical, bacteriological, and

sensory tests. The experimental design was a completely random design for the three treatments with four replications of each. The calculations were made according to the procedure described by Steel and Torrie (24).

CHAPTER IV

RESULTS AND DISCUSSION

Proximate Analyses

The results of the proximate analyses are shown in Table I with the summary of the analysis of variance shown in Table II. No significant differences were found among the averages of the proximate analyses. The protein content showed the largest variation according to the analysis of variance, but the "F" ratio of the mean squares was small. This indicated that the mixing of the sausage materials was thorough and uniform and that treatment did not affect proximate analyses. All analyses were within expected ranges for this type of product. This was in agreement with work reported by the University of Minnesota workers (7).

Physical Tests

The results of the effect of processing treatment on physical attributes of whole hog pork sausage are tabulated in Table III with the summary of the analysis of variance shown in Table IV. The cooking losses were normal for this type of product. The ratio of the mean squares in the summary of analysis of variance for drip loss was not significant. The ratio of the mean squares of gassiness development also was not significant.

On the basis of the trichromatic system of color measurements established by the CIE (12), the surface and the interior surface color

TABLE I

EFFECT OF PROCESSING TREATMENT ON PROXIMATE ANALYSES

Analysis	Hot-Hot[a]	Hot-Cold	Cold-Cold
% Moisture	42.88[b]	42.77	41.49
% Fat	45.50	45.15	46.63
% Protein	11.06	11.29	10.91
Hydrogen Ion Concentration	5.80	5.79	5.68
% Sodium Chloride	1.59	1.56	1.57

[a]Hot-Hot refers to treatment. The dressed carcass was boned hot and all subsequent processing procedures were performed before the meat temperature dropped below 80°F.

Hot-Cold refers to treatment. The dressed carcass was boned hot and packaged chilled.

Cold-Cold refers to treatment. The dressed carcass was boned chilled and all subsequent processing procedures were performed at normal temperatures.

[b]Each datum is the average of four replicates.

TABLE II

SUMMARY OF ANALYSIS OF VARIANCE OF TREATMENT EFFECTS
ON PROXIMATE ANALYSES

Source of Variance	Degrees of Freedom	Mean Squares				
		% Protein	H^+ conc.	% NaCl	% Moisture	% Fat
Treatment	2	1501.00	189.58	9.08	24112.58	18958.33
Error	9	2210.03	977.08	345.19	148044.64	204861.11

TABLE III

EFFECT OF PROCESSING TREATMENT ON PHYSICAL ATTRIBUTES AT FOUR DAYS

Attribute	Hot-Hot	Hot-Cold	Cold-Cold
% Evaporation	20.62[a]	19.85	18.67
% Drip Loss	8.78	11.69	15.36
Gassiness Development	8 days[b]	8 days	13 days

[a]Evaporation and drip losses in grams.

[b]Days the packaged product took to develop a spoiled odor.

TABLE IV

SUMMARY OF ANALYSIS OF VARIANCE OF TREATMENT EFFECTS ON PHYSICAL ATTRIBUTES

Source of Variance	Degrees of Freedom	Mean Squares		
		% Evaporation Loss	% Drip Loss	Gassiness Development
Treatment	2	38613.00	435231.08	833.33
Error	9	421983.80	229839.05	1011.11

of the product can be specified by its chromaticity coordinates (x and y) and lightness. The tristimulus values X, Y, and Z shown in Table V as Equation 1 were used to derive the chromaticity coordinates x and y shown as Equation 2 in Table V. The values of x, X, Y, Z shown in Table V were obtained by measuring with the x, X, Y, Z filters of the Color Eye reflectometer. The tristimulus values A, G, and B were equivalent to the X, Y, Z filter readings. The xSCIE, Yellowness Index, Saturation Index, and Hunter Saturation color notations were calculated by substituting the A, G, and B tristimulus values to the Equations 2(a), 3, 6(b), and 9 respectively as shown in Table V.

The average values are shown in Table VI for the three treatments studied. None of the four color calculations showed significant differences due to treatment effects. Table VII shows the summary of the analysis of variance for treatment effect on color notation.

