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To the Graduate Council:

I am submitting herewith a thesis written by Stanley Thyson Hord entitled "The Effects of Antemortem and Postmortem Management on the Quality of Processed Catfish." 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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192

THE EFFECTS OF ANTEMORTEM AND POSTMORTEM MANAGEMENT
ON THE QUALITY OF PROCESSED CATFISH

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
Stanley Thyson Hord

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ABSTRACT

This study was conducted to determine the effects of method of slaughter and holding time before freezing on the quality of processed channel catfish. Seventy-two channel catfish weighing 454 to 567 grams each were used in this experiment. The fish were divided into three groups (method of slaughter) with one group being immediately beheaded, the second group was electrocuted and the third group was held on ice for 12 hours preceding processing. After processing fish muscle from each group was evaluated for pH, shear, wavelength and purity (color), water holding capacity, rancidity and organoleptic characteristics.

These data indicate that less force was required to shear fish muscle as holding time after slaughter was extended up to twelve hours. Oxidative rancidity tended to develop in the fish muscle as the time between slaughter and freezing was lengthened. The muscle from fish slaughtered by electrocution was significantly ($P < 0.05$) darker than those slaughtered by suffocation in ice or by the beheading method. The data from the organoleptic evaluation indicated that the panel tended to prefer a sample with average texture regardless to method of slaughter or holding time. It can be concluded from these data that fish slaughtered by either of the three methods studied and held up to 12 hours at 4.5°C before freezing will be of acceptable quality to the consumer when battered, breaded and deep fat fried.

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CHAPTER I

INTRODUCTION

Channel catfish (Ictalurus punctatus Rafinesque) is a new and growing product in the Tennessee Valley Region. It is estimated that by 1975, fish producing waters will reach 30,352.5 and yields per hectares will average about 3706.45 kilograms with a projected value of 40 million dollars [17,19]*.

Since channel catfish is a new product little is known about the processing and storage characteristics of this type fish. Research has been conducted in the area of packaging and materials, storage temperatures, and processing. Greig and Donahue [8] concluded that properly packaged channel catfish can be marketed as a frozen product without appreciable loss of quality for a period of several months. Frozen catfish held under controlled conditions (16 months at -20.5°C) were quite acceptable after being cooked.

Drake [6] reported that channel catfish packaged in 1.5 mil polyethylene, regardless of package variables and stored at -17.8°C , were preserved in excellent condition for up to one year without any significant decrease in quality. Catfish presently being processed are slaughtered by one of three methods: (1) the removal of the head with a band saw, (2) electrocution just prior to processing and (3) packed

*The numbers in brackets represent similarly numbered references in the bibliography.

on ice and allowed to die from suffocation. Under some conditions the fish are held for several hours before they are packaged and frozen. The literature indicates that conditions of stress on the fish prior to slaughter and time lapse from slaughter to the frozen state may induce undesirable flavors and texture changes. The purpose of this research was to determine the effects of different methods of slaughter and time lapse from slaughter to freezing on the organoleptic quality of frozen channel catfish.



CHAPTER II

LITERATURE REVIEW

Channel catfish production in the United States is a new farm crop produced mainly in the Southeastern states in pond and raceway culture. The production of channel catfish now exceeds 23.5 million kilograms per year [19]. Research in this field has mainly been in the area of production methods, nutrition, disease and parasite control. This has caused an interest in the evaluation of processing and how the quality of catfish muscle can be improved.

The increased production of catfish has presented the industry with the challenging economical problems of processing large numbers of fish. Fish are not usually dressed at the pond site. They are hauled to a processing plant to be put into a marketable form. These processing plants, in order to serve a larger number of farmers are centrally located in a production area. Farmers on the fringe of these areas often are required to haul fish great distances. This presents the farmer with the problem of moving the fish to the processing plant without appreciable quality loss. At the present time two methods of hauling are used. The first method used is live hauling from pond to the processing plant and placing the fish in holding canals until they are processed. This method of transporting the fish is being replaced by one in which the fish are placed on ice after harvesting and holding temporarily until they are transported to the processing plant and

processed. This method of hauling on ice presents new problems to the processor. In a study of live versus ice hauling by U.S.D.I. [26], it was concluded that dead catfish skinned by hand or machine should not be held on ice for more than 3-4 days. The fish become extremely hard to skin especially around the neck and belly flaps. After 5 days, processing was virtually impossible either by hand or machine. Fish held up to 9 days on ice were considered acceptable organoleptically.

Henton [10] indicated that fish electrically stunned prior to processing underwent changes in the nature of the muscle protein immediately following slaughter which influenced muscle texture. A study of the salt extractable proteins including myosin, actin, and actomysin indicated that the major changes in these proteins occurred in the first 12 hours after processing. Moorjani [18] concluded that the changes in fish during storage on ice are subtle and unlike the changes during frozen storage. They are related to and similar to the protein alterations occurring during rigor mortis and subsequent tenderization during aging.

Peters [20] found that fresh whiting stored for 2 days in either ice or refrigerated sea water had a frozen-storage life of 12 months. Fish that were stored for 4 days on ice or 7 days in refrigerated sea water decreased the frozen-storage life to 6 months. It was also found by Reay [21] that the storage life of frozen haddock decreased in direct proportion to the length of time on ice. This finding was supported by the work of Young [30] with halibut and with shrimp by Dassow [5] and Feiger [7].

Connell [4] concluded from a study of icing cod and haddock that there was no significant difference between fish iced for 2, 5, and 8 days.

Temperature experiences have a cumulative effect on storage life. The longer the prefreezing storage period, the shorter the frozen storage life. The rate at which seafoods are frozen, within broad limits, is of less importance than the subsequent storage temperature insofar as maintaining quality is concerned [14].

