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To the Graduate Council:

I am submitting herewith a thesis written by George Edwin Wofford, entitled "Evaluation of Fresh-Water Whole Fish Meal as a Protein Supplement for Growing-Finishing Swine." 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.

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EVALUATION OF FRESH-WATER WHOLE FISH MEAL AS A PROTEIN SUPPLEMENT FOR GROWING-FINISHING SWINE

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

George Edwin Wofford

December 1968

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ABSTRACT

Thirty-two Duroc and Hampshire pigs were used to determine the effect of fresh water whole fish meal on performance and carcass characteristics of growing-finishing swine. The treatments were: (1) control, 16 percent protein; (2) control with 25 percent of the supplemental protein supplied as fish meal; (3) control with 50 percent of the supplemental protein supplied as fish meal; (4) control with 75 percent of the supplemental protein supplied as fish meal. Significant differences ($P < .05$) were found in the iodine values of the pork fat and percent ether extract of the longissimus dorsi muscle. A significant difference ($P < .01$) was observed in the flavor of the pork from pigs on the different treatments. The flavor of the pork from pigs receiving 75 percent of the supplemental protein from fish meal was least desirable. No significant differences ($P < .05$) were found in average daily gain, feed efficiency, carcass length, backfat thickness, percent lean cuts, color of pork, or saponification value, percent nitrogen, and percent moisture of the fat.

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CHAPTER I

INTRODUCTION

High quality fish meal is considered to be a good source of vitamins, minerals, and an unidentified growth factor(s) as well as being a good source of the amino acids. Salt water fish meal has been used as a protein supplement in swine and poultry rations for many years. Although fresh water fish meal has been used as a protein supplement in poultry rations, there is limited data indicating the value of fresh water fish meal as a protein supplement for swine. Since there is no apparent difference in the amino acid, vitamin, or mineral composition of salt and fresh water fish meal, it is conceivable to produce a fish meal from fresh water fish that would provide a good source of supplemental protein for swine.

Tennessee farmers grossed $56,826,000 or 9.4 percent of the gross farm income from the sale of swine in 1966. The importance of swine production and the abundance of rough fish from which a high quality fish meal might be prepared were reasons to begin studying the possibility of developing a commercial fish meal industry in the Tennessee Valley. The University of Tennessee, in cooperation with the Tennessee Game and Fish Commission, Tennessee Valley Authority, and the Bureau of Commercial Fisheries, U. S. Department of Interior, conducted this study.

The objective of this study was to determine the value of fresh water whole fish meal as a protein supplemental feed for swine.

CHAPTER II

LITERATURE REVIEW

There has been a limited amount of literature published as to the value of fresh water whole fish meal as a supplemental protein. However, various researchers have used salt-water fish meal as a supplemental protein in swine diets.

Producing Fish Meal

Ousterbout and Snyder (1962) found no difference in the nutritive value of fish meal produced by dry or wet rendering. Dry rendering was considered suitable only for fish containing low levels of fat.

Braude (1962) reported that the acceptability of fish meal by the pigs is important in the respect to the results obtained. Fish meal could possibly influence the intake of feed by the pig from the standpoint of smell and taste. If the above condition were extreme the pigs might refuse to eat the ration containing the supplemental protein as fish meal.

Combs (1962) reported that the maximum levels of fish meal a ration can tolerate for animals is determined by the oil content of the fish in the total ration. However, the level of oil which can be tolerated without affecting the flavor of hog carcasses may vary with the type of fish and the processing method.

Feeding Levels in Regard to Performance Traits

Laksesvela (1961) studied seven levels of fish meal in rations for growing-finishing swine. The various rations contained 3, 4, 5, 6, 8, 10, and 12 percent as herringmeal of the total ration. Most improvement in growth rate and efficiency of feed conversion was obtained when the fish meal represented 6 to 8 percent of the total ration throughout the growing period. There were progressive improvements with higher levels, but the improvement became smaller above the 8 percent level. This is in agreement with Ferrin (1946) and Barber et al. (1964) who reported that supplemental protein supplied as fish meal was a more efficient supplement to corn than tankage or soybean oil meal. He showed that the average daily gains of pigs fed fish meal were considerably higher than for tankage or soybean oil meal.

