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The relationships between porcine longissmus dorsi histological traits and carcass and performance characteristics

John David Parks

To the Graduate Council:

I am submitting herewith a thesis written by John David Parks entitled "The relationships between porcine longissmus dorsi histological traits and carcass and performance characteristics." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Food Science and Technology.

Curtis C. Melton, Major Professor

We have read this thesis and recommend its acceptance:

Hugh O. Jaynes, Woodrow W. Overcast

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

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Major Professor

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Accepted for the Council:

Vice Chancellor
Graduate Studies and Research

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THE RELATIONSHIPS BETWEEN PORCINE *LONGISSIMUS DORSI* HISTOLOGICAL TRAITS AND CARCASS AND PERFORMANCE CHARACTERISTICS

A Thesis

Presented for the

Master of Science

Degree

The University of Tennessee

John David Parks

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ABSTRACT

Twenty-six hogs were raised four to a pen until the average weight per pen was 100 kg. Immediately after slaughter the carcass weight, carcass length and back fat thickness were measured. Following a 14 to 16 hour chill, the weights of the trimmed hams and loins were recorded and converted into percentages. The loin eye at the 10th rib was scored for color and marbling and a one inch chop removed for histological examination. Cross sections (16 microns) were stained for ATPase activity and the muscle fiber types differentiated. Their areas and numbers were recorded and the mean areas and percentages of each fiber type were calculated. The fat cells were stained with Oil-Red-O and their mean areas calculated. Six of these cross sections for each sample were given a histologically determined marbling score.

Simple correlation coefficients were calculated. These showed a relationship between histologically determined marbling and loin eye area (-.49), back fat thickness (0.47) and marbling (0.61). The mean fat cell area was significantly correlated with loin eye area (-.60), back fat thickness (0.55) and marbling (0.52).

All the barrows were Durocs and all of the gilts were crossbreeds, therefore any variation between the two groups could not be designated as a result of either sex or breed.

The analysis of variance between the Duroc barrows and crossbreed gilts indicated that the mean fat cell area, back fat thickness and marbling score were significantly ($P < .01$) larger for the Duroc barrows. The crossbreed gilts had significantly ($P < .01$) longer hot carcass lengths, higher percent ham and loin and larger loin eye area.

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CHAPTER I

INTRODUCTION

The demand for protein is increasing throughout the world and animal protein will most likely supply a large portion of the total. Therefore, there is a great need for animals which gain faster and yield high quality meat. One of the goals of research today is to develop a fast gaining, high quality pork carcass. The selection of genetically superior sires by progeny testing is an excellent means of improving a swine herd; however this is time consuming and expensive. Schmidt, Zuidam and Sybesma (1972) and Melton et al. (1974) have shown biopsies to be an effective sampling technique for histological examination without harm to the animal. Melton et al. (1974) have shown that histological characteristics were correlated to carcass quality and composition in beef animals. Due to the high heritability of the factors which influence meat quality, more research is needed to establish relationships between various histological characteristics, carcass quality and composition in meat animals.

The purpose of this study was to determine the relationships among the histological characteristics of

porcine *longissimus dorsi* and their association with carcass and performance traits.

CHAPTER II

REVIEW OF LITERATURE

Skeletal muscle fiber types. Needham (1926) and Denny-Brown (1929) were among the first to describe muscle fibers as being of two types. Dubowitz (1960) classified the fibers into two types based on their enzymatic reactions. The small fibers were found to be low in phosphorylase activity and high in oxidative enzyme activity, while the larger fibers were high in phosphorylase activity and low in oxidative enzymes. The small fibers, being oxidative, contained sufficiently more myoglobin to store oxygen and were called "red" fibers. The larger fibers were referred to as "white" because they contained little or no myoglobin. Romanul (1964) classified muscle fibers of the rat into eight categories based on their oxidative and glycolytic enzymatic reactions. Most researchers generally agree there are only two basic fiber types referred to as type I, red or beta and type II, white or alpha (Ashmore, Tompkins and Doerr, 1972; Engle and Brooke, 1966; Melton et al., 1974). These two fiber types differ in adenosine triphosphotase (ATPase) activity. The ATPase activity was low in the "red" (type I, beta) fiber and high in the "white" (type II, alpha) fibers according to Guth and Samaha (1969).