Boggess [3] showed that different processing and handling practices influences the storage life of the frozen product. Catfish as a frozen product has been shown to be quite acceptable. Greig and Donahue [8] concluded that properly packaged channel catfish can be marketed as a frozen product without appreciable loss of quality for up to 16 months storage at -20.5°C . Drake [6] reported the inability of taste panelists to differentiate between fish frozen for one year in 1.5 mil polyethylene pouches at -17.8°C or below and fresh fish. It was also concluded by Boggess [3] that fish held at -17.8°C for 270 days did not significantly decrease in quality.

Greig and Donahue [8] in a study of frozen catfish showed no significant increases in T.B.A. values over a 16 month period. Drake [6] concluded that frozen channel catfish stored for one year did not increase significantly in T.B.A. values, Boggess [3] also concluded that frozen channel catfish stored at -17.8°C up to 270 days did not have a significant increase in T.B.A. values. These reports are supported by

findings of Lovell [16] who showed channel catfish to be relatively lower in unsaturated fatty acids than most fish species.

Heaton [11] reported substantial differences in quality, especially appearance and flavor among individual fish within similar treatment group. It was also concluded from this experiment that nonprocessed channel catfish changed more in quality during the first 48 hours than between 48 and 96 hours on ice.

CHAPTER III

MATERIALS AND METHODS

I. Preparation and Treatment of Samples

Seventy-two channel catfish 454 to 567 grams each were included in this study. The fish were obtained from a local fish farmer and delivered in water tanks to the Food Technology Laboratories and again placed in aerated water tanks until they were processed.

Twelve fish were randomly allotted to each of three treatment groups which was replicated twice. Treatment one consisted of beheading the live fish immediately after removal from the water tanks. Fish in treatment two were removed from the holding tanks, placed in a small container of water and electrocuted by a 12 volt stream shocker. Treatment three consisted of placing the live fish in an ice pack for twelve hours prior to processing thus allowing suffocation. These three treatments represent slaughter methods commonly used in the catfish industry today.

Following slaughter the fish were eviscerated, skinned and placed in a 4.5° C cooler. At 0, 4, 8, and 12 hour time periods following slaughter and dressing the fish muscle was analyzed for pH, mechanical tenderness, color, thiobarbituric acid (T.B.A.) and water holding capacity (W.H.C.).

The remaining flesh of the three fish in each subtreatment were combined to form a block, and frozen for use in sensory evaluation tests.

II. Methods of Sample Analysis

pH Determination

pH was determined with a Beckman pH meter equipped with a combination electrode. It was standardized and checked periodically with a buffer solution (sodium tetroborate and potassium phosphate) of pH 7.003 at 25°C. The muscle was split and the electrode inserted into the cut tissue for measurement. An average of two measurements were recorded from each fish.

Water Holding Capacity (W.H.C.)

The water-holding capacity of the fish muscle was determined by a method similar to one used by Wierbicki et al. [22,27,28,29]. Three 0.30 gram samples were removed from each fish and placed in the center of No. 1 Whatman filter paper. A set of samples, each set consisting of three pieces of filter paper and three 0.3 gram samples stacked alternately between 4 Plexiglas plates (7×7 inch), was pressed on a Harco hydraulic press (Model LB 6721, Harco Industries, Phoenix, Ariz.) at 102.04 psig' for 1 minute. After pressing, the Plexiglas plates with the meat samples were removed and the pressed meat area was marked with a pencil on the back of the filter paper. The area of the pressed meat and free moisture area was measured with a Keuffel and Essel Compensating polar planimeter (Model 62005, Keuffel and Essel Co., Hoboken, N.J.). From these measurements,

$$\text{Unit Pressure} = \frac{\text{Total Force}}{\text{Unit Area}} = \frac{5000 \text{ lb.}}{49 \text{ sq.in.}} = 102.04 \text{ psig,}$$

the expressible moisture index (E.M.I.) was calculated by the formula:

$$\text{E.M.I.} = (\text{muscle fat} + \text{juice spread, sq.cm.}) - (\text{muscle area, sq.cm.}).$$

Texture Measurement

An Allo-Kramer Shearpress (Model SP-12) was used to determine the tenderness or texture of the muscle [12,13]. A 1000 pound proving ring was used with a 20 second thrust. The samples used for this measurement were taken from the lateral musculature section of the fish immediately anterior to the tail fin. The sample was placed in the standard shear-compression cell for testing. The values recorded from the dial were converted to equivalent pounds force by use of a standard curve.

Measurement of T.B.A. Values for Rancidity

Oxidative rancidity in fat-containing foods leads to the formation of malonaldehyde or derivatives of this compound. The red reaction product formed by the reaction malonaldehyde and 2-thiobarbituric acid (T.B.A.) is an effective means of measuring the extent of auto-oxidation [23,31]. The compound 1,1,3,3-tetraethoxypropane (T.E.P.) hydrolyzes to yield malonaldehyde which reacts with T.B.A. to give the typical red color. T.E.P. was employed as a standard for the T.B.A. determination of malonaldehyde. In this determination the malonaldehyde content of samples was quantitatively measured and the degree of oxidative rancidity expressed in milligrams of malonaldehyde/1000g of sample (T.B.A. value).

Water extract method was used to measure the oxidative rancidity of the samples [25]. Ten grams of tissue sample was blended in a Waring blender with 50 ml of distilled water for two minutes. The slurry was transferred to a beaker with an additional 50 ml of distilled water, filtered into a 100 ml volumetric flask and completed to volume with distilled water. Five ml of clear filtrate was pipetted into a test tube containing 5 ml of T.B.A. reagent, stoppered and set aside for 15 hours at room temperature. Absorbancy was read at 530 mμ on a Perkin-Elmer Double Beam Spectrophotometer (Model Coleman 124, Hitachi Co., Japan).

