November 26, 1968

To the Graduate Council:

I am submitting herewith a thesis written by Robert S. Erwin, entitled"Ultraviolet Radiation Effects on Aging Hams in High Moisture Conditions." 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.

Major Professor

We have read this thesis and recommend its acceptance:

Accepted for the Council:

Vice Chancellor for
Graduate Studies and Research

ULTRAVIOLET RADIATION EFFECTS ON AGING HAMS IN HIGH MOISTURE CONDITIONS

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

Robert S. Erwin

December 1968

ACKNOWLEDGMENTS

The author wishes to extend sincere thanks to the following persons for their efforts in the preparation of this thesis.

To Professor J. W. Cole, major professor, for his advice concerning the research project and manuscript preparation, and for his patient practical guidance during the graduate program. The author is truly indebted to Professor Cole.

To Dr. C. B. Ramsey for his advice concerning the experimental procedures. His guidance throughout the graduate program is gratefully acknowledged.

To Dr. Robert S. Dotson, minor professor, for his sincere interest and reading and critical review of the manuscript. For his cooperation during the course of grduate study.

To Dr. M. R. Johnston, minor professor, for his reading and critical review of the manuscript.

To the members of the Food Science and Institution Management Department of the College of Home Economics and the sensory panel members for their help with the organoleptic evaluations.

To the members of the Animal Husbandry Department and fellow graduate students for their contributions to this thesis.

R. S. E.

ABSTRACT

Hams were aged in two rooms thermostatically controlled at 78°F. with a relative humidity of 80 percent. In one of the rooms a germicidal lamp was installed with the hams placed so that the exposure distance approximated 3, 6, 9 and 12 feet or were shielded entirely from the ultraviolet radiation. There were no significant or definite trends in shrinkage loss among the treatments during the periods of salting, equalizing, smoking and aging. Free fatty acids increased significantly with aging time; however, the FFA content among all treatments did not show a significant difference. The control and shielded hams had significantly more mold growth than those exposed to ultraviolet light rays.

The physical appearance of the exposed hams was significantly more oily than the control group even though there was a fat exudate in all treatments as aging time increased. Although there were no significant differences among treatments in fat color within the four exposed groups the color blended from a bright yellow to medium yellow as the exposure distance was lengthened. Flavor of the hams as scored by a laboratory panel rated only "fair." The reason for this relatively low score is not definitely known; however, the high moisture conditions may be a possible contributing factor.

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CHAPTER I

INTRODUCTION

Country hams are much in demand today because of the distinctive aged flavor as contrasted to the "packing house hams." Country ham production in many Southeastern states is becoming increasingly more important with an enhanced income for the pork industry as a result of the higher selling price for this type ham. However, the production of country hams with the desired aged flavor presents a monetary problem in that capital investment extends over a long period of time, usually one year. Therefore, it would be desirable to develop a procedure whereby the aged flavor of ham is realized in three to six months.

Blumer (1954) found that free fatty acid values were positively associated with aged ham flavor. Cross and Ziegler (1965) stated that the basic meat flavor of cured meat came from precursors other than triglycerides, and that the different aromas of various types of cooked meats depend upon the various carbonyl compounds produced as a result of fat oxidation. These changes which develop the aged flavor occur over an extended period of aging.

It must be remembered that shrinkage of the ham occurs as long as the ham is aging, and according to Kemp et al. (1963) the higher the temperature of aging the more the weight loss. However, Cecil and Woodroff (1953) showed that the higher temperatures resulted in about 6 percent less weight loss for comparable degrees of aging at 86°. Their

results showed that three months of aging produced typically mild aged flavor, moderate aged flavor, and pronounced aged flavor after aging nine months. Therefore, it might be possible to produce an acceptable flavor in a short period of time with germicidal light rays which cause a type of catalytic effect in the production of free fatty acids. These rays may also control mold growth usually present at higher moisture conditions.

Ultraviolet light at wave lengths near 2600 A° (A.M.I.F., 1960) critically alters the nucleic acids of molds and bacteria causing photochemical degeneration. Frazier (1967) states it takes as much as five times exposure to kill vegetative cells of some bacteria as of others, but in general, the killing exposure does not differ widely among different species. The resistance of molds is reported to be from ten to fifty times that of bacteria. Pigmented molds are more resistant than the nonpigmented, and spores more resistant than mycelium.