Research done by Ashmore and Doerr (1971a) resulted in a system of classification in which the "red", type I fiber was called a "Beta red" and "Alpha white" type II fiber was designated as either "alpha red or alpha white" dependent upon its metabolic state. All muscle fibers appeared to be of the red (beta red and alpha red) type at birth; however, some of those fibers (alpha red) may alter their metabolic functions so they become white (alpha white) fibers. The beta red fibers do not have the ability to change and therefore the number of these remains constant (Ashmore and Doerr, 1971b).

The "white" fibers (alpha white) are larger than the "red" fibers (beta red or alpha red). The "red" fibers exhibit aerobic metabolism and therefore have more capillaries (5 to 7) per fiber than "white" fibers (1 to 3). The sarcoplasmic reticulum was less extensive in the "red" fibers due to the fact that the "red" fibers contract slower than "white" fibers and therefore do not require the high concentration of calcium ions needed for quick contraction (Price and Schweigert, 1971).

Distribution of fiber types. Beecher et al. (1965) studied fiber type distribution in the porcine longissimus dorsi and they concluded that this muscle contained less than 30 percent red fibers. In the porcine longissimus

dorsi the red fibers were generally grouped in clumps inside the bundle and were surrounded by white fibers (Price and Schweigert, 1971).

Joubert (1956) measured 4,000 individual muscle fibers from each of the following: rabbits, pigs, sheep and cattle. This worker concluded that a mean diameter of 100 fibers was a representative indicator of the size for a given muscle at a given age. Melton (1974) measured 100 fibers in the bovine longissimus dorsi at five different locations and calculated the mean fiber area. He found no significant ($P < .05$) difference in mean fiber diameter at the five different areas.

Relationships of fiber type to meat quality. Joubert (1956), and Covington et al. (1970) found fiber diameter increased as the animal matured. Romans, Tuma and Tucker (1965) studied beef ribs representing four maturity levels (A,B,C,D) and two marbling levels (slight and moderate) and found that the fibers were significantly ($P < .01$) larger in the moderate marbling group. This work also indicated that as maturity increased so did fiber diameter.

Henning, Moody and Kemp (1973) studied six porcine carcasses selected to represent a high cutability group and six carcasses to represent a low cutability group. The mean white fiber area was always larger ($P < .05$) in the high

cutability group than in the low cutability group. The same was true for the mean red fiber area.

Carpenter et al. (1962) found as the fiber diameter of raw porcine longissimus dorsi muscle increased the shear force decreased. When the meat was cooked the shear force increased with the fiber size. This work showed cooking had a tenderizing effect on the connective tissue which was more abundant in the muscle with smaller fibers. Anderson (1971) found that chops from the longissimus of fat hogs had smaller muscle fibers, lower Warner-Bratzler shear reading and more desirable flavor, tenderness and juiciness scores. Cross, Smith and Carpenter (1972) studied steaks from ovine leg and found that the steaks with smaller muscle fiber size were more tender. Tuma et al. (1962) found that muscle fiber diameter was a poor indicator of tenderness of bovine longissimus dorsi. Marsh and Leet (1966) studied sarcomere lengths in relation to tenderness and found that longer sarcomere lengths were associated with more tender meat. Beecher (1966) found that red fibers had longer sarcomeres than did white fibers.

Fat cell size in relationship to quality. Moody and Cassens (1968) studied fat cell size and distribution in bovine longissimus muscle which contained traces, small and moderate degrees of marbling. The work indicated that the

fat cell size increased as the number of cells per loci increased and also that the fat cell size was greater in the more highly marbled groups. This confirmed work by Allen, Bray and Cassens (1967).

Kropf and Graf (1958) studied 334 beef carcasses representing Choice, Good and Commercial grades and concluded that loin steaks with higher marbling levels had a more desirable flavor.

CHAPTER III

MATERIALS AND METHODS

Twenty-six Duroc and crossbreed hogs weighing from 14.5 to 32.7 kg were fed rations of varying protein levels in an experiment conducted by the Department of Animal Science of the University of Tennessee. The hogs were fed four to a pen until the average weight per pen was 100 kg. They were then slaughtered at a local packing plant. Immediately after slaughter the carcass length, back fat thickness and carcass weight were recorded. The carcasses were then chilled for 14 to 16 hours. As the carcasses were broken into wholesale cuts the weights of the trimmed hams and loins for each hog were recorded. The loin from the left side of the carcass was broken at the 10th rib and a one inch chop removed for histological examination of the tissues. The cut face of the longissimus muscle was scored for color using the University of Wisconsin color standards and subjectively evaluated for marbling. The outline of the longissimus was traced on acetate paper and the area calculated.