Color Measurement

Color measurements were carried out by The Hunter Lab Digital Color Difference Meter (Model D2502M/L, Hunter Associates Laboratory, Fairfax, Virginia), to measure the tristimulus values of the samples. The reference standard (Illuminant "C"-barium sulfate Standard number D25 C2-136) was used to calibrate the instrument before use. The sample, whole fish, was placed over the sample port and three readings were taken and averaged. The values taken from the instrument were the Commission International de l'Eclairage (C.I.E.) X, Y, and Z values, from which were calculated the chromaticity coordinates x and y. Purity and the dominant wavelength were obtained by reference to the C.I.E. chromaticity diagram [9]:

$$x = X/(X + Y + Z)$$

$$y = Y/(X + Y + Z)$$

Purity and dominant wavelength values were obtained by reference to the C.I.E. chromaticity diagram.

Sensory Evaluation

Test Method. A hedonic preference test was used to evaluate the overall acceptability and to determine the degree of acceptance for each sample [1,15]. A nine-point scale was used with the descriptions ranging from "like extremely" to "dislike extremely". The descriptive terms on the score sheet were assigned a numerical value for analysis of the data with values ranging from one to nine. The sensory test was replicated three times by a panel of ten judges and the same persons were used throughout the test sessions.

Test Procedures. The 12 samples of the study were randomly assigned to two servings and only six of the samples were served to the panel at any one time, because an excessive number of samples causes the panel member to lose the ability to detect differences. The samples were served on paper plates and identified by code numbers. They were battered (Golden Dip 70-65) and breaded (Golden Dip 48-01), deep-fat fried in cottonseed oil at 205°C for four minutes and served to the taste panel members.

III. Statistical Analysis

The Statistical Analysis System [2] computer program at the University Computer Center was used for the calculation of analysis of

variance. Data on pH, shear, W.H.C., T.B.A., taste panel and color determinations were analyzed as a randomized complete block design. Correlation coefficients among all variables were determined. Differences between means were analyzed by the Duncan's Multiple Range Test [24].

CHAPTER IV

RESULTS AND DISCUSSION

I. Effects of Slaughter Methods and Chilling Time Before Freezing on pH of Fish Muscle

The summary of the analysis of variance for the effect of method of slaughter and holding time before freezing of channel catfish muscle is presented in Table 1. There was no significant difference ($P > .05$) in muscle pH among treatments, time and replication. Although non-significant muscle pH increased from 0 to 12 hours chill time. The pH was 6.48 immediately following slaughter and 6.74 at 12 hours for the three slaughter methods. This pH rise of postmortem fish muscle was the reverse of the reaction which occurred in the red meat animals and was not expected in this study. In salt water fish ultimate muscle pH postmortem normally is 6.2 to 6.6. The increased pH during the 12 hour time period could possibly have resulted from the build-up of end products of bacteriological breakdown of proteins which would tend to increase the pH. The fish were also chilled quickly thus slowing the glycolytic processes and in 12 hours the pH did not fall as expected.

II. Effects of Slaughter Methods and Chilling Time Before Freezing on Shear Values of Fish Muscle

The summary of the analysis of variance for the effect of method of slaughter and holding time before freezing on shear value is shown

TABLE 1

Analysis of Variance for the Effect of Slaughter Method and
Chilling Time Before Freezing on the pH of Catfish Muscle

Source	D.F.	M.S.
Treatment ¹	2	.036 N.S.
Time ²	3	.088 N.S.
Replication	1	.006 N.S.
Residual Error	17	.038
Total	23	

¹The fish were slaughtered by beheading, electrocution, or holding on ice for 12 hours postmortem.

²Fish were chilled at 4.5°C for 0, 4, 8, and 12 hours prior to freezing. Samples were collected for analysis at each time period.

in Table 2. Treatment, time, and replication significantly affected the pound force necessary to shear the catfish muscle. Shear value means for slaughter treatment and time of chilling postmortem are presented in Table 3. No difference was observed in mean shear force for fish electrocuted and chilled for 0, 4, or 8 hours prior to freezing. The fish slaughtered by suffocation in ice showed a significant ($P < 0.05$) increase in tenderness at the 8 hour time period. The fish slaughtered by suffocation were placed in ice for 12 hours prior to evisceration and dressing so that when shear values for the 0 time period were recorded the fish had been dead for several hours and would be expected to differ in respect to postmortem muscle characteristics such as tenderization. The results for the three slaughter methods indicates that a tenderization of the fish muscle does occur beginning at about 8 hours postmortem in some cases. Although not tested in this study the possibility exists that longer chilling period prior to marketing catfish may result in over tenderization frequently turned mushy. Method of slaughtering fish apparently influences the conditions which have an affect on fish muscle tenderness and should be considered when choosing a slaughter method. Further study is needed to determine the affects of holding chilled fish for longer than twelve hours. The relationships of chill time after slaughter and method of slaughter to shear values are graphically illustrated in Figure 1.

TABLE 2

Analysis of Variance for the Effect of Slaughter Method and Chilling Time Before Freezing on the Shear Values¹ of Fish Muscle

Source	D.F.	M.S.
Treatment ²	2	261.26*
Time ³	3	224.01*
Replication	1	212.41*
Residual Error	17	46.89
Total	23	

* $P < 0.05$.

¹Shear values were recorded as kilograms per gram required to shear the muscle sample.

²The fish were slaughtered by beheading, electrocution, or holding on ice for 12 hours postmortem.

³Fish were chilled at 4.5°C for 0, 4, 8, and 12 hours prior to freezing. Samples were collected for analysis at each time period.

TABLE 3
Shear Values¹ for Slaughter Method and Chilling Time²
Prior to Freezing of Catfish Muscle³

Slaughter Methods	0	4	8	12
Beheaded	33.23a	27.54abc	26.59abc	24.21bc
Electrocuted	32.97a	32.31a	31.25ab	26.65abc
Held on Ice	28.02abc	25.83abc	21.72c	23.44c

Values followed by the same letter are not significantly different, ($P > 0.05$).

¹Shear values were recorded as kilograms per gram required to shear the muscle sample.

²The fish were held in a 4.5°C cooler for the various time periods prior to freezing.