Feeding Levels in Regard to Carcass Characteristics

According to Vestal et al. (1945) rations containing 10 percent menhaden fish meal with 1 percent fish oil produced pork with considerable fishy flavor.

Barber et al. (1964) reported that pigs which were fed supplemental protein as fish meal had more depth of loin eye muscle than pigs with no fish meal in the diet.

According to Woodman et al. (1951), pigs receiving 7 percent white fish meal had a distinctly higher nitrogen retention than pigs on a ration supplemented with 8 percent plant protein.

Comparative Value of Fresh Water Fish Meal to Salt Water Fish Meal

Anderson and Draper (1955) reported that the feeding value of carp meal is equal to or better than fish meals sold commercially for poultry diets. This is in agreement with Johnston (1968) who showed that broilers fed diets containing carp and shad meal appear to be as acceptable as those containing commercially available salt water fish meal.

CHAPTER III

EXPERIMENTAL PROCEDURE

Production of Fish Meal

Net-run rough fish, taken from the Kentucky Lake in Tennessee, were processed into fish meal at East Tennessee Packing Company, Knoxville, Tennessee. The rough fish were harvested during the month of May, with the following species percentage composition: Shad 58; Drum 24; Carp 11; Gar 5; and Miscellaneous 2. The fish were packaged in burlap bags which contained forty to fifty pounds. The bags of fish were frozen in a fifteen degree Fahrenheit air blast freezer and remained frozen until they were ground by a stationary hammer mill. The raw fish meal was steamed and then cooked in a steam-jacketed atmospheric horizontal tank with rotary scraper-mixing arms. The cooked meal passed to a screen bottom bin for free oil draining and cooking. Additional oil was expelled by an Anderson Continuous Soybean Oil Press. Prepared fish meal was reground and passed to holding bins.

This meal was held at 40°F from June 5 until November 21, 1967, when the study began. Prior to storage, fifteen pounds of the meal was packed in double wall 1.5 millimeter polyethylene bags. They were then flushed for three minutes with nitrogen gas prior to sealing. Quantities of fish meal were removed from storage as needed to mix feed for a ten to fifteen day feeding period. In this way, no fat anti-oxidant was incorporated in the meal or the ration. Average composition

of fish meal used in the various rations was protein 62.79, fat 9.11, and dry matter 98.41 percent.

Rations

A ration formula meeting National Research Council (NRC) standards was used as a control ration for this experiment. For the different treatments, 25, 50, and 75 percent of the supplemental protein in the control ration was furnished by fresh water fish meal. Composition of these rations is shown in Table I.

Facilities

The pigs were fed in five by twenty foot concrete pens, one-half of which was under roof. Each pen contained an automatic waterer and a self feeder.

Allotting of Experimental Animals

Thirty-two weanling Duroc and Hampshire pigs were divided into eight groups of four pigs each on the basis of age, breed, sex, and weight. Two groups were randomly assigned to each of the following treatments: (1) control, 16 percent protein ration; (2) control with 25 percent of the supplemental protein supplied by fresh-water fish meal; (3) control with 50 percent of supplemental protein supplied by fresh-water fish meal; and (4) control with 75 percent of the supplemental protein supplied by fresh-water fish meal.

Pigs were started on the test at an average weight of 49 pounds and continued on the test until each pig weighed 210 pounds. When the

TABLE I

COMPOSITION OF EXPERIMENTAL RATIONS

	Control	25%	50%	75%
Yellow corn, ground	1502	1514	1562	1582
Soybean meal (44%)	300	170	176	100
Meal and bone meal	100	40	20	--
Dehydrated alfalfa (17%)	60	60	60	60
Dicalcium phosphate	20	20	20	20
Salt	10	10	10	10
Trace mineral premix[a]	2	2	2	2
Vitamin premix[b]	4	4	4	4
Antibiotic[c]	2	2	2	2
Fish meal	--	70	144	220
Ground limestone	--	8	--	--
	2000	2000	2000	2000
Approximate Protein	16%	16%	16%	16%
Approximate Fat (Ether Extract)	3.6%	3.8%	4.2&	4.6%

[a]Provides an addition to the ration of 100 ppm manganese, 2.4 ppm iodine, 2 ppm cobalt, 40 ppm iron, 10 ppm copper, and 80 ppm zinc.