It was the purpose of this study to determine the effects of ultraviolet light radiation on mold growth, oxidative rancidity development as measured by free fatty acids, shrinkage loss of the hams and palatability characteristics.

CHAPTER II

EXPERIMENTAL PROCEDURE

Source of Hams

Fifty-five hams, including 11 single hams and 22 pairs of left and right hams, were obtained from gilts and barrows of the Yorkshire, Hampshire and Duroc breeds in The University of Tennessee Swine Testing Station. The hogs weighed approximately 210 pounds each.

After chilling at 37°F. for 48 hours prior to cutting, the hams were removed from the carcass packer style (PS) by cutting between the second and third sacral vertebrae on a line perpendicular to the line of the leg, and country style (CS) by cutting between the last two lumbar vertebrae on a line perpendicular to the back. The system described in the Wisconsin Extension Bulletin No. 9 was used to give a quality and marbling score.

Curing and Smoking

The hams were dry cured using two ounces of a curing mixture, containing eight pounds of salt, two pounds of brown sugar and two ounces of sodium nitrate per pound of ham. The curing mixture was applied in thirds at seven day intervals. Curing lasted 30 days. At the end of the curing period, the hams were washed in water at room temperature to remove excess curing ingredients from the surface. The hams were hung with the shank end down in a cooler at 37° $\pm$ 2°F. for

21 days to equalize. Then the hams were smoked for 42 hours at 90° to 95°F. using hickory sawdust. After smoking, the hams were randomly assigned to treatments within both packer style and country style groups.

Aging

Two rooms with dimensions of 8 x 15 x 12 feet equipped with a thermostatically controlled refrigeration unit which constantly circulated the air within the rooms were used for the six treatments. Because of the high outside temperature, moisture was added to the rooms by running a small stream of water across the floor and a portable dehumidifier was used to help maintain the desired relative humidity. The two rooms were maintained at a temperature of 78°F. and a relative humidity of 80 percent. Room one did not contain a germicidal lamp. Room two contained a germicidal lamp and was divided into light side and shielded side. A sheet of six mm. black polyethylene tacked to the ceiling and around the central refrigeration unit effected a division. According to Jawetz (1968), circulating the air in front of a germicidal lamp provides the equivalent of one air change per minute by the destruction of airborne organisms. The black polyethylene curtain from the floor to ceiling provided complete darkness and prevented the visible expression of the germicidal light rays, and therefore was termed the shielded area. A Vic-Sun-Ray[1] lamp equipped with a 25 watt sealed ultraviolet bulb was placed at the end of the room designated light exposure.

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[1]George King Company trade name for the the germicidal lamp.

The sixteen hams in the light exposure were hung 3, 6, 9 and 12 feet from the germicidal lamp. The three packer style and one country style hams of each groups were hung with the aitch bone turned away from the germicidal lamp.

Weighing and Sampling

The initial weights taken before the fresh hams were put into cure were used in calculating the subsequent shrinkage of each period. The initial fat samples were also taken at this time, again after smoking and at the completion of 30 and 60 days aging. These samples were taken from the butt portion according to the procedure developed by Kemp et al. (1957). Samples were wrapped and frozen at -10° ± 2°F. until analyzed for free fatty acid (FFA) content.

Free Fatty Acids

Fat samples were cut into one-fourth inch cubes and rendered in disposable aluminum dishes at 121°C. for one hour and ten minutes in a convection oven. This method was found to be satisfactory by Kemp et al. (1957) in preparing samples for the analysis of free fatty acids. The free fatty acids content was determined using A.O.A.C. (1960) procedures.

Salt Analysis of Samples

At the end of the aging period the ham was first sliced parallel to and just posterior to the aitch bone, leaving the aitch bone on the butt portion. One 1/4 inch slice was taken through the cushion of the ham and used for the salt analysis. The ham slice was sectioned in a

manner similar to that developed by Moulton (1939). The section including the bone part of the slice was excluded. See Figure 1.

At the time the hams were sliced to obtain the taste panel samples, six hams were found to have bone sour spoilage. Salt analysis of the spoiled slices showed less than 3.5 percent salt.

The titratable chloride ions were measured in parts per million and expressed as percent NaCl on a wet basis by the Quantabs[2] method. Each ham sample was cut in small 1/4 inch squares and blended with 10 parts of hot distilled water for five minutes in a Waring Blender and filtered. One Quantab was put in the filtrate and left until the color reaction on the wick was completed before reading the value. The portion of the cooked slices left after taking the samples for the sensory taste panel were analyzed for salt content within 24 hours after the samples were cooked using the above procedure.