³Time means are composed of 12 observations.

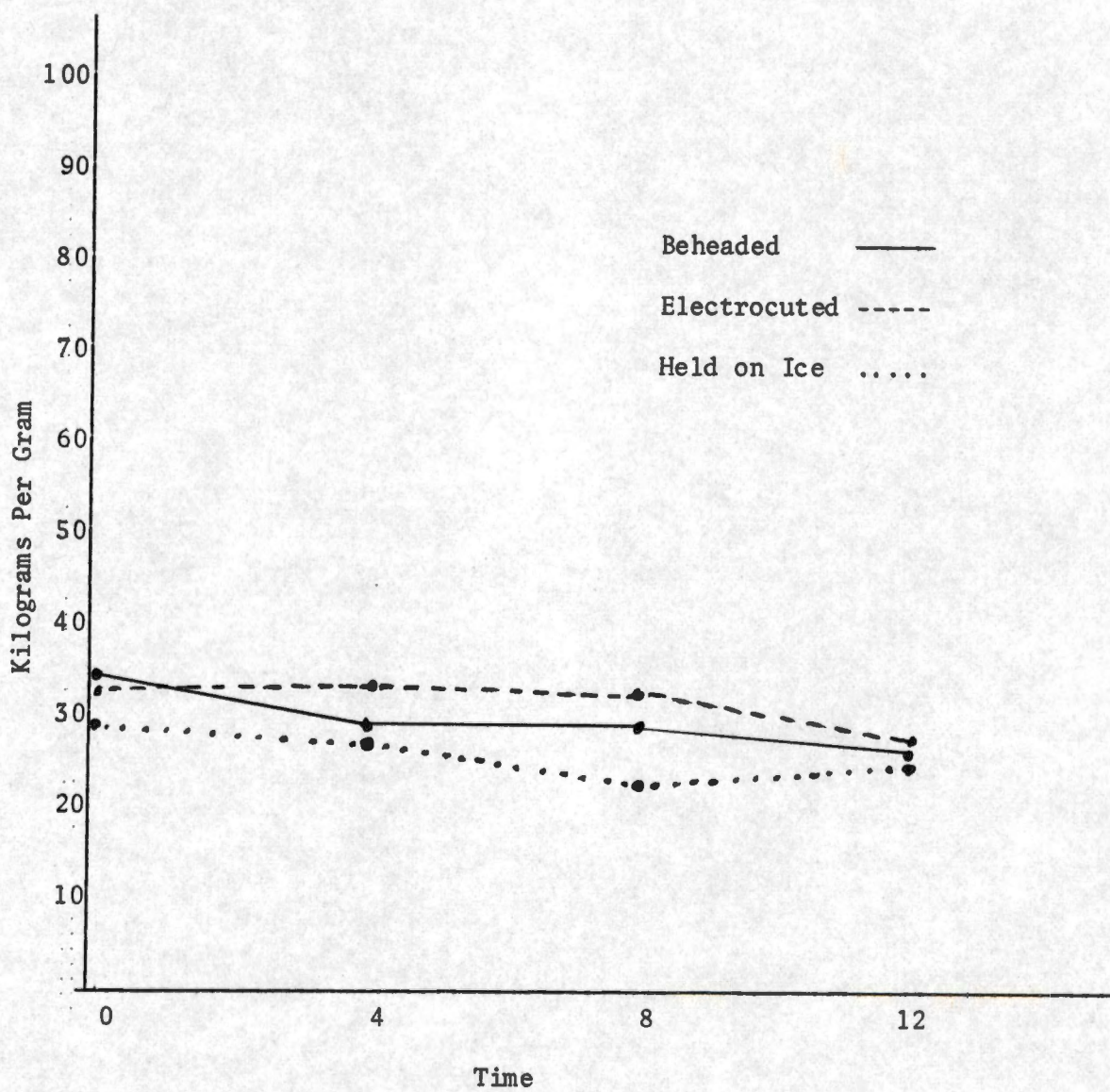


Figure 1. Relationship of shear values to chilling time before freezing on fish muscle slaughtered by three different methods.

III. Effects of Slaughter Method and Chilling Time Before Freezing on the Color of Fish Muscle

The results of color values calculated from the Hunter Lab digital color difference meter readings are presented in Tables 4 through 6. The analysis of variance of wavelength (reflectance) and purity of catfish muscle indicates significant treatment affects due to slaughter method (Table 4). The significant difference between the treatments for both wavelength and purity is due to the changing of the flesh color of fish in the electrocution treatment. The flesh of the electrocuted fish had a reddish tint that was observed while dressing. The flesh of fish in the beheaded and suffocated in ice groups was grayish-white in color. The reflectance means presented in Table 5 indicate that the dominant wavelength reflected from the fish muscle samples was in the orange region of the light spectrum. One value at the 8 hour time period in the suffocated in ice group was significantly different from all other means resulting in a significant treatment and time affect when these data were subjected to an analysis of variance. Since the 12 hour value was the same as 0 and 4 this apparently is an error in measurement and until studied further should not be emphasized.

The affect of slaughter method and chill time prior to freezing of catfish muscle on color purity values is presented in Table 6. These data indicate that fish slaughtered by electrocution were significantly darker in color beginning at the 8 hour time period. This darker color was observed at slaughter and became increasingly apparent as time of chilling was extended. This color difference might present a

TABLE 4

Summary of the Analysis of Variance for the Effect of Slaughter Method
and Chilling Time Before Freezing on Wavelength and
Purity of the Fish Muscle Color

Source	D.F.	Wavelength M.S.	Purity M.S.
Treatment ¹	2	69.12**	40.94**
Time ²	3	12.48 N.S.	9.74 N.S.
Replication	1	5.04 N.S.	14.64 N.S.
Residual Error	17	11.34	5.37
Total	23		

** P < 0.01.

¹The fish were slaughtered by beheading, electrocution, or holding on ice for 12 hours postmortem.