Histological examination. Muscle samples measuring 1x1x1 cm were cut from a position in the pork chop that

would approximate a biopsy at the 10-11th rib as described by Melton (1970). The samples were placed on wet cork squares and frozen in isopentane precooled with liquid nitrogen. These were then placed in plastic bags and stored on dry ice until sectioning.

The samples were placed in a Lipshaw model 1800 cryostat and allowed to equilibrate to -23C. Cross sections, 16 microns in thickness, were placed on cover glasses and allowed to air dry for 1 to 2 hours. The sections were fixed in 2 percent calcium chloride, pH 7.0, for five minutes and then stained for adenosine triphosphotase (ATPase) by a modification of a method described by Padykula and Herman (1955)(Appendix A). All muscle fibers were differentiated into either ATPase negative or ATPase positive. After the slides were prepared a photograph of each slide was made using a Wild M20 microscope with a camera attachment. A grid of known dimensions was also photographed with each roll of film. The relative diameters of approximately 100 fibers from each 20x25 cm print and the relative distances across each grid were measured using a Carl-Zeiss Particle Size Analyzer. The numbers of each fiber type were recorded and percentages calculated. The mean relative diameter was converted into actual diameter in millimeters by solving for X in the following formula:

$$\frac{\text{Actual measurement of grid (0.05 mm).}}{\text{Particle size analyzer measurement of grid}} = \frac{X}{\text{Particle size analyzer measurement of fiber}}$$

Actual areas (mm^2) were then calculated.

Intramuscular lipid staining. Sections were made at 16 microns and stained with Oil-Red-O (Appendix B) for five minutes at room temperature to illustrate the intramuscular fat cells. The coverslides were photographed and actual areas (mm_2) were determined as described above for muscle fibers.

The sections were also examined with a dissecting microscope at a magnification of 24X. Six sections for each sample were examined and a histological marbling score (1 to 9) was given each sample. The score corresponded to the nine marbling levels (Abundant = 9, ... , devoid = 1) which were used to score the longissimus at the 10th rib.

Muscle pH. The pH was measured by making a homogenate using 30 ml distilled, demineralized water and 10 grams of tissue taken from a site adjacent to that from which the histological samples were removed. A Beckman Ion Analyzer was used to record pH.

Statistical analysis. Simple correlation coefficients were calculated for histological, carcass and performance

traits. The corrected sums of squares and cross products for Duroc barrows and crossbreed gilts were pooled and intraclass correlation coefficients calculated to remove variations between these two groups of swine. A simple analysis of variance was calculated to determine a combined sex-breed affect on the histological, carcass and performance traits in this study.

CHAPTER IV

RESULTS AND DISCUSSION

Approximately one-hundred muscle fibers from the porcine longissimus dorsi were measured after differentiation by a modification of the ATPase method described by Padykula and Herman (1955). The means and standard deviations for histological, carcass and performance traits are presented in Table 1 for Duroc barrows and crossbreed gilts included in this study. Since all Durocs were barrows and all crossbreed hogs were gilts the differences between the various traits studied cannot be attributed to either sex or breed.

Analysis of variance mean squares presented in Table 2 indicated these two groups of hogs differed significantly for fat cell area, marbling scored histologically, loin eye area, back fat thickness, percent ham and loin, hot carcass length and marbling score. No differences were observed for muscle fiber areas or percentages, carcass weight, color score, muscle pH, live weight or average daily gain.

The Duroc barrows were fatter and less heavily muscled as indicated by a smaller loin eye area, shorter carcass length, a larger back fat thickness and smaller percentage of ham and loin. The fatter hogs also had a significantly