Subjective Analysis

Subjective evaluation of mold growth was made every 30 days. Scores for mold growth ranged from one (no mold) to six (very moldy). Visual scores for color and consistency of the subcutaneous fat were recorded after 60 days aging. Color scores ranged from 1 (pale yellow), 2 (medium yellow) to 3 (dark yellow). Consistency scores ranged from 1 (slightly oily), 2 (oily) to 3 (very oily).

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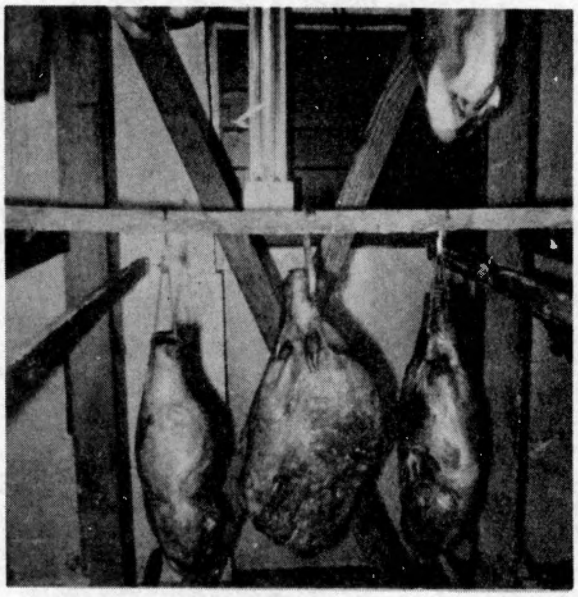
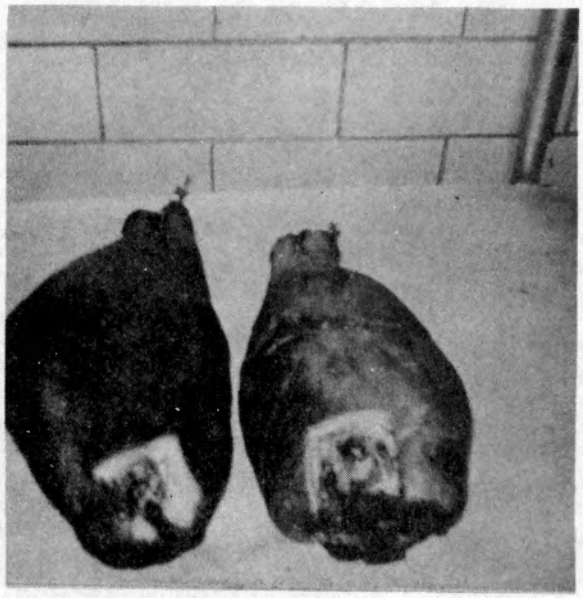
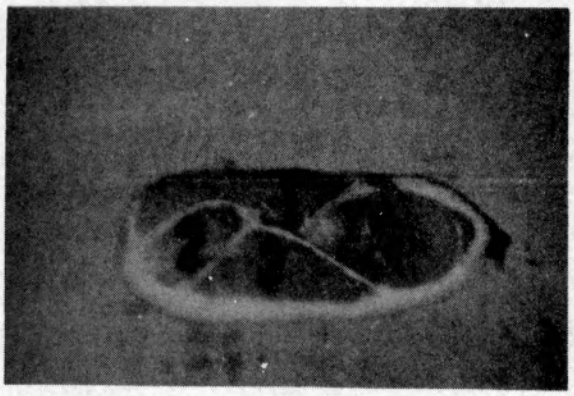
[2]Trademark of the Ames Company Inc., Elkhart, Indiana.



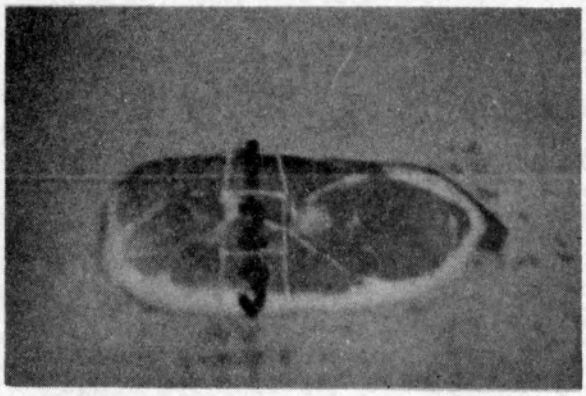
A. Three feet exposure treatment showing germicidal lamp.