[b]Provides an addition to the ration of 2 gm riboflavin, 4 gm pantothenic acid, 9 gm niacin, 10 gm choline, 10 mg B_{12}, 500,000 I.U. vitamin A and 250,000 I.U. vitamin D.

[c]Provides 20 gm chlortetracycline.

pigs were removed from the test, they were held 24 hours before being slaughtered in The University of Tennessee Meats Laboratory, they were not given any feed but were given free access to water during the holding period.

Slaughter and Cutting

After slaughter, the warm carcasses were hung in a thermostatically controlled 38°F cooler for 48 hours before measurements were taken and the carcasses cut. Carcass length was measured to the nearest millimeter from the anterior edge of the aitch bone to the anterior edge of the first rib. Backfat measurements, including skin thicknesses, were taken to the nearest millimeter at the first rib, last rib, and last lumbar vertebra and averaged. A tracing of the cross-section of the longissimus dorsi muscle was taken between the tenth and eleventh ribs. The loin eye area was measured to the nearest 0.01 square inch with a compensating planimeter. The right side of each carcass was cut according to Reciprocal Meat Conference (1952) procedures. Each cut was weighed to the nearest 0.1 pound.

Sections of the right loin, seventh through eleventh ribs and third through sixth ribs, were taken for taste panel and chemical analysis, respectively. Backfat samples were also taken from the third through sixth ribs. These samples were frozen and stored until all animals had completed the feeding trial.

Chemical Analysis

Chemical analysis was conducted in two parts: (1) protein, ether extract, and moisture of the loin eye (longissimus dorsi muscle), and (2) saponification number, iodine number, ultraviolet spectrum, and melting point on the backfat.

The Kjeldahl method of nitrogen was used to determine the percent nitrogen and these values were multiplied by 6.25 to convert to protein. For moisture determination, a two gram sample was dried in a 100°C mechanical drying oven for seven hours, removed and placed in a desiccator for two hours to allow the samples to come to an equal temperature. They were weighed and percent moisture determined. Dried samples were then used for ether extract determination. Samples were placed in folded filter paper so that none of the sample could be shaken out. The folded filter paper which contained the sample was placed in a stainless steel thimble. To extract the fat from the sample the thimble was inserted into the thimble holder of the Goldfisch apparatus. Thirty-five milliliters of anhydrous ether was used in the four-hour extraction. After the sample had refluxed, the ether was removed from the sample. The ether extract was placed in a mechanical drying oven at 100°C for 30 minutes, cooked, weighed, and the percent ether extract calculated.

Fat was extracted from the backfat by using a methanolcholoroform extraction. For fat analysis, four carcasses were sampled from each treatment which were control, 25 percent, 50 percent, and 75 percent of supplemental protein as fish meal. Duplicate analyses were made which gave eight observations for each treatment.

Lipids were extracted from the backfat using the method described by Bligh and Dyer (1959). Samples were blended in a mixutre of methanol and chloroform which was a monophasic solution. After filtration of the mixture, water was added to form a biphase in which the methanol contained all the non-lipids and the chloroform contained all of the lipids. Chloroform was separated and evaporated by a flash evaporator. Residue was used for various analyses.

Saponification procedure described by Jacobs (1947) was used to determine the average molecular weight of the extracted fat. A sample of the fat weighing approximately four grams was refluxed with 50 cc of alcoholic potassium hydroxide until the fat was completely saponified. The solution was heated, and the excess potassium hydroxide titrated with approximately 0.5 N Hydrocloric acid using phenolpthalein as an indicator. Saponification numbers were calculated.

The Hanus Method as described by Jacobs (1947) was used for analysis of iodine values which gives an indication of the saturation of the fatty acids. From 0.1 gram to 0.5 gram of fat was dissolved in 10 cc of chloroform to which 25 cc of the Hanus iodine solution was added. The solution was titrated with approximately 0.1 N sodium thiosulfate using a 1 percent starch solution as an indicator.