TABLE 1. MEANS AND STANDARD DEVIATIONS OF HISTOLOGICAL, CARCASS AND PERFORMANCE TRAITS

Item	Duroc-barrow Mean	Duroc-barrow S.D.	Crossbreed-gilt Mean	Crossbreed-gilt S.D.	Pooled Mean	Pooled S.D.
Histological traits						
Area, White fiber[a]	2.117	0.314	1.965	0.152	2.048	0.186
Area, Red fiber[a]	1.609	0.192	1.366	0.120	1.500	0.119
White fiber (%)	80.14	1.477	82.51	2.378	81.21	1.341
Red fiber (%)	19.86	1.475	17.49	2.378	18.79	1.340
Area, Fat cells[a]	2.422	0.173	1.594	0.233	2.049	0.141
Histological marbling[b]	5.7	0.689	3.1	0.539	4.6	0.451
Carcass traits						
Carcass weight, kg	72.34	3.108	71.26	3.393	71.89	2.292
Loin eye area, cm^2	30.38	0.133	38.45	0.236	34.06	0.129
Back fat thickness, cm	3.70	0.039	2.97	0.042	3.37	0.029
Ham and loin (%)	39.90	0.405	43.50	0.741	41.52	0.400
Hot carcass length, cm	76.55	0.240	80.28	0.206	78.23	0.161
Marbling[c]	5.4	0.472	2.1	0.200	3.9	0.276
Color score[d]	2.9	0.152	2.5	0.220	2.7	0.130
Muscle pH[e]	5.8	0.062	5.6	0.044	5.7	0.040
Performance traits						
Live weight, kg	102.0	3.055	99.8	3.988	101.1	2.456
Average daily gain, kg	0.85	0.042	0.79	0.066	0.83	0.037

[a]Actual area in mm^2 obtained by multiplying by 10^{-3}.

[b]Histological sections were observed at 24X magnification and subjectively scored for marbling.

[c]Abundant = 9, ... , devoid = 1.

[d]Wisc. color standards were used; 4.0 = dark, 1.0 = light color of lean observed in longissimus at the 10-11th rib.

[e]pH of longissimus muscle homogenates from the 10-11th rib.

TABLE 2. ANALYSIS OF VARIANCE FOR HISTOLOGICAL, CARCASS AND PERFORMANCE TRAITS

Item	Mean squares[a]	
	Sex[b] (1)	Error (18)
Histological traits		
Area, White fiber	0.114	0.694
Area, Red fiber	0.292	0.282
White fiber (%)	27.875	35.962
Red fiber (%)	28.277	35.911
Area, Fat cell	3.393**	0.400
Histological marbling	33.879**	4.060
Carcass traits		
Carcass weight	29.250	105.097
Loin eye area	7.719**	0.332
Back fat thickness	0.424**	0.017
Ham and loin (%)	64.145**	3.200
Hot carcass length	10.766**	0.521
Marbling	52.366**	1.524
Color score	0.655	0.336
Muscle pH	9.340	3.104
Performance traits		
Live weight	122.688	120.663
Average daily gain	0.081	0.028

[a]Numbers in parenthesis represent degrees of freedom.

[b]Barrows were all Durocs and gilts were all crossbreeds.

**P < .01.

($P < .01$) larger mean fat cell area. This was in agreement with the simple correlation coefficients between mean fat cell area and loin eye area (-.60), back fat thickness (0.55), percentage ham and loin (-.52) and marbling (0.52). These results were in agreement with studies by Moody and Cassens (1968) which showed when more fat cells were present their mean size was larger than in tissue containing less fat cells. The simple correlation between fat cell area and average daily gain showed the faster gaining hogs had significantly larger mean fat cell areas (Table 3).

Percent red and white fibers. As illustrated in Table 4, the hot carcass length was significantly correlated with the percentages of both white and red muscle fibers. The longer carcass contained a higher percentage of white fibers and a lower percentage of red fibers. With any breed-sex affect removed the correlations (Table 4) between percentages of white and red muscle fiber and loin eye area approaches significance. A higher percentage of red fibers and lower percentage of white fibers may tend to indicate a somewhat larger loin eye area. A highly significant correlation existed between the percentages of muscle fibers and the live weight. Although not significant, heavier carcasses tended to have a higher percentage of white fibers and a lower percentage of red fibers as indicated by the