B. Sampling fat for FFA analysis.



C. Muscles used for sensory panel.



D. Muscle sections for salt analysis.

FIGURE 1

METHODS USED TO EVALUATE CHARACTERISTICS OF AGING

Sensory Panel

Four hams from each treatment were evaluated organoleptically by a six member sensory panel. The second 1/4 inch center slice was used for the taste panel. After the skin was removed, the ham slices were placed on racks in shallow pans and broiled for four minutes in an oven preheated to 425°F. The slices were turned and broiled for three minutes on the second side. Each slice was separated into six portions, and every panel member received the same anatomical portion of each slice for every ham evaluated. The adductor, semitendinosus, semimembranosus and biceps femoris muscles were evaluated for flavor, juiciness, tenderness and saltiness. Subcutaneous fat was evaluated for flavor only.

A modified hedonic scale for measuring food preference where nine (excellent) to 1 (extremely poor) was used to score flavor, juiciness and tenderness of the lean. The scale measuring saltiness where 9 (correct amount of salt) to 1 (extremely salty) was used to evaluate the salt content of the samples.

Statistical Analyses

The data were analyzed using a method of least squares and analysis of variance as described by Harvey (1960). Duncan's (1955) Multiple Range Test, as extended by Kramer (1957), was used to test significance between means (Steel and Torrie, 1960).

CHAPTER III

RESULTS AND DISCUSSION

Producers of country hams are vitally interested in producing a uniformly high quality product with the minimum amount of spoilage, lowest percentage of shrinkage possible, development of an aged flavor with high consumer acceptance and investment of capital for the shortest perceivable aging time.

Previous work by Kemp (1957), Hunt (1939), Cecil and Woodroof (1954), Skelly (1963) and other workers using conditions of a relative humidity of approximately 60 percent and temperature ranging from 65°F. to 108°F. produced acceptable aged hams in four to six months. These studies indicate that more research needs to be done to determine the effect of relative humidity to the aging process.

Shrinkage

In this study, shrinkage of the ham was observed from the time the ham was separated from the intact carcass. It is clearly shown by this study that shrinkage of the ham continues through all the periods of curing and aging (Table I). This agrees with work done by Skelly *et al.* (1963), Fields *et al.* (1952) and other workers. The greatest amount of shrinkage occurred during the curing process in all hams studied, but there were no significant differences among the three treatments. In all the subsequent periods there was not any definite trend shown. In

TABLE I

LEAST SQUARES MEANS FOR PERCENT HAM SHRINKAGE[a]
BY PERIODS

	Treatments		
Periods	UV Exposure	Shielded	Control
Curing	8.1[b]	9.4[b]	8.3[b]
Equalizing	2.3[b]	3.6[c]	3.5[c]
Smoking	2.8[b]	1.9[c]	2.1[c]
Aging			
30 days	6.8[b]	7.0[b]	6.6[b]
60 days	3.8[b]	3.9[b]	3.4[c]
Total	23.8[b]	25.8[b]	23.9[b]

[a]Shrinkage calculations are based on initial weights.

[bc]Means with common superscripts are not significantly different. All others differ significantly ($P<.05$).

total shrinkage the shielded hams with 25.8 showed the highest shrinkage for all treatments; however, these differences were not significant ($P>.05$).

In comparing the two styles of trimming, packer style hams had a significantly higher shrinkage loss during the curing and equalizing periods than country style hams. Total shrinkage after 60 days aging (Table II) showed 26.2 percent shrinkage for the packer style hams as contrasted to 22.9 for the country style, but the difference was not significant.

According to Skelly et al. (1963) the higher the temperature of aging the more the weight loss. Cecil and Woodroof (1953) showed with a 65 percent relative humidity that the higher temperatures resulted in about 6 percent less weight loss for comparable degrees of aging. The shrinkage loss of the hams aged at 95°F. compared with the same hams aged at room temperature lost 6 percent less moisture because the length of the aging period to develop the mild, medium and pronounced degrees of aged flavor was shortened. In this study, there was less shrinkage loss during the 60 days of aging than reported by Winfree and Ramsey (1968). This is probably due to the higher relative moisture conditions 80 percent maintained throughout the experiment.