Melting points of the fat samples were determined according to the procedure by Jacobs (1947). One centimeter of melted fat was drawn into a capillary tube and the tube sealed. Capillary tubes containing the fat were stored on ice overnight. Tubes were warmed in a water

bath while attached to a thermometer and the point of complete fusion was taken as the melting point temperatures.

A 0.5 and 0.2 percent solution of the fat samples were prepared using 2,2,4-trimethylpentane as a solvent to compare the ultraviolet spectra with a Perkin-Elmer model 202 spectrophotometer. The wave length was recorded when the curve left the base line of zero transmittance. Percent transmittance of the solution was determined between 270 and 280 millimicrons.

Taste Panel

For taste panel evaluation, a section of the frozen loin, seventh through tenth ribs, was prepared by cooking in a 350°F oven to an internal temperature of 76°C.

The panel consisted of two groups of seven members each, one from The University of Tennessee Food Technology Department and the other from the Animal Husbandry Department. A forced ranked order analysis of four samples was used for the evaluation of pork loins from the various diets. Color was evaluated under cool white fluorescent light with the same set of samples being viewed by all panel members. Samples for flavor evaluation were judged under red-filtered fluorescent lights. A value of one was given for first place and so on to a value of four for the fourth ranked sample. Therefore, in totaling the scores for each, the one with the lowest total score was judged best and the one with the highest total score was judged poorest by the panel. Statistical analyses of the taste data were by the Chi Square Test (Steel and

Torrie, 1960) and the differences between treatment means were determined by Kramer's Standard Tables (Kramer, 1956).

Statistical Analysis

Data for all observations except the taste panel results were analyzed by the method of analysis of variance (Steel and Torrie, 1960). When differences were noted, Duncan's multiple range test (Steel and Torrie, 1960), was used for mean separation.

CHAPTER IV

RESULTS AND DISCUSSION

Effect on Performance Traits

Feed required per pound of gain and average daily gain (ADG) of pigs on the various treatments are shown in Table II. There were no significant differences in ADG or feed required per pound of gain for the pigs receiving the different levels of fresh water whole fish meal. Although the differences were not significant, pigs on the rations containing fish meal tended to grow faster and required less feed per pound of gain than did the pigs on the control ration. This is in agreement with the results of Barber *et al*. (1964) and Ferrin (1946), who found that the addition of salt water fish meal as a supplemental protein increased gain and reduced the amount of feed required per pound of gain.

Carcass Characteristics

Carcass characteristics for pigs on the various treatments are shown in Table III. There were no significant differences ($P > .05$) in the carcass characteristics of the pigs fed different levels of fresh water fish meal. These results agree with those of Laksesvela (1961) who reported that there were no significant differences ($P > .05$) in carcass loin eye, backfat, and length when pigs were fed salt water fish meal compared to no fish meal in the diet. However, Barber *et al*.

TABLE II

PERFORMANCE CHARACTERISTICS OF PIGS FED
VARIOUS LEVELS OF FISH MEAL

	Control	25% Supplemental Protein as Fish Meal	50% Supplemental Protein as Fish Meal	75% Supplemental Protein as Fish Meal
No. lots/treatment	2	2	2	2
No. pigs/treatment	8	8	8	8
Initial age	77	75	76	76
Av. age end of treatment	173	165	170	172
Av. initial wt. pounds	49	49	49	49
Av. final wt. pounds	214	215	219	217
Av. daily gain	1.69	1.83	1.81	1.78
Feed/100 lb. gain, pounds	322	303	314	298
Av. daily feed, pounds	5.4	5.5	5.7	5.3

TABLE III

CARCASS COMPOSITION OF SWINE ON THE
DIFFERENT LEVELS OF FISH MEAL

	Control	25% Supplemental Protein as Fish Meal	50% Supplemental Protein as Fish Meal	75% Supplemental Protein as Fish Meal
No. of animals	8	8	8	8
Av. backfat (in.)	1.30	1.35	1.27	1.33
Loin eye (sq. in.)	4.49	4.60	4.72	4.48
Penetrometer at L. Dorsi	232	257	251	210
Penetrometer of backfat	51	47	45	38
% lean cuts	54.5	54.7	54.8	55.5
Length (in.)	29.4	29.2	29.6	29.3

(1964) reported that pigs which were fed salt water fish meal had a greater depth of loin eye muscle than those which were fed no fish meal.