²Fish were chilled at 4.5°C for 0, 4, 8, and 12 hours prior to freezing. Samples were collected for analysis at each time period.

TABLE 5
 The Affect of Slaughter Method and Chilling Time¹
 Prior to Freezing on Reflectance (Wavelength)
 of Catfish Muscle²

Slaughter Methods	Time			
	0	4	8	12
Beheaded	583a	582ab	582ab	578ab
Electrocuted	579ab	580ab	578ab	576ab
Held on Ice	576ab	576ab	574b	576ab

Values followed by the same letters are not significantly different ($P > 0.05$).

¹The fish were held in a 4.5°C cooler for the various time periods prior to freezing.

²Time means are composed of 18 observations.

TABLE 6

Purity Values for Slaughter Method and Chilling Time¹
Prior to Freezing of Catfish Muscle²

Slaughter Methods	Time			
	0	4	8	12
Beheaded	3.8a	6.5a	4.1b	7.6ab
Electrocuted	6.2a	8.2a	11.2a	12.3a
Held on Ice	7.1a	5.8a	4.1b	6.1b

Values followed by the same letters are not significantly different ($P > 0.05$).

¹The fish were held in a 4.5°C cooler for the various time periods prior to freezing.

²Time means are composed of 18 observations.

merchandizing problem to industry. The exact voltage used in this study was not determined and could have an affect on the extent of this off white color which was observed. Further study of voltage levels used in this particular slaughter method and their affects on fish muscle is needed. In the beheaded and suffocated in ice groups no differences in color purity was observed. Figures 2 and 3 graphically present the slaughter method and chill time relationships for wavelength reflectance values and color purity respectively.

IV. Effects of Slaughter Method and Chilling Time Before Freezing on the T.B.A. Values (Rancidity) of Fish Muscle

The summary of the analysis of variance for the effect of slaughter method and holding time before freezing on rancidity of fish muscle is shown in Table 7. Method of slaughter and chilling time significantly ($P < 0.01$) affected the T.B.A. values. A significant replication effect was also observed in this study.

Slaughter method and chilling time means are presented in Table 8. Fish slaughtered by the suffocation on ice method had significantly higher T.B.A. values at 8 and 12 hours than either those beheaded or electrocuted. This higher rancidity development is probably due to these fish dying several hours prior to the dressing and chilling periods thus allowing more time for oxidative rancidity to develop. The significant increase in T.B.A. values from 0 to 12 hours was the same for the three slaughter methods. These data indicate that the fish slaughtered by the suffocation method have higher rancidity which could lead to a

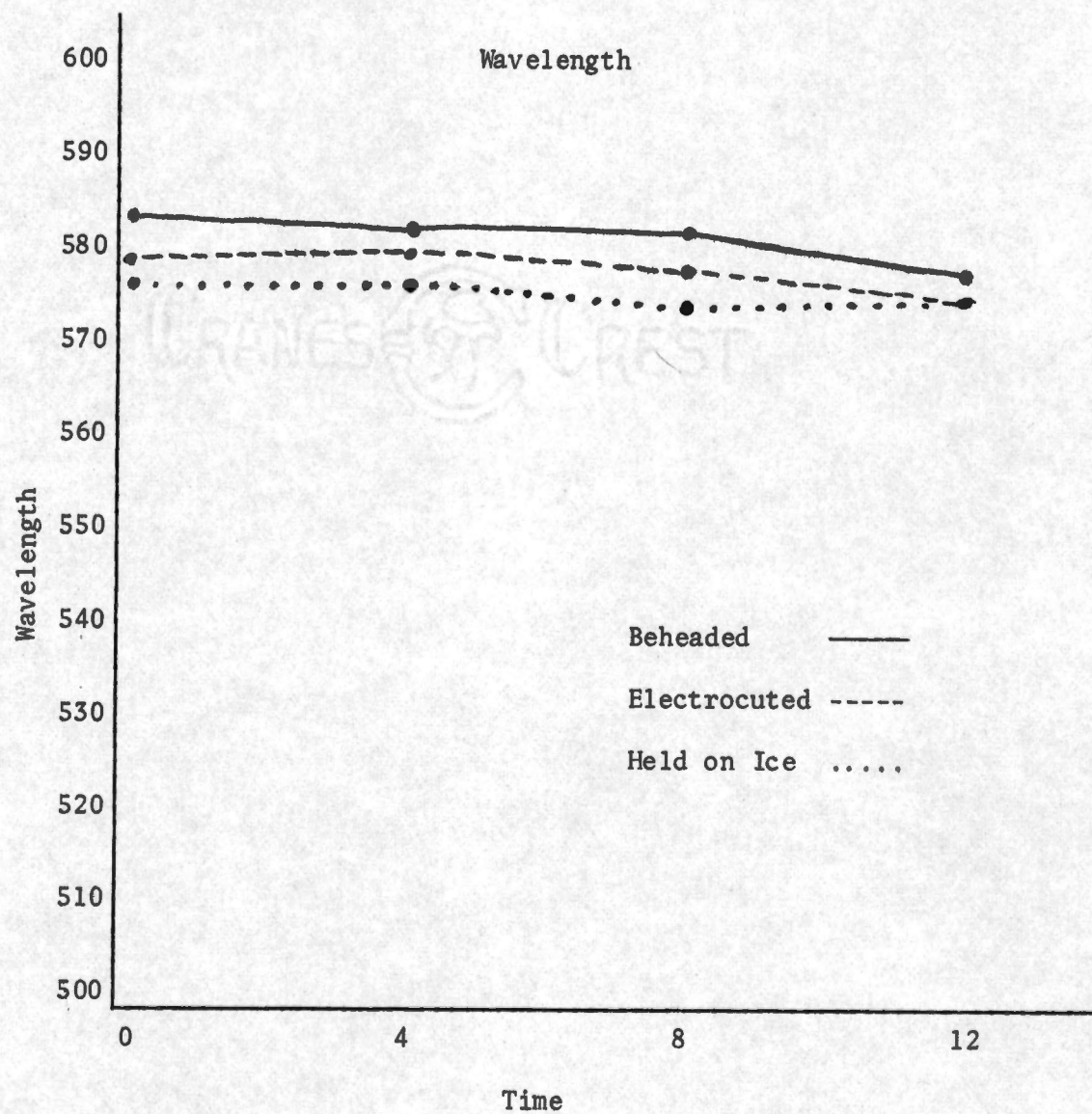


Figure 2. Relationship of wavelength to chilling time before freezing on fish muscle slaughtered by three different methods.