Table VIII shows the influence of the process treatment on dominant wave length and the excitation purities. There was no marked difference in the dominant wave lengths, although the hot process did have a higher value, indicating a darker color. The hot-hot and cold-cold treatments had identical purities, whereas, the hot-cold treatment had a more faded color.

Figure 3 shows the dominant wave length of the three treatments determined by plotting the x and y chromaticity coordinants in a chromaticity diagram of the International Commission on Illumination to indicate the color of the product as seen by the average observer. Figure 3

TABLE V

EQUATIONS FOR CALCULATION OF COLOR NOTATIONS

Color Eye Filters - x, X, Y, Z.

CIE - A $\simeq$ X
CIE - C $\simeq$ Y
CIE - B $\simeq$ Z

1. X = 0.8X + 0.18x
   Y =
   Z = 1.18Z

2. $x = \frac{X}{X + Y + Z}$ $\qquad y = \frac{Y}{X + Y + Z}$

3. Yellowness Index = $\frac{A - B}{G}$

4. Hunter a = $\frac{A - G}{A + 2G + B}$ $\qquad$ Hunter b = $\frac{0.4(G - B)}{A + 2G + B}$

5. ICIx c = $\frac{0.8A \quad 0.18B}{0.8A + G + 1.36B}$ $\qquad$ ICIy d = $\frac{G}{0.8A + G + 1.36B}$

6. $\emptyset = \frac{b}{a}$ (Hue Angle) $\qquad S = (a^2 + b^2)Y$ (Saturation Index)

   L = Y (Lightness Index)

7. $e = \frac{2.5(A - G)}{10G}$ (Achromatic A) $\qquad f = \frac{G - B}{10G}$ (Achromatic B)

8. $YI = \frac{a}{2.5b} \times 100$ (Yonkin Index)

9. $HS = a^2 + b^2$ (Hunter Saturation)

10. BI = A + G + B (Brightness Index)

TABLE VI

EFFECT OF PROCESSING TREATMENT ON COLOR NOTATIONS

Treatment	xSCIE	YELIND	SATIND	HUNSAT
Hot-Hot	0.385	0.587	0.030	0.072
Hot-Cold	0.376	0.523	0.023	0.063
Cold-Cold	0.382	0.568	0.028	0.069

TABLE VII

SUMMARY OF ANALYSIS OF VARIANCE OF TREATMENT EFFECT ON COLOR NOTATIONS

Source of Variance	Degrees of Freedom	Mean Squares			
		xSCIE	YELIND	SATIND	HUNSAT
Treatment	2	0.0002	0.0087	0.0002	0.0002
Error	20	0.0001	0.0032	0.0001	0.0001

TABLE VIII

INFLUENCE OF PROCESSING TREATMENT ON CALCULATED CIE COLOR NOTATIONS

Treatment	Dominant Wave Length, Millimicron	Percent Purity
Hot-Hot	590	39.0
Hot-Cold	588	32.5
Cold-Cold	589	39.0

