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Effect of various levels of bird resistant grain sorghum on the live performance and carcass characteristics of meat type swine

Calvin F. Prince

To the Graduate Council:

I am submitting herewith a thesis written by Calvin F. Prince entitled "Effect of various levels of bird resistant grain sorghum on the live performance and carcass characteristics of meat type swine." 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 Animal Husbandry.

Frank B. Masincupp, Major Professor

We have read this thesis and recommend its acceptance:

J. B. McLaren, C. C. Melton, E. R. Lidvall

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

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

February 15, 1974

To the Graduate Council:

I am submitting herewith a thesis written by Calvin F. Prince, Jr., entitled "Effect of Various Levels of Bird Resistant Grain Sorghum on the Live Performance and Carcass Characteristics of Meat Type Swine." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Animal Husbandry.

Frank B. Masincupp
Major Professor

We have read this thesis
and recommend its acceptance:

E. R. Sidwall

Curtis C. Metton

J. B. McLaren

Accepted for the Council:

Stelton A. Smith
Vice Chancellor for
Graduate Studies and Research

EFFECT OF VARIOUS LEVELS OF BIRD RESISTANT GRAIN SORGHUM ON THE LIVE PERFORMANCE AND CARCASS CHARACTERISTICS OF MEAT TYPE 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

Calvin F. Prince, Jr.

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ABSTRACT

Data were collected on 40 Duroc hogs at the University of Tennessee Agricultural Experiment Station, Knoxville, Tennessee to determine the effect of various levels of bird resistant grain sorghum on live performance and carcass characteristics in meat type swine. Rations containing 25, 50, 75, or 100 percent grain sorghum in the grain portion of the ration, were compared with a control ration consisting of 100 percent corn. The protein level (16 percent) remained constant throughout the experiment.

There were no significant differences between any of the rations for average daily gains (ADG) during the periods from 40 to 90 pounds, 90 to 140 pounds, 140 to 190 pounds, or 40 pounds to market weight. However, the highest ADG resulted when pigs were fed the 100 percent corn or 25 percent grain sorghum rations. In the periods from 40 to 140 pounds, all of the rations appeared to be equal in producing gain.

In a comparison of feed conversion from 40 pounds to market weight between the control ration and rations containing 50, 75, and 100 percent grain sorghum, there was a significant difference ($P < .05$) in favor of the control. There was also a significant ($P < .01$) linear relationship between the percentage of grain sorghum in the ration and the amount of feed required per pound of gain. As the percentage of grain sorghum in the ration increased, the amount of feed required per pound of gain also increased. The increased amount of feed required per pound of gain for the pigs fed the grain sorghum rations ranged from 3 to 8 percent above that amount required by pigs fed the control ration.

decreased digestibility of the grain sorghum rations is possibly responsible for the poor feed conversion of the animals fed these rations as shown by the feeding trials.

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CHAPTER I

INTRODUCTION

In recent years, grain sorghums have increased in importance as a feed grain in many parts of the United States, including Tennessee. The rapid increase in grain sorghum production has been a result of the introduction of high yielding hybrids, and also the introduction of bird resistant hybrids. The latter has allowed growers to harvest and feed their grain with minimal loss to wild birds. In areas of low rainfall, sorghum serves the same purpose that corn does in the corn belt but is grown instead of corn because it is more tolerant to heat and drought. Where corn is often a near or complete failure, sorghum has demonstrated its ability to produce good crops under unfavorable conditions. Grain sorghums are also more resistant than corn to injury by grasshoppers, corn borers, and rootworm.

There is some controversy surrounding the subject of grain sorghum level effects and comparisons with other feedstuffs on swine feedlot performance and carcass characteristics. The decision to feed grain sorghum may be largely a question of economics and the availability of it in a given area.

The objectives of this study were (a) to compare the difference in average daily gain and feed conversion of pigs fed corn versus four different levels of grain sorghum, (b) to compare differences in carcass characteristics of pigs fed corn and the different levels of grain sorghum, and (c) to compare the differences in digestibility of grain sorghum and corn by pigs at two stages of growth.