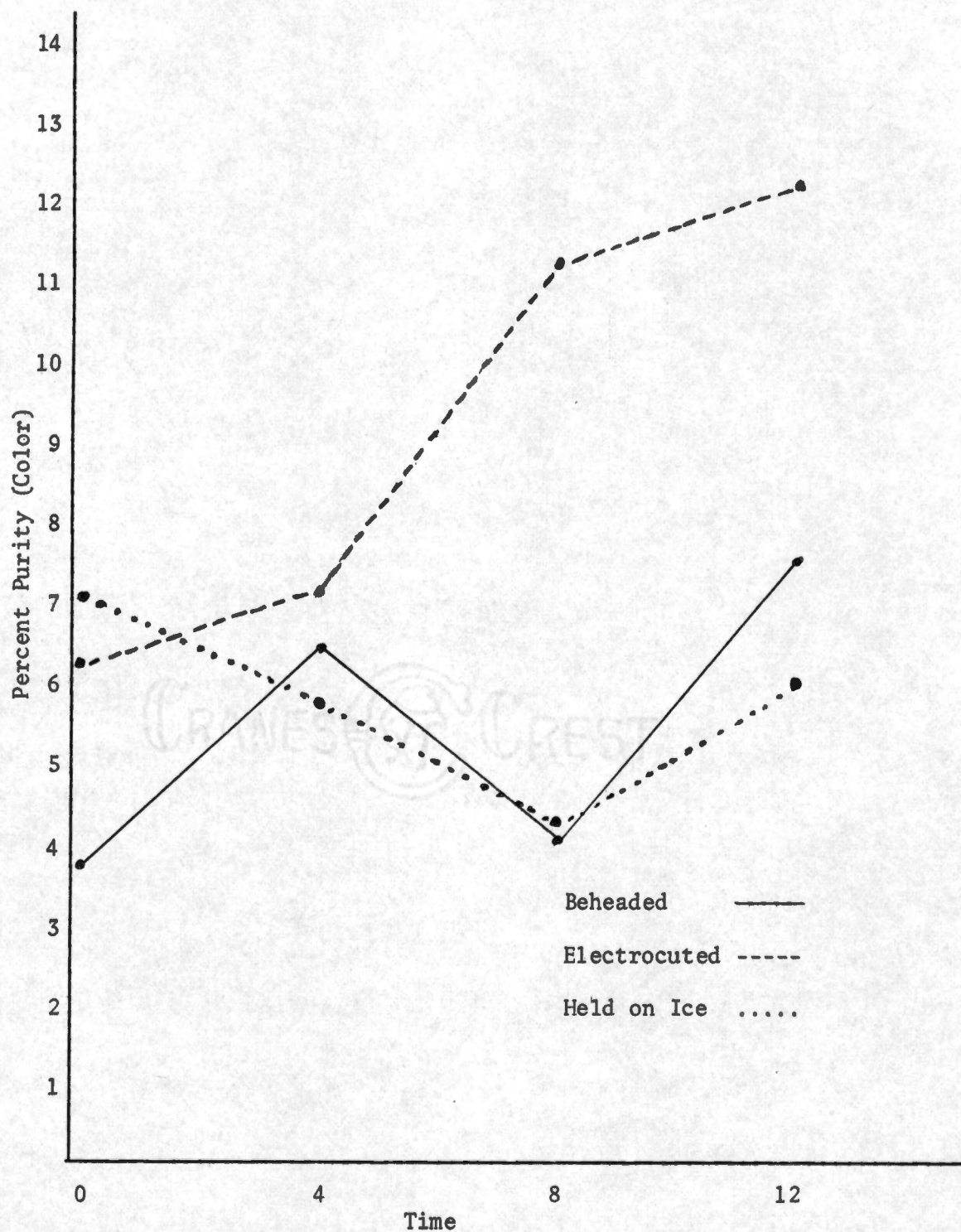


Figure 3. Relationship of purity (color) of chilling time before freezing on fish muscle slaughtered by three different methods.

TABLE 7

Analysis of Variance for the Effect of the Slaughter Method
and Chilling Time Before Freezing on the Rancidity
(T.B.A. Values) of Catfish Muscle

Source	D.F.	M.S.
Treatments ¹	2	0.014**
Time ²	3	0.011**
Replication	1	0.009**
Residual Error	17	0.00064
Total	23	

** P < 0.01.

¹The fish were slaughtered by beheading, electrocution, or holding on ice for 12 hours postmortem.

²Fish were chilled at 4.5°C for 0, 4, 8, and 12 hours prior to freezing. Samples were collected for analysis at each time period.

TABLE 8

T.B.A. Values for Slaughter Method and Chilling Time¹
Prior to Freezing of Catfish Muscle²

Slaughter Methods	Time			
	0	4	8	12
Beheaded	.30e	.33de	.38cd	.41bc
Electrocuted	.32de	.37cde	.37cde	.42bc
Held on Ice	.38cd	.42bc	.45ab	.48a

Values followed by the same letter are not significantly different ($P > 0.05$).

¹The fish were held in a 4.5°C cooler for the various time period prior to freezing.