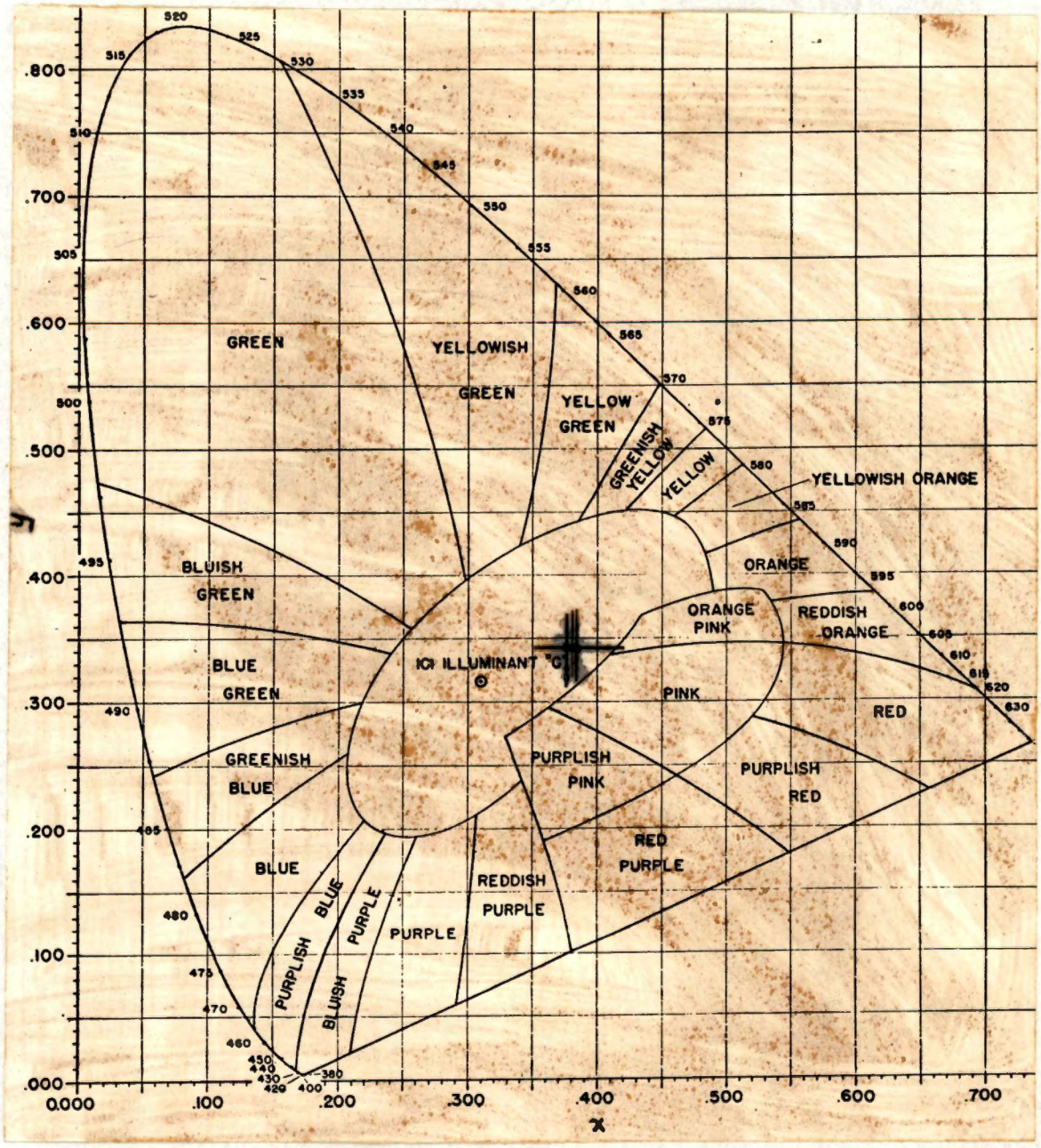

Figure 3. The (x,y)-chromaticity diagram of the CIE system (12) showing the locus of dominant wave length of the colors.

shows the colors to be very light and approaching the ICI illuminant "c" which is white. Figure 3 further shows that there was very little difference in the locus of colors.

Bacteriological Counts

The results of the bacteriological study are presented in Table IX with the summary of analysis of variance. The average total plate counts were very high as shown in Table X. Both total plate counts and coliform counts were, on the average, higher for the hot processed treatments than the cold process. However, this difference was not significant at the .05 percent level of probability. The generally higher counts for the hot processed product would seem to follow the normal expectation as the hot material provides a more favorable medium for the bacterial contaminants from the manufacturing apparatus than the cold material would. This trend agreed with the results of the University of Minnesota workers (7) and Pullian and Kelly (16) who worked with hams, but was not in agreement with Shannon's statement (21).

Sensory Evaluation

The average taste panel scores are tabulated in Table XI with the summary of the analysis of variance shown in Table XII. Of the three attributes studied, flavor, color, and texture, none showed significant difference due to treatment effect.

Yields

The effect of processing treatment on percentage of useable pork material, transferred to the sausage department, from pounds of live

TABLE IX

EFFECT OF PROCESSING TREATMENT ON BACTERIOLOGICAL COUNTS

Count	Hot-Hot	Hot-Cold	Cold-Cold
Total Plate Count 3-day	543,000[a]	201,132	33,825
Coliform Count 3-day	3,118	7,093	685
Total Plate Count 7-day	1,386,030	5,537,060	280,002
Coliform Count 7-day	3,540	699	519

[a]Each datum is the average of four replications in viable colonies per gram.