CHAPTER II

LITERATURE REVIEW

I. CLASSIFICATION OF GRAIN SORGHUM

The term "grain sorghum" includes several groups of grains; such as kafirs, milos, feteritas, durras, shallu, kaoliangs, and hegari, according to Leonard and Martin (1963) and the National Academy of Sciences (1964). Leonard and Martin (1963) stated that most of the grain sorghum hybrids and varieties grown in the United States were derived from crosses between milo and kafir and occasionally other groups but are not typical of any of the above groups. They indicated that Texas 660, a grain sorghum hybrid, is a result of crossing Combine Kafir-60 with Caprock, a milo type grain sorghum.

Matz (1969) reported that in commerce, grain sorghum has been referred to as "milo", while "milo maize", "kafir corn", and "gyp corn" are other terms used to identify the grain.

Baker and Reinmiller (1939), Aubel (1959), Lawrence (1969), Peo and Hudman (1958), Lodge (1967), and Van Spaendonk, Nauwynck, and Vanschoubroek (1964) used the term "grain sorghum" in reporting their research. Other researchers, Aubel (1956), Jensen et al. (1969), Handlin et al. (1961), Fletcher (1953), Hillier, Martin, and Waller (1959), and Jenson, Becker, and Harmon (1965) used the term "milo".

Since the grain sorghum hybrids in the United States today are not true milos, as reported by Leonard and Martin (1963), in this thesis the author will use the term "grain sorghum" when referring to the bird resistant hybrids.

II. GRAIN SORGHUM AS A SUBSTITUTE FOR CORN

Feeding Value

Several reports (Peo and Hudman, 1958; Hillier et al., 1959; Hale and Lyman, 1961; and Jensen, Becker, and Terrill, 1959) have shown that properly fortified, good quality milo compares favorably with corn when used in diets for growing-finishing swine. Jensen et al. (1959) also suggested that, when substituted on an equal weight basis in diets having soybean meal as the supplementary protein, milo had a higher feeding value than did wheat, oats, and barley.

Baker and Reinmiller (1939) made nine comparisons between shelled corn and various grain sorghums and reported that the grain sorghums proved to be 89 percent as efficient as shelled corn in feeding value. Hillier, MacVicar, and Pond (1954) found grain sorghum to have from 93 percent to 98 percent the value of No. 2 yellow corn when comparing it to four varieties of grain sorghum.

Lodge (1967) reported that grain sorghum had a higher net energy value than barley and that a 7 percent improvement in feed efficiency resulted when grain sorghum was compared to barley. Jensen et al. (1965) reported that milo was inadequate as the sole source of protein for finishing swine, but the addition of .25 percent lysine to such diets resulted in gain and feed efficiency ratios equal to pigs fed a 12 percent corn-soybean meal diet.

Live Performance

Fletcher (1953), Loeffel (1957), Peo and Hudman (1958), Handlin et al. (1961), and Jensen et al. (1969) reported that grain sorghum and

corn produced approximately the same average daily gain, but that 8 to 20 percent more feed was required per pound of gain with the grain sorghum. Aubel (1959) also reported that pigs fed whole sorghum grain made daily gains comparable to corn-fed pigs but were not as efficient in feed conversion.

Van Spaendonk et al. (1964) found no significant difference in gain and feed efficiency when used to compare maize and grain sorghum for fattening swine and also stated that growth curves for both groups of pigs were similar. Howell et al. (1971) reported no difference in gain and feed efficiency for growing-finishing swine fed corn, grain sorghum, and wheat, when substituted on an equal weight basis.