Chemical Analysis

Results of the chemical analysis of carcasses from pigs on the various treatments are presented in Table IV. There was a significant difference ($P < .05$) in the iodine value of fat from pigs on different treatments. This difference was found between the groups receiving 75 percent of the supplemental protein from fish meal and the other treatments. The backfat from pigs receiving the 75 percent level of supplemental protein as fish meal had more unsaturated fatty acids than the other treatments. This could be accounted for by the fact that the higher level of fish meal provided more unsaturated fatty acids in the pigs' diet. The iodine value of the backfat showed no differences between the control and the groups receiving 25 and 50 percent of supplemental protein from fresh water fish meal.

The longissimus dorsi muscle from pigs receiving the 75 percent level of supplemental fresh water fish meal had a significantly ($P < .05$) higher percentage of ether extract than the other treatments. The pigs receiving the 50 percent level of fish meal had a higher ($P < .05$) percentage of ether extract than the control. The higher ether extract values for the pigs receiving the higher levels of fish meal could be due to the fat in these diets.

There were no statistical differences in saponification value, melting point, the percent of nitrogen, and the percent of moisture in the carcasses from various treatments.

TABLE IV

CHEMICAL ANALYSIS OF CARCASS FROM PIGS
FED VARIOUS LEVELS OF FISH MEAL

	Control	25% Supplemental Protein as Fish Meal	50% Supplemental Protein as Fish Meal	75% Supplemental Protein as Fish Meal
Number animals	4	4	4	4
Iodine value[a]	61.25[c]	64.78[c]	64.40[c]	68.35[d]
Saponification value[b]	185.93[c]	186.34[c]	179.13[c]	181.58[c]
Melting points C°	42.2[c]	41.9[c]	42.2[c]	40.7[c]
Nitrogen %	21.35[c]	21.13[c]	20.73[c]	21.10[c]
Ether extract %	8.48[c]	7.73[cd]	7.33[d]	10.1[e]
Moisture %	70.4[c]	71.9[c]	70.7[c]	69.5[c]

[a]The number of grams of iodine absorbed by 100 grams of oil.

[b]The number of milligrams of potassium hydroxide required to saponify 1 gram of oil or fat.

[cde]Means followed by the same letter are not significantly different at 0.05 level of probability.

Spectrophotometric data are shown in Table V. There does not appear to be any relationship between the treatments and the percent transmittance of the fat samples.

Taste Panel

Results of the taste panel evaluation for color and flavor, shown in Table VI, were analyzed by the Chi Square method (Steel and Torrie, 1960) and rank order analysis by Kramer (1956). Significant differences ($P < .05$) were found in the flavor of the meat from the various treatments. Meat from the pigs receiving the 25 percent supplemental protein ration was given the best flavor score, while the lowest scores were given to the meat from the pigs that received the 75 percent level. According to Vestal et al. (1945), a salt-water fish meal added to pigs' ration as a supplemental protein at rates of 10 percent of the total ration produced a fishy flavor in the meat. Since 75 percent of the supplemental protein is equal to 11 percent of total ration, these results would be in agreement with the above workers.

There were no significant differences ($P > .05$) found in the color of the pork from the various treatments. Color of pork from all treatments was acceptable. Table V shows the Chi Square analysis of the taste panel results.

TABLE V

OPTICAL PROPERTIES OF FATS FROM PIGS FED VARIOUS LEVELS OF FISH MEAL

		Control	25% Supplemental Protein as Fish Meal	50% Supplemental Protein as Fish Meal	75% Supplemental Protein as Fish Meal
Wave length at which it leaves 0% transmission	.5% solution	230	229	228	229
	2% solution	250	250	248	248
Percent transmission between 270-280 Mu	.5% solution	57	58	63	59
	2% solution	35	42	39	51

NOTE: 1 - Solution in 2,2,4 trimethylpentane.