TABLE X

SUMMARY OF ANALYSIS OF VARIANCE OF TREATMENT EFFECTS ON BACTERIOLOGICAL COUNTS

Source of Variance	Degrees of Freedom	Mean Squares			
		3-day Total Plate Count	3-day Coliform Count	7-day Total Plant Count	7-day Coliform Count
Treatment	2	$< 1 \times 10^{14}$	$< 1 \times 10^{14}$	$< 1 \times 10^{14}$	$< 1 \times 10^{14}$
Error	9	$< 1 \times 10^{14}$	$< 1 \times 10^{14}$	$< 1 \times 10^{14}$	$< 1 \times 10^{14}$

TABLE XI

EFFECT OF PROCESSING TREATMENT ON SENSORY EVALUATIONS

Attribute	Hot-Hot	Hot-Cold	Cold-Cold
Color and Appearance	25.0[a]	27.5	23.2
Texture	24.5	24.0	29.5
Flavor	25.5	26.1	26.2

[a]Each datum is the average of four replicates obtained by total scoring based on 3 points for a first place rating, 2 for a second place rating, and 1 for a third place rating.

TABLE XII

SUMMARY OF ANALYSIS OF VARIANCE OF TREATMENT EFFECTS ON SENSORY EVALUATIONS

Source of Variance	Degrees of Freedom	Mean Squares		
		Color and Appearance	Texture	Flavor
Treatment	2	24.08	37.00	0.75
Error	9	23.86	20.89	19.83

weight is tabulated in Table XIII. This table shows that the percentage is extremely close with a 0.56 percent advantage for the hot-process. This is expected because of the cooler shrink involved in the cold process. However, errors in splitting the carcass into sides could have accounted for some or all of the difference.

Table XIV shows the boning yields of whole hog pork sausage and indicates an 0.30 percent advantage for the cold process. The boner, who was the same for all four replications, expressed his preference for boning chilled carcasses on several occasions. Therefore, there may have been the likelihood of a certain amount of psychological bias involved. This probably was due to the equipment being designed primarily for a cold boning operation.

The packaging yields shown in Table XV show an advantage of 0.60 percent for the cold process method. This was expected because of the adherance of the hot materials to processing equipment. Also of interest was the fact that the problem of "give-away" is much more acute in the packaging of hot material. The Cartridge-Pak operator indicated several times that it was very difficult to regulate the package weight of the hot material.

By combining the advantage of the total yield to the Sausage Department in Table XIII and the total advantage of the packaging yield in Table XV, a net yield advantage of only 0.04 percent for the cold process was found. Thus, in this study, the total advantage from the boning and packaging of cold material was extremely small.

TABLE XIII

EFFECT OF PROCESSING TREATMENT ON PERCENTAGE OF USEABLE SAUSAGE MATERIAL TRANSFERRED TO THE SAUSAGE DEPARTMENT

Replication	Live Weight	Weight of Split Carcass, Lbs.		Weight of Useable Sausage Material, Lbs.		Useable Sausage Material % of Live Weights	
		Hot Process	Cold Process	Hot Process	Cold Process	Hot Process	Cold Process
1	1,065	532.5	532.5	298.0	297.0	55.96	55.77
2	840	420.0	420.0	220.0	207.0	52.38	49.28
3	1,155	577.5	577.5	290.0	285.0	50.22	49.35
4	731	365.6	365.5	182.0	189.0	49.79	51.71
Average Percentage Useable Sausage Material from Live Weights						52.09	51.53
Difference						+ 0.56	

TABLE XIV

EFFECT OF PROCESSING TREATMENT ON BONING YIELDS

Replication	Wt. of Boned Meat and Credits, lbs.[a]		Boned wt., lbs.		Boned wt., lbs.		Percent Boned Yield	
	Hot Process	Cold Process	Hot Process	Credits wt., lbs.	Cold Process	Credits wt., lbs.	Hot Process	Cold Process
1	398.5	392.0	298,0	100.5	297.0	95.0	74.8	75.8
2	302.0	296.0	220.0	82.0	207.0	89.0	72.8	69.9
3	419.0	405.0	290.0	129.0	285.0	120.0	69.2	70.4
4	262.0	264.0	182.0	80.0	189.0	75.0	69.5	71.6
Average Boning Yields							71.6	71.9
Difference								+ 0.30

[a]Credits include ribs, lard, skins, feet, and bones.