In the first of two trials, Aubel (1952) reported that there was no significant difference in daily gain and feed efficiency between corn and the Martin, Midland, and Colby varieties of grain sorghum. In the second trial, Westland and Midland varieties of grain sorghum produced gains approximately 12 percent greater than that of corn and both varieties of grain sorghum were converted to pork more efficiently than corn. Aubel (1955) further reported that daily gains of pigs fed ground milo were about 12 percent greater than those of corn-fed pigs, while whole milo produced approximately 8 percent greater gains in pigs than corn.

Lawrence (1969) fed high cereal diets consisting of maize, sorghum, and barley and found that the sorghum-fed pigs grew faster and converted feed more efficiently than those fed maize, but the difference was not significant. Cole, Client, and Luscombe (1969) compared flaked maize and

maize meal with grain sorghum and reported that daily gains for sorghum-fed pigs were significantly higher. However, no significant differences were noted in the feed efficiency ratios.

Carcass Characteristics

Several researchers have compared the carcasses of corn- and sorghum-fed pigs based on criteria such as dressing percentage, carcass length, loin eye area, backfat thickness, percent lean cuts, and carcass weight.

Van Spaendonk (1964), Cole et al. (1969), and Howell et al. (1971) reported no significant differences in any of the previously mentioned carcass characteristics when used in these comparisons. Lawrence (1968) reported that the dressing percentages of pigs fed maize were significantly higher than the sorghum-fed pigs, although no difference was noted in carcass length and loin eye area. Handlin et al. (1961) found no significant differences in backfat thickness or carcass length between pigs fed corn and sorghum diets. However, they reported that the carcasses from hogs fed milo were significantly lower in percent lean cuts than those fed corn based rations.

Lawrence (1969) reported greater carcass fat thicknesses at the shoulder, middle, and loin from pigs fed maize, with all other criteria being non-significant.

Jensen et al. (1965) evaluated milo supplementation of lysine and methionine as a source of protein for meat-type swine. They reported that milo diets supplemented with lysine produced carcasses which yielded higher percent lean cuts and had larger loin eye areas than did the milo control

diet. Baker and Reinmiller (1939) reported that carcasses of hogs fed grain sorghum were equal to those of corn-fed pigs with respect to finish, yield, firmness, and grade.

III. DIGESTIBILITY OF GRAIN SORGHUM AND CORN

Digestion trials involving pigs fed maize, sorghum, wheat, and barley were conducted by Lawrence (1968) when the pigs weighed 60 pounds and again when they weighed 130 pounds. He reported that the digestibility of maize was significantly higher than that of sorghum and other cereal grain rations. Lawrence (1969) reported also that dry matter and crude protein digestibility of maize was significantly greater than that of sorghum. Howell et al. (1971) suggested that the protein in grain sorghum was significantly lower in digestibility (66 percent) than that of corn (75 percent) or wheat (79 percent).

Several studies have suggested that the tannin content of grain sorghum may be responsible for its lower digestibility. Chang and Fuller (1964) and Fuller, Potter, and Brown (1966) reported that the feeding value of brown sorghum grain was lower than that of red or yellow grain when fed to growing chicks. McGinty (1969) found that in vitro dry matter digestibility of brown sorghum grain was lower than that of white, red, or yellow grain. It has also been shown by Donnelly and Anthony (1970) that when tannin content of sericea lespedeza increases, dry matter digestibility decreases. Harris, Cummins, and Burns (1970) reported that the seed of high tannin sorghum hybrids were not digested as efficiently as those having lower tannin content.

Effect of Age

Anderson and Bowland (1966) reported that crude protein digestibility in pigs between three and nine weeks of age improved as age increased. Lassiter (1956) indicated that pigs weighing approximately 68 kg apparently digested 2 to 4 percent more crude protein than pigs on the same ration weighing 23 kg. Dammers (1965) concluded that most other nutrients are also digested better by older animals. Examination of the data presented by McConnell (1970) indicated that the apparent digestibilities of dry matter and crude protein usually increased several percentage units as the animals became older.