TABLE VI

CHI SQUARE ANALYSIS OF TASTE PANEL RANKED ORDER OF LOIN ROASTS FROM SWINE FED VARIOUS LEVELS OF FISH MEAL

	Flavor	Color
Control	115	99
25% of Supplemental Protein as Fish Meal	69[a]	100
50% of Supplemental Protein as Fish Meal	97	99
75% of Supplemental Protein as Fish Meal	139[a]	122
Chi Square[b]	24.91	3.66

[a]Scores lower than 75 or higher than 135 are significantly different ($P < .01$).

[b]Chi Square with three degrees of freedom at probability .01 is equal to 11.34.

CHAPTER V

SUMMARY

A whole fish meal was prepared from rough fish harvested from the Kentucky Lake in Tennessee and it was used as a protein supplement at different levels for swine. Four rations were used in this study: (1) control, 16 percent protein; (2) 25 percent of supplemental protein supplied as fish meal: (3) 50 percent of the supplemental protein supplied as fish meal; and (4) 75 percent of supplemental protein supplied as fish meal. These rations were fed to determine the effect on performance and carcass characteristics of growing-finishing swine.

A significant difference ($P < .01$) was found in flavor of pork from pigs on various treatments. The pork from pigs receiving 75 percent of supplemental protein from fish meal was least desirable. Significant differences ($P < .05$) were also found in iodine value and percent ether extract from carcasses of pigs on the various treatments. The pigs receiving 75 percent of supplemental protein from fish meal had a higher percentage of fat in the longissimus dorsi and a higher content of unsaturated fats. There were no significant differences ($P > .05$) among treatments for average daily gain, feed efficiency, carcass length, backfat thickness, percent lean cuts, color of the pork, or saponification values, percent nitrogen, and percent moisture of the fat.

Based on these results, it appears that one-half of the supplemental protein of swine rations may be supplied by fresh-water whole fish meal without affecting pig performance or carcass desirability. A level 75 percent of supplemental protein from fresh water whole fish meal did not affect pig performance; however, carcasses from these pigs had a higher degree of fat in the loin eye muscle (*longissimus dorsi* muscle), a higher percentage of unsaturated fatty acids in the backfat, and were less desirable in flavor.

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APPENDIXES

APPENDIX A

TABLE VII

PERFORMANCE CHARACTERISTICS

	Control	25% Supplemental Protein as Fish Meal	50% Supplemental Protein as Fish Meal	75% Supplemental Protein as Fish Mean
Average Daily Gain				
Rep 1	1.81	1.89	1.76	1.70
Rep 2	1.58	1.76	1.86	1.86
Average	1.68	1.82	1.81	1.78
Feed Required per 100 Gain				
Rep 1	325	295	327	303
Rep 2	318	310	300	292
Average	321	302	313	298

APPENDIX B

TABLE VIII

SAPONIFICATION VALUES OF BACKFAT OF PORK CARCASSES FROM THE VARIOUS TREATMENTS

	Control	25% Fish Meal	50% Fish Meal	75% Fish Meal
A	196.57	186.43	192.44	193.09
	195.62	194.25	194.40	193.49
B	191.85	195.48	157.54	176.14
	193.52	196.07	175.61	177.10
C	177.49	179.14	177.67	177.80
	177.46	177.92	177.20	177.61
D	177.41	178.23	178.99	178.52
	177.59	183.20	179.26	178.97
Average	185.94	187.09	179.14	181.59

TABLE IX

IODINE VALUES OF BACKFAT OF PORK CARCASSES FROM VARIOUS TREATMENTS

	Control	25% Fish Meal	50% Fish Meal	75% Fish Meal
A	56.70	60.59	59.25	66.75
	59.40	64.15	60.31	62.96
B	64.87	67.98	58.96	72.46
	62.37	63.56	64.71	65.77
C	62.33	68.82	69.52	70.71
	63.45	68.04	69.15	68.82
D	62.34	62.86	69.90	75.49
	58.67	62.23	63.94	63.83
Average	61.25	64.78	64.47	68.25