TABLE XV

EFFECT OF PROCESSING TREATMENT ON PACKAGING YIELDS

Replication	Boned Weight, lbs.		Packaged Weight, lbs.		Percent Packaged Yield	
	Hot Process	Cold Process	Hot Process	Cold Process	Hot Process	Cold Process
1	298.0	297.0	284.0	280.0	95.2	94.3
2	220.0	207.0	193.0	187.0	87.7	90.3
3	290.0	285.0	268.0	262.0	92.4	91.9
4	182.0	189.0	166.0	174.0	91.2	92.1
Average Packaging Yields Difference					91.6	92.2 + 0.60

Cost Analysis

The costs computed on a dollars-spent basis was summarized in Table XVI. The purchase and slaughtering costs were not different for the two processes because the division was assumed to be equal due to the unreliability of the dressed weight scales. Table XVI shows a net advantage of only 0.4 of a cent per hundred-weight of saleable pork sausage for the cold processed product. However, it should be pointed out that the credits (skin, bones, lard, and ribs) of the hot processed product were not chilled. Thus, a reduction in the refrigeration load of about 15 percent of the product was an advantage of the hot processing technique.

TABLE XVI

COSTS FOR TOTAL PRODUCTION

Cost	Hot	Cold
Purchase and Slaughtering[b]	$333.49[a]	$333.49
Boning[c]	7.58	7.20
Manufacturing[d]	61.71	60.87
Administrative, Selling and Distribution[e]	30.69	30.60
Total Costs	$433.47	$432.16
Lbs. of Finished Product	908	906
Total Cost of Production/cwt.	$ 47.73	$ 47.69
Difference	+ $ 0.04	

[a]Each datum is the sum of four replicates.

[b]The purchase costs were computed on the basis of current market conditions. The total price was calculated and then each technique of processing assessed one half of the total price. This was done due to the unreliability of the dressed carcass weight scales.

Purchase	$16.50/cwt. live wt.
Slaughter Labor	0.51/cwt. live wt.
Slaughter Overhead	0.56/cwt. live wt.

[c]Boning labor including 20 percent above hourly wage fringe benefits.

Hot Process	2.43 hrs. at $2.66/hr.
Cold Process	2.28 hrs. at $2.66/hr.
Boning Overhead	0.04 cents/cwt. live wt.

TABLE XVI (continued)

[d]Manufacturing labor including 20 percent above hourly wage fringe benefits.

Hot Process	1.22 hrs. at $2.47/hr.
	0.84 hrs. at $2.38/hr.
	0.97 hrs. at $2.60/hr.
	1.03 hrs. at $2.66/hr.
	0.55 hrs. at $2.47/hr.
Cold Process	0.55 hrs. at $2.47/hr.
	0.87 hrs. at $2.60/hr.
	1.13 hrs. at $2.38/hr.
	1.17 hrs. at $2.66/hr.
	0.40 hrs. at $2.53/hr.
Manufacturing Ingredients	
Spice	0.93 of a cent/cwt. packaged product used at rate of 2 bags at $2.32 each for 500 lb. batch sausage.
NaCl	0.02 of a cent/cwt. packaged product used at rate of 1.12 oz./cwt. at $1.20/100 lbs.
Packaging Materials	
Films	0.75 of a cent/cwt. at $7.50/1000
Boxes	0.56 of a cent/cwt. at $68.00/1000; each holds 12 lbs. of product.
5 Percent Packaging Materials Loss	0.037 of a cent/cwt.
Total Packaging Materials Cost	$1.38/cwt. packaged product
Manufacturing Overhead	$2.39/cwt. packaged product
[e]Administrative, selling and distribution	$3.38/cwt. packaged product

CHAPTER V

SUMMARY

This study was designed to compare the relative merits of two processing techniques of whole hog pork sausage and the effect of packaging while hot. The objectives were to compare the two techniques by calculating yields and costs, and by studying selected quality attributes.