Free Fatty Acid

Kemp et al. (1961) showed that free fatty acid (FFA) content of ham fat steadily and significantly ($P<.01$) increased during aging. In this present study, FFA content significantly ($P<.01$) increased with

TABLE II

COMPARISON OF COUNTRY STYLE AND PACKER STYLE HAMS--PERCENT SHRINKAGE BY PERIODS

Periods	Percent Shrinkage	
	Packer style	Country style
Curing	9.3**	7.7
Equalizing	12.3**	9.6
Smoking	14.7	12.6
Aging		
30 days	21.8	19.2
60 days	26.2	22.9

**(P<,01).

[a]Comparisons included twenty-two pairs of hams across all treatments.

aging in all of the treatments (Table III). These levels are higher than those reported by Kemp et al. (1961) for hams handled in a similar manner without the presence of a germicidal lamp. They found FFA levels were about 1.8 percent after smoking, about 4.5 percent after 60 days aging, and under 7 percent after 180 days aging. In previous work at the Tennessee Station, Winfree and Ramsey (1968) found that average FFA levels increased from 2.1 percent to 6.9 percent during 60 days aging without a germicidal lamp.

Blumer (1954) found that FFA values were positively associated with aged ham flavor. It may be possible to produce an aged flavor in hams more quickly by exposing them to ultraviolet light rays (Winfree, 1968).

In the present study, the FFA content of hams before curing ranged from 0.7 to 1.1 and after smoking ranged from 1.9 to 2.3 among all treatments. In the randomization of hams to the six treatments those hams with the lowest FFA values before curing were allotted for the exposure groups. Although these hams showed a trend of significant difference during the periods before cure and after smoking, there was not a significant difference among the treatments after aging for 30 or 60 days. However, there was a marked increased in FFA values during the first 30 days of aging and the ensuing 30 days showed an increase less pronounced. Within the exposed treatments the hams nearest the light had the highest FFA values, but these differences among the exposed group were small. Differences in FFA content of subcutaneous fat from

hams 3, 6, 9 and 12 feet from the germicidal lamp were not significant after 60 days aging.

Mold Growth, Fat Color and Fat Consistency

With the conditions of 78 degrees farenheit and 80 percent relative humidity mold growth was expected to develop on the hams. The hams were evaluated for mold growth after aging 30 to 60 days and these results are given in Table IV. In the hams exposed to ultraviolet radiation, mold scores were determined on the ham side away from the light. Jensen (1942) states, that the mesophilic molds including many Aspergilli, Penicillia and Mucors grow well at 98°F. but some grow at both higher and lower temperatures.

After the aging period Mundt (1968) identified six species of organisms from the surface of hams in this study. He identified four species of Aspergilleae, and one each of Syncephalastrum and Chlemydomyceae. Frobisher (1958), Fulton and Coblentz (1928) and Frazier (1957) found untraviolet light to be a powerful inhibitor of growth.

In the control of molds germicidal light appears to be effective by direct radiation and by sterilization of the surrounding air. According to Jawetz (1968), circulating the air in front of a germicidal lamp provides the equivalent of one air change per minute by the destruction of air-borne organisms. The subcutaneous fat surface of the hams turned toward the light did not develop any mold in the exposure distances up to 9 feet at the end of 60 days. The surface of the ham turned away from the direct radiation in the 6, 9 and 12 feet distance groups did

TABLE IV

MOLD GROWTH, FAT COLOR AND FAT CONSISTENCY SCORES BY TREATMENTS

Treatment	Mold Score[a] 30 days	Mold Score[a] 60 days	Fat color[b]	Fat consistency[c]
Control				
No lamp	1.90[d]	2.00[e]	1.57[d]	2.24[d]
Germicidal lamp				
Shielded	1.63[d]	1.95[e]	1.63[d]	2.63[e]
Exposure distance				
3 feet	1.00[d]	1.25[d]	2.25[d]	2.50[e]
6 feet	1.00[d]	1.75[e]	2.00[d]	2.50[e]
9 feet	1.00[d]	2.00[e]	1.75[d]	2.50[e]
12 feet	1.00[d]	1.50[e]	1.25[d]	2.25[d]

[a] 1 = no mold, 2 = very slight mold, 3 = slight mold, 4 = moderately molded, 5 = molded, 6 = very molded. Scores made on side of ham away from light.