²Time means are composed of 12 observations.

reduced shelf life when marketed. Since it appears that time after death is the primary cause of higher T.B.A. values it would behoove catfish processors to freeze or market the fresh fish as soon after death as possible. The rise in rancidity after slaughter is shown graphically in Figure 4.

V. Effects of Slaughter Method and Chilling Time Before Freezing on the Water Holding Capacity (W.H.C.) of Fish Muscle

The summary of the analysis of variance for the slaughter method and chilling time before freezing on the W.H.C. of fish muscle is shown in Table 9. There was no significant ($P > 0.05$) difference in either method of slaughter or chilling time before freezing on the W.H.C. of the fish muscle. W.H.C. has been shown to be positively related to muscle pH. Since in this study the muscle pH remained at a high level W.H.C. would not be expected to decrease. Analysis of variance revealed nonsignificant ($P > 0.05$) treatment and time affects for both W.H.C. and muscle pH.

VI. Effects of Slaughter Method and Chilling Time Before Freezing on the Organoleptic Evaluation of Battered and Breaded Deep Fried Fish Muscle

The summary of the analysis of variance for the method of slaughter and holding time before freezing on the sensory panel scores for deep-fried channel catfish are presented in Table 10. Flavor and overall acceptability were not significantly ($P > 0.05$) affected by either the

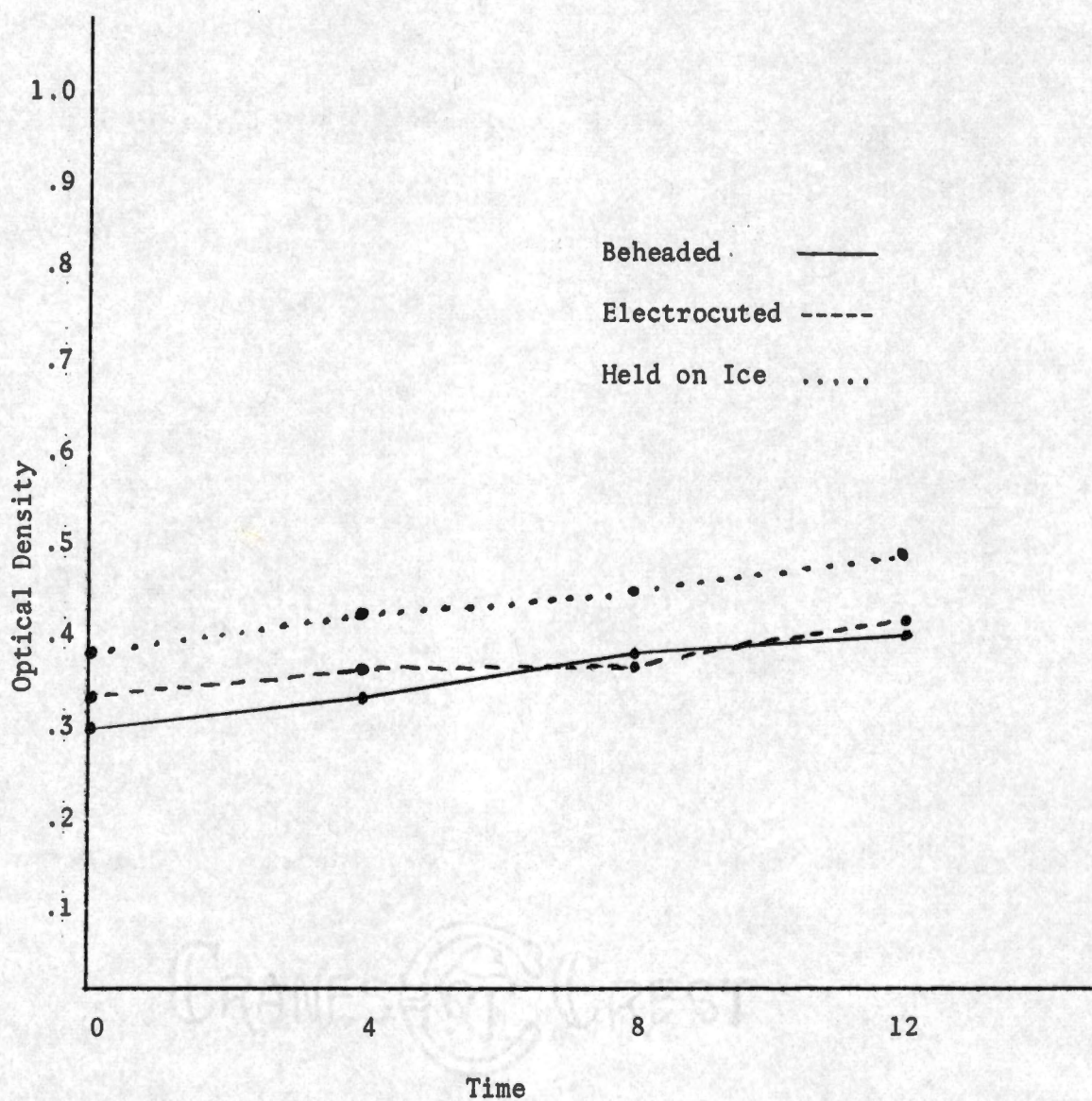


Figure 4. Relationship of T.B.A. values to chilling time before freezing on fish muscle slaughtered by three different methods.

TABLE 9

Analysis of Variance for the Effect of the Slaughter Method
and Chilling Time Before Freezing on the W.H.C.
of Catfish Muscle

Source	D.F.	M.S.
Treatment ¹	2	0.00033 N.S.
Time ²	3	0.00025 N.S.
Replication	1	0.00101 N.S.
Residual Error	17	0.00032
Total	23	

¹The fish were slaughtered by beheading, electrocution, or holding on ice for 12 hours postmortem.

²Fish were chilled at 4.5°C for 0, 4, 8, and 12 hours prior to freezing. Samples were collected for analysis at each time period.