The quality attributes studied included proximate analyses, bacteriological counts, physical tests and sensory evaluations. According to the analysis of variance no statistical significance due to treatment effect was observed for any of these areas of study.

From the lack of significance in the statistical analysis of the quality attributes and from the lack of difference in the yields and cost-analysis data, a choice of either method of processing whole hog pork sausage would not seem to be advisable.

LITERATURE CITED

LITERATURE CITED

1. A.O.A.C. 1965. Official Methods of Analysis. 10th Ed. Association of Official Agr. Chemists, Washington, D.C.

2. American Can Co. 1963. Flexible packaging in maraflex. Seminar Reference Manual A. 16-21.

3. American Meat Institute Foundation. 1960. The Science of Meat and Meat Products. p. 234.

4. Barbe, Charles D., R. W. Mandigo, and R. L. Henrickson. 1966. Bacterial flora associated with rapid-processed ham. J. Food Sci. 31, 988-993.

5. Briskey, E. J., L. L. Kastenschmidt, J. C. Forrest, G. R. Beecher, M. D. Judge, R. G. Cassens, and W. G. Hoekstra. 1966. Biochemical aspects of post-mortem changes in porcine muscle. J. Agr. and Food Chem. 14, 201-206.

6. Brown, W. D., and A. L. Tappel. 1958. Pigment antioxidant relationships of meat-color stability. Proc. of 10th AMIF Research Conf. pp. 81-89.

7. Davidson, W. K., R. L. Cleplef, R. J. Meade, and L. E. Hanson. 1968. Post-mortem processing treatment on selected characteristics of ham and fresh pork sausage. Food Technol. 22, 114-116.

8. Davies, R. E., Ed. 1963. Owens country sausage goes back to the farm. Meat Processing. Reprint from November issue (vol. and pp. not available).

9. Haas, Martin C. and L. J. Bratzler. 1965. Determination of myoglobin oxygenation rates in pork, beef, and lamb by Munsel and reflectance colorimetry. J. Food Sci. 30, 64-68.

10. Hamm, Reiner. 1959. Biochemistry of meat hydration. Proc. Eleventh Research Conf., AMIF, Chicago, pp. 17-25.

11. Iverson, Cliff, Ed. 1965. Breaking the rancidity barrier. Meat. 40-42.

12. Judd, B. Deane. 1950. Colorimetry. National Bureau of Standards Circular No. 478, p. 7.

13. Draft, A. A., and J. C. Ayres. 1954. Effect of display case lighting on color and bacterial growth on packaged fresh bean. Food Technol. 8, 290-295.

14. Landrock, A. H., and G. A. Wallace. 1955. Discoloration of fresh meat and its relationships to film oxygen permeability. Food Technol. 9, 194-196.

15. Mandigo, R. W. 1967. How soon accelerated pork processing? Meat. 33, 25-27.

16. Pulliam, James D., and Donald C. Kelly. 1965. Bacteriological comparison of hot processed and normally processed hams. J. Milk and Food Technol. 28, 285,286.

17. Roughton, F. W., and J. C. Kendrew (eds.). 1941. Hoemoglobin. New York: Interscience Publishers.

18. Saffle, Robert L. 1968. Get better binding with hot-boned meat. Meat. 34, 31,44.

19. Salwin, Harold, I. K. Block, and J. H. Mitchell. 1955. Rapid determination of fat in meat products. J. Agri. and Food Chem. 3, 588-593.

20. Shannon, W. J. 1965. Conferences during plant visits. Knoxville, Tennessee.

21. Shannon, W. J. 1966. What's happening in sausage manufacture. The National Provisioner. 80-84, 118-120.

22. Sharf, J. M., Ed. 1966. Recommended Methods for the Microbiological Examination of Foods, 2nd Ed. pp. 111-118, 131-141. New York: American Public Health Association, Inc.

23. Solberg, Myron. 1967. Warsaw food congress yields new information on meat research. Meat Processing, 6, 55.

24. Steel, G. D., and J. H. Torrie. 1960. Principles and Procedures of Statistics. pp. 99-128. New York: McGraw-Hill Book Company, Inc.

25. Stewart, Margaret R., Bobbie K. Hutchins, Marelynn W. Zipser, and Betty M. Watts. 1965. Enz-matic reduction of metmyoglobin by ground beef. J. Food Sci. 30, 487-491.