TABLE 4. CORRELATION COEFFICIENTS BETWEEN HISTOLOGICAL AND CARCASS TRAITS

		Histological traits					
	Correlation coefficients	Area, White fiber	Area, Red fiber	Area, Fat cell	Histological marbling	White fiber (%)	Red fiber (%)
Carcass traits							
Carcass weight	Intraclass	-0.049	-0.072	0.178	-0.047	0.387	-0.385
	Simple	-0.036	-0.041	0.216	0.031	0.351	-0.349
Loin eye area	Intraclass	0.204	0.262	-0.327	-0.116	-0.432	0.431
	Simple	0.062	-0.007	-0.603**	-0.486*	-0.126	0.125
Back fat thickness	Intraclass	-0.376	-0.338	0.213	0.079	0.060	-0.058
	Simple	-0.168	-0.033	0.546*	0.473*	-0.118	0.121
Ham and loin (%)	Intraclass	-0.071	0.022	-0.190	0.188	-0.146	0.145
	Simple	-0.117	-0.154	-0.518*	-0.302	0.050	-0.051
Hot carcass length	Intraclass	-0.141	-0.100	0.291	0.627**	0.565**	-0.566**
	Simple	-0.165	-0.237	-0.250	-0.058	0.526*	-0.527*
Marbling	Intraclass	0.194	0.216	0.119	0.312	0.283	-0.282
	Simple	0.191	0.312	0.516*	0.607**	-0.002	0.004
Color	Intraclass	0.002	0.060	-0.180	-0.043	0.089	-0.089
	Simple	0.032	0.129	0.036	0.142	0.020	-0.019
Muscle pH	Intraclass	-0.161	0.013	0.213	-0.156	0.042	-0.044
	Simple	-0.112	-0.101	0.377	0.093	-0.039	0.038

*P < .05.

**P < .01.

correlation coefficients of 0.39 and -.39 (Table 3). The mean percentages of white and red muscle fibers were in agreement with mean percentages found by Anderson and Parish (1972).

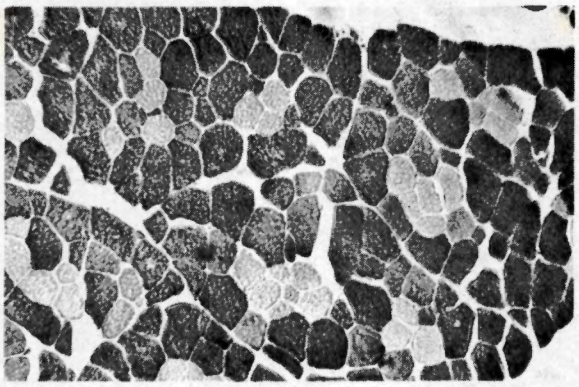
Histological marbling. The simple correlations (Table 4) revealed a relationship between histologically determined marbling and loin eye area, back fat thickness and intramuscular marbling. As the histologically determined marbling increased, the loin eye area decreased (-.49), the back fat thickness increased (0.47) and the intramuscular marbling increased (0.61). This was in agreement with the simple correlation coefficients between mean fat cell and loin eye area (-.60), back fat thickness (0.55) and intramuscular marbling score (0.52).

Performance traits. As shown in Table 3 the average daily gain was significantly correlated to carcass weight (0.67), back fat thickness (0.73) and percent ham and loin (-.55). This indicated that the faster gaining hogs had a greater carcass weight, thicker back fat and smaller percentage of ham and loin. These data indicated that the fatter hogs were less muscular.

Abnormal reacting tissue. During the ATPase staining procedure, six of the twenty-six sets of samples reacted differently while the staining conditions remained constant.

Photomicrographs of both the normal and abnormal stained tissue are shown in Figure 1.

The means of the histological, carcass and performance traits of the samples which reacted normally and abnormally to the ATPase staining reaction are shown in Table 5. The mean areas of both the white and red fibers were smaller in the normal reacting tissue. The percent white fibers in the normal tissue was similar to the percent white plus intermediate fibers in the abnormally reacting tissue, indicating the intermediate fibers of the abnormally reacting tissue were more closely related to the white fibers than the red fibers. The mean fat cell area was lower for the abnormally reacting tissue as was the mean marbling level. This supports the previous conclusions that larger fat cell area results in a higher marbling score.



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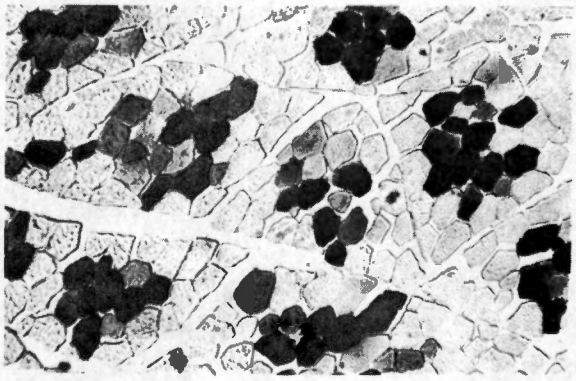