[b] 1 = light yellow, 2 = medium yellow, 3 = intense yellow.

[c] 1 = dry, 2 = slightly oily, 3 = oily.

[de] All means with common superscripts in the same column are not significantly different. Others are significant ($P<.05$).

develop a very slight mold. However, the entire surface of the hams in the 3 feet exposure showed complete control of mold growth. After 30 days aging the shielded hams had significantly less mold growth than the control hams ($P<.05$). This would indicate that the ultraviolet radiation is not only effective as direct exposure, but may have a limited activity in sterilization of the air.

Frazier (1967) and AMIF (1960) state that the effectiveness of a germicidal lamp depends upon time, intensity and penetration. The longer the time exposure at a given concentration the more effective will be the treatment. This study and work by Winfree and Ramsey (1968) show this to be true, the closer the hams were to the lamp the more effective the control of molds, as the distance increased there was a decreased effectiveness of ultraviolet radiation. Koller (1965) states although the degree of killing of bacteria and molds resulting from the germicidal light exposure does not vary greatly from one species to another, it depends greatly on the conditions of irradiation. The moisture conditions exert a very marked effect. Where bacteria are suspended in air an increase in relative humidity results in greatly decreased death rate. This effect is most noticeable at humidities greater than 50 percent.

The hams in this study were smoked for a period of 42 hours, and therefore the concentration of phenolic compounds from the smoking hickory sawdust increased and may have given an inhibitory effect to the future growth of molds. Frazier (1967) states wood smoke contains a large number of volatile compounds that differ in their bacteriostatic

and bactericidal effect. Formaldehyde is considered the most effective of these compounds with phenols and cresols next in importance. Wood smoke is more effective against vegetative cells than against bacterial spores, and the concentration of mycostatic materials from wood smoke necessary to prevent mold growth increases with a rise in the humidity of the atmosphere of storage. Had the hams been smoked only for 24 hours, it is possible that more mold growth might have been observed.

The external appearance of the hams nearer the ultraviolet light after 60 days aging had a more intense yellow color (Table IV, page 16). The yellow color was less intense as distance from the light increased. This yellow color did not appear to be typical of that of aged hams. The color differences among treatments were small and nonsignificant.

The consistency of the subcutaneous fat was affected by the distance from the light. Hams nearer the germicidal lamp had an oilier appearing fat; however, those hams shielded from the germicidal lamp had a similar appearance. The explanation for this is not known. There was no significant difference in the appearance of the hams 12 feet from the germicidal lamp compared with the hams in the control room at the end of 60 days aging. The hams of all treatments had an exudative material in evidence particularly after the first 30 days aging.

Salt Content

A center slice from each ham used for sensory panel evaluation was analyzed for salt content using the Quantabs method. Each cross-sectional slice was divided into three equal sections (Figure 1, page 7)

and analyzed separately. The purpose of this analysis was to evaluate equalization of salt within the hams.

The hams in the shielded treatment had the lowest percent salt, but the difference in salt content among all treatments was not significant. The shielded hams were the heaviest hams and the initial salt intake by these hams may not have been as rapid as that of lighter hams. Kemp (1961) stated that the curing room without a control of humidity might possibly affect the salt concentration of the hams.

The taste panel scores on saltiness substantiate the salt analyses, in that, there was not any significant difference in the saltiness scores. All of the salt scores were within the range of acceptability. The pooled analyses of the sections 1, 2 and 3 (Table V) showed the salt content of the raw slices ranged from 3.9 to 4.9 percent.

Sensory Panel

A laboratory panel of three women and three men evaluated the characteristics of flavor of lean and fat, juiciness, tenderness and saltiness for each of the 18 hams. There were no significant differences among treatments for lean flavor, fat flavor, juiciness and tenderness. The flavor of fat was evaluated from a separate sample given to the panel after the lean portion had been evaluated for palatability.