TABLE X

MELTING POINT OF BACKFAT OF PORK CARCASSES FROM THE VARIOUS TREATMENTS

	Control	25% Fish Meal	50% Fish Meal	75% Fish Meal
A	42.5	42.2	42.4	38.5
	43.0	42.7	42.8	38.8
B	39.8	40.9	40.9	39.0
	39.6	42.7	42.9	38.8
C	40.2	40.0	39.8	41.8
	41.0	40.8	39.6	41.7
D	46.4	42.5	44.0	44.5
	45.0	43.2	43.8	42.8
Average	42.2	41.9	42.2	40.7

TABLE XI

SPRECTROPHOTOMETER VALUES OF BACKFAT OF PORK CARCASSES OF VARIOUS TREATMENTS--0.5 PERCENT SOLUTIONS

	Control	25% Fish Meal	50% Fish Meal	75% Fish Meal
Wavelengths at which the line leaves 0% transmittance in Mu:				
A	230	240	235	225
B	230	225	225	240
C	230	225	225	225
D	230	225	225	225
Average	230	229	228	229
% Transmittance the line shows between 270 and 280 Mu:				
A	48	22	57	69
B	50	65	66	24
C	66	66	55	72
D	65	70	73	70
Average	57	56	63	59

TABLE XII

SPRECTROPHOTOMETER VALUES OF BACKFAT OF PORK CARCASSES OF VARIOUS TREATMENTS--2 PERCENT SOLUTIONS

	Control	25% Fish Meal	50% Fish Meal	75% Fish Meal
Wavelength at which the line leaves 0% transmittance in Mu:				
A	250	250	255	250
B	250	250	250	250
C	250	250	250	250
D	250	250	250	245
Average	250	250	250	249
% Transmittance the line shows between 270 and 280 Mu:				
A	4	25	6	50
B	43	36	39	30
C	50	50	48	68
D	44	58	62	54
Average	35	49	39	51

TABLE XIII

PERCENT CRUDE PROTEIN OF LOIN EYE MUSCLE OF PORK CARCASSES FROM THE VARIOUS TREATMENTS

	Control	25% Fish Meal	50% Fish Meal	75% Fish Meal
A	19.2	18.6	19.9	19.6
	20.1	21.0	19.5	18.9
B	23.1	23.0	22.1	22.6
	23.0	21.9	21.4	23.4
Average	21.4	21.1	20.7	21.1

TABLE XIV

PERCENT MOISTURE OF LOIN EYE MUSCLE OF PORK CARCASSES FROM THE VARIOUS TREATMENTS

	Control	25% Fish Meal	50% Fish Meal	75% Fish Meal
A	70.2	70.0	72.8	66.6
	68.6	70.0	72.8	68.1
B	71.5	74.1	69.4	71.6
	71.3	73.7	68.9	71.7
Average	70.4	72.0	70.7	69.5

TABLE XV

PERCENT ETHER EXTRACT OF LOIN EYE MUSCLE OF PORK CARCASSES FROM THE VARIOUS TREATMENTS

	Control	25% Fish Meal	50% Fish Meal	75% Fish Meal
A	8.6	8.0	7.3	11.5
	8.9	7.8	7.8	10.8
B	8.3	6.4	6.4	9.4
	8.1	6.7	5.8	8.7
Average	8.5	7.2	6.8	10.1

VITA

George Edwin Wofford was born in Newbern, Tennessee, on December 24, 1941. He is the son of Mr. and Mrs. George S. Wofford and is the oldest of three children. He was reared on a farm near Newbern, Tennessee, where he attended high school. Upon graduation in 1959, he enrolled at The University of Tennessee at Martin. In 1961 he joined the United States Marines and received an honorable discharge in 1965. In July, 1964, he was married to Miss Mary Blakemore of Pittsburgh, Pennsylvania. He returned to The University of Tennessee at Knoxville and received a Bachelor of Science degree in Agriculture in 1967; after graduation he continued to pursue a Master of Science degree with a major in Animal Husbandry. After graduation from The University of Tennessee in December, 1968, he plans to teach Vocational Agriculture in West Tennessee and operate his own livestock farm.