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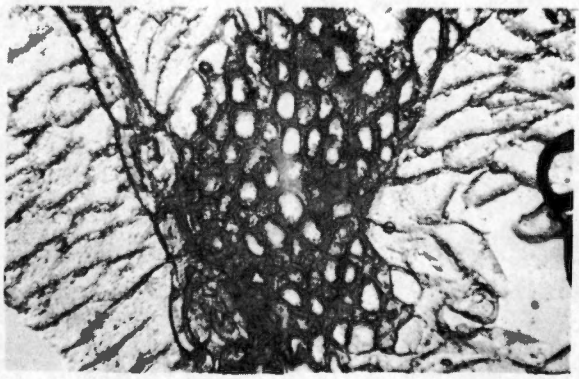

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Figure 1. Cross sections (16 microns) of porcine longissimus dorsi, 75X.

A. Fiber type exhibiting normal ATPase staining characteristics (Padykula and Herman, 1955).

B. Fiber type exhibiting abnormal ATPase staining characteristics (Padykula and Herman, 1955).

C. Intramuscular fat cells stained with Oil-Red-O (Humason, 1967).

TABLE 5. MEANS OF HISTOLOGICAL, CARCASS AND PERFORMANCE TRAITS OF SWINE WITH DIFFERENT ATPASE STAINING CHARACTERISTICS

Item	Normal mean	Abnormal mean
Histological traits		
Area, White fiber[a]	2.048	2.371
Area, Red fiber[a]	1.500	2.046
Area, Intermediate fiber[a]	--	2.014
Area, White and Intermediate fibers[a]	--	2.192
Area, Red and Intermediate fibers[a]	--	2.030
White fibers (%)	81.21	51.72
Red fibers (%)	18.79	20.95
Intermediate fibers (%)	--	27.33
White and Intermediate fibers (%)	--	79.05
Red and Intermediate fibers (%)	--	48.28
Area, Fat cell[a]	2.049	1.785
Carcass traits		
Carcass weight, kg	71.89	68.49
Loin eye area, cm^2	34.06	38.49
Back fat thickness, cm	3.37	2.84
Ham and loin (%)	41.5	42.4
Hot carcass length, cm	78.23	79.24
Marbling[b]	3.9	1.1
Color[c]	2.7	1.9
Muscle pH	5.7	5.4
Performance traits		
Live weight, kg	101.1	96.16
Average daily gain, kg	0.83	0.76

[a]Actual area in mm^2 obtained by multiplying by 10^{-3}.

[b]Abundant = 9, ..., devoid = 1.

[c]Wisc. color standards were used; 4.0 = dark, 1.0 = light color of lean observed in longissimus at the 10-11th rib.

CHAPTER V

SUMMARY

Twenty-six hogs were slaughtered and the hot carcass length and back fat thickness measured. After a 14 to 16 hour chill, the weights of the trimmed hams and loins were recorded and converted into percentages. The loin eye at the 10th rib was scored for color and marbling and a chop removed for histological examination. Cross sections of the longissimus dorsi were stained using the ATPase method and also with Oil-Red-O. One hundred muscle fibers were classified into either white or red types and their sizes and numbers were recorded. A marbling score was determined histologically for the cross sections of each sample.

Significant simple correlation coefficients between histologically determined marbling and loin eye area (-.49), back fat thickness (0.47) and marbling (0.61); mean fat cell area and loin eye area (-.60), back fat thickness (0.55) and marbling (0.52) indicated a possibility of using muscle biopsies for prediction of carcass composition and quality.

The analysis of variance between the Duroc barrows and crossbreed gilts showed the mean fat cell area, back fat thickness and marbling score were significantly larger for the Duroc barrows. The hot carcass length of the crossbreed

gilts was significantly longer and the percent ham and loin eye area were larger.

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APPENDIXES

APPENDIX A

ADENOSINE TRIPHOSPHOTASE STAINING PROCEDURE

Modification of Calcium Method (Padykula and Herman, 1955).

1. Section frozen tissue at 16 microns.
2. Air dry for 1 to 2 hours.
3. Fix in 2 percent CaCl (pH 7.0) for five minutes.
4. Wash for 2 minutes with distilled water.
5. Incubate for twenty minutes at 37°C in incubation media prepared as follows:

0.1 M sodium barbituate ($NaC_8H_{11}N_2O_3$)	20.0 ml
2 percent calcium chloride ($CaCl_2$)	62.5 ml
Distilled water	17.5 ml
ATPase (sodium salt)	152.0 mg

   Adjust pH to 9.4 with 0.1N NaOH and 3 percent HCl
6. Rinse in three changes of 1 percent $CaCl_2$.
7. Transfer into 2 percent cobalt chloride for 3 minutes.
8. Wash in four changes of distilled water for a total of one minute.
9. Treat with dilute ammonium sulfide, $(NH_4)_2S$, for 1 to 2 minutes.