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TABLE 10

Analysis of Variance for the Effect of the Slaughter Method
and Chilling Time Prior to Freezing on the Organoleptic
Evaluation of Fish Muscle

Slaughter Method	D.F.	M.S.
Treatment ¹	2	0.053 N.S.
Time ²	3	0.074 N.S.
Replication	1	0.018 N.S.
Residual Error	17	0.036
Total	23	

¹The fish were slaughtered by beheading, electrocution, or holding on ice for 12 hours postmortem.

²Fish were chilled at 4.5°C for 0, 4, 8, and 12 hours prior to freezing. Samples were collected for analysis at each time period.

method of slaughter or chill time before freezing. Boggess et al. [3] found significant differences in aroma and flavor in fish slaughtered at different processing plants by different methods. However, they baked the fish wrapped in foil. The organoleptic differences that these workers observed could possibly have been present in the fish in this study but could have been masked by the flavor enhancing properties created by the cooking method used. The battering and deep fried method was chosen for this study because it is the one most commonly used in cooking catfish.

CHAPTER V

SUMMARY

This study was conducted to determine the effects of method of slaughter and chilling time before freezing on the quality of processed channel catfish. Seventy-two channel catfish weighing 454 to 567 grams each were used in this experiment. The fish were divided into three groups (method of slaughter) with one group being immediately beheaded, the second group was electrocuted and the third group was held on ice for 12 hours preceding processing and allowed to die by suffocation. After processing fish muscle from each group was evaluated for pH, shear, wavelength and purity (color), water holding capacity, rancidity and organoleptic characteristics at 0, 4, 8 and 12 hours postmortem.

These data indicated that less force is required to shear fish muscle as holding time after slaughter was extended up to twelve hours. Fish slaughtered by the electrocution method were significantly ($P < 0.05$) darker than those slaughtered by suffocation in ice or by the beheading methods. Oxidative rancidity tended to develop in the fish muscle as the time period between slaughter and freezing was lengthened. Data from the organoleptic evaluation indicated that the panel tended to prefer a sample with a shear value between 27.2 and 31.8 kilograms per gram regardless to the method of slaughter or chilling time. It can be concluded from these data that fish slaughtered by one of the three

methods studied and not chilled for more than 12 hours before freezing will be of acceptable quality to the consumer when deep fat fried.



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APPENDIX



ORGANOLEPTIC SCORE SHEET

NAME		DIVISION	DATE
CODE	CODE	CODE	CODE

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COMMENTS	COMMENTS	COMMENTS	COMMENTS

TABLE 11

Replication I, The Affect of Method of Slaughter and Chilling Time
Prior to Freezing on Channel Catfish Muscle¹

Method of Slaughter	Chilling Time (hrs.)	pH	Shear Force (kg/gm)	Wave-length (N.M.)	Purity	T.B.A.	W.H.C.	Panel
Beheaded	0	6.65	35.64	587	3.53	.29	.315	2.86
Beheaded	4	6.90	31.87	582	4.85	.35	.360	2.47
Beheaded	8	6.77	29.29	587	3.90	.40	.324	2.82
Beheaded	12	6.82	26.76	574	6.82	.42	.322	2.90
Electrocuted	0	6.38	35.50	582	5.81	.33	.343	2.78
Electrocuted	4	6.40	33.53	582	6.87	.37	.349	2.76
Electrocuted	8	7.08	33.03	576	7.06	.39	.354	2.95
Electrocuted	12	6.98	29.21	575	11.87	.45	.347	2.80
Held on Ice	0	6.73	25.35	574	7.30	.39	.306	2.78
Held on Ice	4	6.80	27.71	574	4.11	.45	.307	2.52
Held on Ice	8	6.67	22.99	575	4.57	.50	.309	3.13
Held on Ice	12	6.97	22.18	578	7.54	.56	.314	3.09

¹Variable means for replication I; each value is the mean of 3 fish samples.

TABLE 12

Replication II, The Affect of Method of Slaughter and Chilling Time
Prior to Freezing on Channel Catfish Muscle¹

Method of Slaughter	Chilling Time (hrs.)	pH	Shear Force (kg/gm)	Wave-length (N.M.)	Purity	T.B.A.	W.H.C.	Panel
Beheaded	0	6.28	30.81	580	4.04	.31	.327	2.70
Beheaded	4	6.68	23.21	582	8.22	.34	.360	2.77
Beheaded	8	6.74	23.88	578	4.21	.37	.324	2.44
Beheaded	12	6.66	21.65	581	8.51	.39	.322	2.77
Electrocuted	0	6.60	30.45	575	6.84	.32	.338	2.77
Electrocuted	4	6.95	30.89	579	9.57	.36	.340	2.81
Electrocuted	8	6.97	29.48	580	15.57	.36	.340	2.81
Electrocuted	12	6.50	24.09	577	13.01	.38	.336	2.59
Held on Ice	0	6.77	30.69	578	6.85	.36	.348	2.62
Held on Ice	4	6.92	28.45	579	7.51	.40	.350	2.62
Held on Ice	8	6.75	19.56	572	3.97	.41	.374	2.96
Held on Ice	12	6.95	27.74	574	4.70	.42	.350	3.33

¹Variable means for replication II, each value is the mean of 3 fish samples.

VITA

Stanley Thyson Hord was born in Raleigh, Mississippi, on November 2, 1949. He attended elementary school in Raleigh, and attended high school at West Point High School, West Point, Mississippi, and graduated on June 2, 1967. The following September, he entered Jones County Junior College, located in Ellisville, Mississippi. In August, 1969, he transferred to Mississippi State University, located at State College, Mississippi. In May of 1971, he received a Bachelor of Science degree in Food Science and Technology.

After graduation from Mississippi State University, he entered The University of Tennessee Graduate School and received a Graduate Research Assistantship in Food Technology. From June, 1971, to June, 1973, he has been working to complete the requirements for the degree of Master of Science in Food Technology.

He and his wife, the former Miss Linda Kay Loveday, were married on March 17, 1972.