26. Tauber, F. W., and S. Simon. 1963. Changes in the color of meat under various processing conditions. Food Technol. 17, 1317-1319.

27. Trautman, J. C. 1964. Fat-emulsifying properties of pre-rigor and post-rigor pork proteins. Food Technol. 18, 1065-1066.

28. Vogel, V. W., and P. W. Vogel. 1964. Process of preparing and packaging fresh pork sausage. Patent No. 3, 124,462.

29. Weiner, P. D., D. H. Kropf, D. L. Mackintosh, and B. A. Koch. 1966. Effect on muscle quality of processing pork carcasses within one hour post-mortem. Food Technol. 20, 541-543.

30. Wintrobe, M. M. 1956. Clinical Hematology. 4th Ed. Philadelphia: Lea and Febiger.

31. Wismer, Pedersen J., and E, J. Briskey. 1961. Relationship of post-mortem acidity and temperature. Food Technol. 15, 232-236.

APPENDIX

TABLE XVII

PROXIMATE ANALYSES OF FRESH PORK SAUSAGE

		Hot-Hot	Hot-Cold	Cold-Cold
Percent Moisture	1.	39.24	37.99	36.06
	2.	43.29	42.89	41.98
	3.	47.00	47.70	46.50
	4.	42.00	42.50	41.40
	Av.	42.88	42.77	41.49
Percent Fat	1.	48.50	49.50	82.00
	2.	45.50	45.50	46.00
	3.	40.00	39.00	40.00
	4.	48.00	47.50	48.50
	Av.	45.50	45.15	46.63
Percent Protein	1.	11.06	11.80	10.51
	2.	10.77	11.12	11.10
	3.	11.86	11.40	11.40
	4.	10.56	10.85	10.62
	Av.	11.06	11.29	10.91
pH	1.	5.55	5.40	5.45
	2.	6.00	5.60	5.40
	3.	5.75	5.85	5.75
	4.	5.90	6.30	6.10
	Av.	5.80	5.79	5.68
Percent NaCl	1.	1.64	1.52	1.51
	2.	1.75	1.85	1.88
	3.	1.46	1.42	1.43
	4.	1.49	1.43	1.45
	Av.	1.59	1.56	1.57

TABLE XVIII

TESTS OF PHYSICAL CHARACTERISTICS OF FRESH PORK SAUSAGE

Cooking Losses

	Replication	Treatment		
		Hot-Hot	Hot-Cold	Cold-Cold
Percent Evaporation by Weight	1	15.80	16.90	10.70
	2	14.77	18.31	14.97
	3	25,80	19.40	18,00
	4	26.10	24.80	31.00
	Av.	20.62	19.85	18.67
Percent Drip by Weight	1	10,10	12.90	24.40
	2	13,16	13.95	13.29
	3	7.25	11.65	15.20
	4	4.60	8.25	7.55
	Av.	8.78	11.69	15.36
Gassiness Development	1	6 da.	4 da.	14 da.
	2	6 da.	8 da.	12 da.
	3	8 da.	10 da.	10 da.
	4	10 da.	8 da.	14 da.
	Av.	8 da.	8 da.	13 da.

TABLE XIX

FRESH PORK SAUSAGE COLOR AS MEASURED BY THE x,X,Y,Z FILTERS OF THE COLOR EYE REFLECTOMETER

Replications		Hot-Hot	Hot-Cold	Cold-Cold
	Surface Readings			
1.	x	21.8	19.1	23.5
		20.7	21.9	22.4
	X	41.5	36.9	45.6
		42.2	40.0	40.6
	Y	33.3	29.6	37.1
		33.7	33.1	33.8
	Z	22.1	18.2	23.3
		21.6	21.2	21.7
2.	x	23.1	25.3	20.8
		25.5	29.1	21.7
	X	41.0	38.8	35.1
		42.6	48.1	35.2
	Y	35.5	34.5	31.5
		37.3	42.5	31.4
	Z	23.1	24.2	21.5
		25.1	28.6	21.8
3.	x	25.0	24.4	28.3
		21.9	23.0	25.8
	X	43.3	41.7	48.0
		37.9	41.9	43.3
	Y	36.4	36.0	41.3
		31.5	35.2	36.7
	Z	23.5	23.8	28.4
		20.7	22.5	24.8
4.	x	17.3	23.0	22.5
		19.2	21.4	22.3