10. Wash in distilled water for 5 minutes.
11. Fix in 2 percent $CaCl_2$ for 2 minutes.
12. Rinse twice in distilled water.
13. Mount in glycerol jelly.

APPENDIX B

INTRAMUSCULAR FAT STAINING PROCEDURE

(Oil-Red-O)

Steps 1, 2, 3, and 4 same as in Appendix A (ATPase staining procedure, modification of calcium method, Padykula and Herman, 1955).

5. Incubate sections at room temperature for 10 minutes in the following Oil-Red-O solution:

Stock solution	
Oil-Red-O	250 mg
99% ethanol	100 ml

Working solution	
Stock solution	60 ml
Distilled water	40 ml

Filter and use immediately

6. Wash with distilled water for 3 to 5 minutes.

APPENDIX C

TABLE 6. HISTOLOGICAL, CARCASS AND PERFORMANCE DATA

Item	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Histological traits																				
Area, White fiber[a]	1.898	2.474	1.994	1.705	2.046	1.826	1.701	1.361	1.909	2.400	1.456	1.331	2.589	1.194	1.917	2.634	5.006	1.353	1.997	2.175
Area, Red fiber[a]	1.423	2.071	1.152	1.172	1.811	0.974	1.497	0.853	1.114	1.384	1.300	0.967	1.714	0.811	1.870	2.355	2.951	1.414	1.515	1.652
White fiber (%)	75.25	78.18	86.76	81.94	77.05	81.92	82.14	85.60	92.60	69.66	86.84	88.30	83.67	78.76	83.54	76.71	78.57	89.23	72.60	74.70
Red fiber (%)	24.75	21.82	13.24	18.06	22.55	18.28	17.86	14.40	7.69	30.34	13.16	11.70	16.33	21.24	16.46	23.29	21.43	10.77	27.40	25.30
Area, Fat cells[a]	1.115	1.110	1.298	2.192	2.886	1.589	2.414	2.061	3.048	0.921	1.859	3.233	1.161	3.080	2.189	1.893	2.760	1.437	1.895	2.889
Histological marbling[b]	1	2	4	3	2	5	8	6	2	2	5	9	5	6	7	4	4	3	4	9
Carcass traits																				
Carcass weight, kg	73.5	71.2	67.6	68.9	68.5	77.1	78.0	68.9	80.7	66.7	78.0	65.8	68.0	73.9	70.8	69.4	74.4	75.8	65.3	74.8
Loin eye area, cm^2	46.39	43.74	37.29	33.61	24.26	27.74	29.36	36.00	38.32	41.74	33.03	28.29	36.07	31.81	33.49	32.65	31.16	33.10	29.87	32.97
Back fat thickness, cm	2.79	3.30	2.54	2.97	3.73	4.06	4.96	2.97	3.38	3.12	3.89	3.48	2.46	3.89	3.48	3.38	3.30	3.23	3.38	4.24
Ham and loin (%)	42.5	47.7	44.9	42.4	39.3	38.9	37.9	45.2	41.3	44.0	40.6	42.0	43.1	40.4	40.6	41.8	38.2	40.4	39.2	40.0
Hot carcass length, cm	78.49	80.26	80.26	80.01	73.15	75.95	76.45	78.99	82.04	78.23	77.72	78.23	81.79	76.96	78.23	75.44	76.20	82.55	73.66	80.01
Marbling[c]	1	2	2	2	5	6	6	2	3	2	3	6	3	4	9	5	6	2	4	5
Color score[d]	1.5	2.0	3.0	1.5	4.0	3.0	2.5	3.0	2.5	3.0	3.0	2.5	3.0	2.0	3.0	3.0	2.5	3.0	3.0	3.0
Muscle pH[e]	5.5	5.6	5.5	5.8	6.2	5.6	5.9	5.5	5.8	5.8	5.8	5.7	5.7	5.7	6.1	5.6	5.6	5.6	5.7	5.7
Performance traits																				
Live weight, kg	98.43	95.71	96.62	99.34	96.62	107.96	102.97	97.98	111.59	93.90	107.50	99.79	99.79	103.87	102.97	102.06	104.78	105.24	92.08	102.51
Average daily gain, kg	0.75	0.76	0.71	0.79	0.75	0.94	0.95	0.79	0.99	0.84	0.85	0.84	0.69	0.90	0.81	0.79	0.82	0.85	0.84	0.91

[a]Actual area in mm^2 obtained by multiplying by 10^{-3}.