The combination of 78 degrees farenheit and 80 percent relative humidity are quite a deviation from the "normal" aging conditions. The desirable flavor and aroma appears to have been diminished with the abnormally high moisture present. Winfree and Ramsey (1968) showed that

TABLE V

SENSORY PANEL SCORES AND SALT ANALYSIS BY TREATMENTS[a]

Treatments	Percent salt analysis cooked slices[b]	Sensory Panel Scores				
		Salti-ness	Lean flavor	Fat flavor	Juici-ness	Tender-ness
Control						
No lamp	7.2	7.2	5.2	6.3	6.9	6.8
Germicidal lamp						
Shielded	5.9	7.0	5.4	5.7	7.5	7.1
Exposure distance						
3 feet	6.9	7.5	5.9	5.2	6.8	5.8
6 feet	7.0	7.2	4.4	4.9	6.6	6.1
9 feet	6.0	7.7	6.3	6.3	6.8	6.4
12 feet	6.4	7.2	6.3	6.3	6.8	6.6

[a]No significant difference was present among the six variables for all treatments ($P>.05$).

[b]Panel saltiness scores: 1 = extremely salty, 2 = very salty, 3 = salty, 4 = moderately salty, 5 = moderate amount of excess salt, 6 = small amount of excess salt, 7 = slightly salty, 8 = very slight excess of salt and 9 = correct amount of salt.

Other scores based on 9 point scale (9--most desirable).

with high temperature and a relative humidity of 75 percent hams had an acceptable aged flavor. Generally a score of seven or above for lean flavor, juiciness and tenderness is considered acceptable. The flavor of the hams in this study could not be attributed to the germicidal lamp because this condition was present in hams from all treatments. According to a study by Landmann et al. (1966), the oxidative deamination and mild oxidation of fats are the primary reactions responsible for the production of volatile flavor components.

CHAPTER IV

SUMMARY

The effects of germicidal light on country hams aging at 78°F. and 80 percent relative humidity, conditions above "normal," were observed in six treatments for 60 days. Two rooms equipped with humidity and temperature controls and a central refrigeration unit were used. Room one was designated the control room, and room two was equipped with a large sheet of six mm. black polyethylene which effected a division of the room. The side of the room with a Vic-Sun-Ray germicidal lamp was designated the exposure side and the other side completely darkened side referred to as shielded. There was free air exchange in both rooms, and air in room two circulated in front of the ultraviolet light caused sterilization of the air.

The total shrinkage among all treatments was not significantly different, but there were some significant differences between treatments within periods. In comparing the shrinkage of packer and country style hams, there were significant differences in both the curing and equalizing periods, but significant differences were not present after 60 days aging.

The free fatty acid (FFA) content of the hams allotted to the exposure distance treatments through 60 days aging showed the FFA difference among treatments to be nonsignificant.

There was not a significant difference in the color of the hams among all the treatments after 60 days aging. The color of the hams in the exposure group showed that nearer the ultraviolet light a darker intense yellow color developed, and those hams 12 feet from the light had a softer yellow color. The color of the hams, 3, 6, and 9 feet from the ultraviolet light was not the typical color of aged hams. The consistency of the fat of the hams nearer the ultraviolet light was oilier and softer than the hams 12 feet from the light.

The mold growth was evaluated at 30 and 60 days aging, and there was a significant difference ($P<.05$) between the exposure group and the shielded and control treatments. The recorded mold growth on the exposure hams were taken from the side away from the light. There was a signigicant difference in mold growth during the first 30 days of aging, and the exposure treatments of 3, 6, 9 and 12 feet away from the germicidal lamp had significantly less mold growth after 30 days aging than the shielded and control treatments. After 60 days aging those hams 3 feet from the light had significantly ($P<.05$) less mold development than the hams in the control, shielded, and 6, 9 and 12-feet exposure treatments.

In conclusion, ultraviolet rays emitted from a germicidal lamp were effective in controlling mold growth and produced an oilier, softer fat in aged hams. In this study, ultraviolet light did not improve the palatability of the hams aged in the high controlled moisture conditions, as there was no significant difference among the treatments in the panel palatability scores. High moisture conditions gave a negative effect in the development of the high quality aged flavor.

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LITERATURE CITED

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VITA

Robert Scott Erwin was born in Florence, Alabama, June 17, 1941 to Mr. and Mrs. Jesse Holston Erwin. He is one of two children. He went to Karns High School and was active in sports. After graduation from high school in 1959, he enrolled at The University of Tennessee in the College of Agriculture. He majored in Animal Husbandry and was active in the Block and Bridle Club. In his senior year he served as treasurer of the Block and Bridle Club and was a member of the livestock judging team. He graduated in 1964 and in the fall, 1964, entered graduate school at The University of Tennessee to pursue a master of science degree.

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