TABLE XIX (continued)

Replications		Hot-Hot	Hot-Cold	Cold-Cold
	X	37.1	42.6	42.8
		36.6	41.1	42.6
	Y	28.5	35.4	34.9
		29.7	32.3	34.4
	Z	18.5	24.0	23.2
		19.3	22.4	23.0
	Cross Section Readings			
1.	x	19.5	22.5	20.8
		16.6	22.6	20.7
	X	36.9	39.8	39.1
		34.2	41.5	41.6
	Y	30.3	32.4	31.2
		26.7	33.3	31.7
	Z	20.4	21.9	19.0
		17.6	21.8	19.3
2.	x	24.6	22.6	25.4
		19.4	21.7	28.0
	X	46.7	38.6	42.3
		39.4	40.5	42.4
	Y	38.0	31.2	35.9
		31.8	32.3	36.0
	Z	25.7	22.7	25.2
		21.1	23.1	24.8
3.	x	21.4	22.7	22.1
		21.9	21.4	22.1
	X	41.1	38.2	40.2
		43.1	36.4	44.1

TABLE XIX (continued)

Replications		Hot-Hot	Hot-Cold	Cold-Cold
	Y	33.4	33.1	32.4
		33.7	30.3	34.8
	Z	22.2	22.1	21.4
		21.6	20.6	22.6
4.	x	17.7	24.0	23.0
		20.0	19.6	20.4
	X	38.8	43.6	42.5
		40.8	38.8	40.5
	Y	30.1	36.1	34.8
		29.6	31.0	21.4
	Z	19.8	25.8	24.9
		19.4	20.5	21.6

TABLE XX

BACTERIOLOGICAL EXAMINATION--VIABLE COLONIES PER GRAM OF FRESH PORK SAUSAGE

		Hot-Hot	Hot-Cold	Cold-Cold
Total Plate Count 3 days	1.	110,500	4,944,000	36,300
	2.	1,920,500	455,000	35,000
	3.	208,000	46,300	20,800
	4.	32,000	2,600,000	43,200
	Av.	567,750	2,011,325	33,825
Coliform Count 3 days	1.	10,480	25,440	660
	2.	1,340	1,300	1,180
	3.	270	310	100
	4.	380	1,320	800
	Av.	3,118	7,092	685
Total Plate Count 7 days	1.	1,237,600	1,388,000	376,200
	2.	2,704,000	2,004,000	365,200
	3.	1,567,892	136,240	80,610
	4.	346,600	8,620,000	298,000
	Av.	1,464,023	3,037,060	280,002
Coliform Count 7 days	1.	12,480	24,320	620
	2.	1,180	2,420	680
	3.	200	305	75
	4.	300	920	700
	Av.	3,540	699	519

TABLE XXI

TASTE PANEL SCORES OF COOKED PORK SAUSAGE

	Scoring (3-2-1)			
		Treatment		
	Replication	Hot-Hot	Hot-Cold	Cold-Cold
Color and Appearance	1.	32	22	24
	2.	23	31	24
	3.	30	32	15
	4.	25	26	27
		27.5	27.5	22.5
Texture	1.	25	20	33
	2.	24	23	31
	3.	25	32	21
	4.	24	21	33
	Av.	24.5	24.0	29.5
Flavor	1.	27	22	29
	2.	25	26	27
	3.	27	33	18
	4.	23	24	31
	Av.	25.5	26.1	26.2

VITA

The author was born on July 22, 1940, in Memphis, Tennessee. He was graduated from Beech Bluff High School in June 1958. He was enrolled at The University of Tennessee from 1958 to 1961 when active duty call up for the Berlin crisis interrupted his studies. In 1962 he resumed study and received his B,S. in Animal Science in 1964. He was employed as Laboratory Director with East Tennessee Packing Company, Knoxville. Since 1964 he has been working part-time to complete the requirements for the degree, Master of Science. He was married in August 1965 to the former Miss Mildred Scates of Louisville, Tennessee. A precious baby girl, Donna Lynne, was born in April 1967.