[b]Histological sections were observed at 24X magnification and subjectively scored for marbling.

[c]Abundant = 9, ..., devoid = 1.

[d]Wisc. color standards were used; 4.0 = dark, 1.0 = light color of lean observed in longissimus at the 10-11th rib.

[e]pH of longissimus muscle homogenates from the 10-11th rib.

APPENDIX D

TABLE 7. HISTOLOGICAL, CARCASS AND PERFORMANCE DATA FOR SIX HOGS THAT EXHIBITED ABNORMAL ATPASE STAINING REACTIONS

Item	Animal numbers 1	2	3	4	5	6	Mean
Histological traits							
Area, White fiber[a]	2.611	1.686	1.536	2.392	2.281	3.717	2.371
Area, Red fiber[a]	1.850	1.520	1.859	1.947	2.087	3.013	2.046
Area, Intermediate fiber[a]	1.922	1.821	1.607	1.809	1.970	2.955	2.014
Area, White and Intermediate fibers[a]	2.266	1.753	1.571	2.101	2.125	3.336	2.192
Area, Red and Intermediate fibers[a]	1.886	1.671	1.732	1.878	2.028	2.984	2.030
White fibers (%)	36.78	53.78	70.45	67.80	52.48	29.03	51.72
Red fibers (%)	41.38	13.64	13.64	20.34	10.89	25.81	20.95
Intermediate fibers (%)	21.84	32.58	15.91	11.86	36.63	45.16	27.33
White and Intermediate fibers (%)	58.62	86.36	86.36	79.66	89.11	74.19	79.05
Red and Intermediate fibers (%)	63.22	46.22	29.55	32.20	47.52	70.97	48.28
Area, Fat cell[a]	0.001	4.073	2.187	1.199	2.397	0.855	1.785
Carcass traits							
Carcass weight, kg	76.20	72.12	62.14	73.02	64.86	62.59	68.49
Loin eye area, cm^2	33.93	41.16	32.38	34.19	33.74	31.16	38.26
Back fat thickness, cm	3.81	2.61	2.10	2.71	3.12	2.71	2.84
Ham and loin (%)	38.3	41.1	44.5	42.8	42.1	45.7	42.4
Hot carcass length, cm	77.72	77.97	81.28	82.29	76.78	78.99	79.24
Marbling[b]	Dev.	Dev.	Dev.	Dev.	Dev.	Tr.	
Color[c]	1.5	2.5	2.0	1.0	1.5	3.0	1.9
Muscle pH	5.2	5.6	5.6	5.0	5.5	5.6	5.4

Table 7 (Continued)

Item	Animal numbers 1	2	3	4	5	6	Mean
Performance traits							
Live weight, kg	98.43	99.33	92.08	104.78	91.17	91.62	96.16
Average daily gain, kg	0.87	0.74	0.61	0.83	0.75	0.74	0.76

[a]Actual area in mm^2 is obtained by multiplying by 10^{-3}.

[b]Abundant = 9, ... , devoid = 1.

[c]Wisc. color standards were used; 4.0 = dark, 1.0 = light color of lean observed in longissimus at the 10-11th rib.

VITA

John David Parks was born August 2, 1947, in Urbana, Illinois, to Mr. and Mrs. George Ogan Parks. He attended grade school and junior high school in Joliet, Illinois. In January of 1962, he moved to Marietta, Georgia with his family. He graduated from Marietta High School in 1965. He attended Mercer University in 1965. From 1966 through 1967, he attended Kennesaw Junior College in Marietta, Georgia while working in his father's restaurant. In 1968 he transferred to Shorter College in Rome, Georgia where he majored in biology. He received his Bachelor of Arts degree in August of 1970.

From February 1971 to June 1972 he served in the United States Army as a food analysis laboratory technician in Washington, D. C.

In June 1972, he enrolled in graduate school at the University of Tennessee. On September 1, 1973, he accepted a Research Assistantship.

He was married to Carolyn Cox Covington in June, 1971.