IV. TANNINS IN GRAIN SORGHUM

Bird Resistant Qualities

A large number of brown-seeded grain sorghum hybrids have appeared on the market in recent years. The bird resistant qualities of these hybrids has allowed the expansion of the area of adaptation to include the humid southeastern United States and other areas with large populations of grain-feeding birds.

This "bird resistance" in grain sorghum is apparently due to an astringent or bitter flavor associated with the presence of a brown color of the subcoat of the seed as reported by Bate-Smith and Rasper (1969) and Harris (1970). This flavor component is due to the presence of anthocyanogens (Blessin, Van Etten, and Dimler, 1963) which are precursors of condensed tannins (McGinty, 1969). Therefore, the bird resistant quality is based on the rejection of grains containing tannins by birds and by the availability of more desirable food.

Bate-Smith and Rasper (1969) reported that the low palatability of most varieties of grain sorghum is due to a high level of tannin. These tannins in sorghum are only found in grasses of the tribe Andropognae to which sorghum belongs.

According to Bate-Smith and Rasper (1969), the tannin content of grain sorghum showed some correlation with seed coat color. Those with low tannin levels had white or yellowish seeds, while the red-brown or dark brown seeds were indicative of high tannin content. Harris et al. (1970) reported that tannin content was directly related to the presence of a brown color in the seed. They also reported that as the brown color decreased, the tannin percentage also decreased.

Characteristics of Tannin

Tannin or tannic acid is the name given a group of substances that are widely distributed in plants and in the seed coat of many seeds. According to Gortner and Gortner (1950), tannins have been divided into three general classifications. They are: (1) condensed tannins, (2) hydrolyzable tannins, and (3) unclassified tannins.

Condensed tannins are tannins that cannot by hydrolyzed by acids or enzymes. Gortner and Gortner (1950) reported that the most important condensed tannins are Indian cutch, cube gambir, and quebracho tannins.

Gortner and Gortner (1950) stated that hydrolyzable tannins were classified into gallotannins, ellagitannins, and caffetannins. These yield respectively gallic acid, ellagic acid, and caffeic acid. They also reported that gallotannins have a very astringent taste and are widely distributed in the leaves and stems of many plants.

Unclassified tannins, as the name implies, are those tannins of which research has provided insufficient information for their classification.

CHAPTER III

EXPERIMENTAL PROCEDURE

I. FACILITIES

The experimental animals were fed in pole type barns open to the south with the north closed during winter and open for ventilation during the summer. The pens were five feet wide and 20 feet long with an automatic waterer and one two-hole self feeder in each pen. The feeder was located under the roof and the waterer at the opposite end of the pen. The floor was solid concrete with a slight slope to the outside gutter to provide drainage.

II. RATIONS

Composition of the rations fed in this experiment is shown in Table 1. The variety of grain sorghum used in this experiment was McNair 546, a bird resistant hybrid. The grain sorghum was purchased as whole grain and ground by a commercial firm. The corn was ground through a hammer mill and the supplement and grain sorghum were then weighed in proper proportions before mixing. A proximate analysis was performed on the corn and grain sorghum, and both grains contained 9 percent protein. This allowed the supplement to remain constant while the grain portions were varied. All of the rations contained 16 percent protein as indicated by a proximate analysis, and this protein level remained constant throughout the experiment. In the rations, grain sorghum replaced 25, 50, 75, or 100 percent of the corn, with the control ration being 100 percent corn.

TABLE 1. PERCENTAGE COMPOSITION OF RATIONS

Ingredient	16 percent protein				
No. 2 Yellow Corn (9%)	751	563	390	187	---
Grain Sorghum (9%)	---	187	390	563	751
SBOM (44%)	150	150	150	150	150
Meat Scraps (50%)	50	50	50	50	50
Dehy. Alf. Meal (17%)	30	30	30	30	30
Dical. Phos.	10	10	10	10	10
Salt	5	5	5	5	5
Trace Min. Premix[a]	1	1	1	1	1
Antibiotics[b]	1	1	1	1	1
Vit. Premix[c]	2	2	2	2	2
Total	1000	1000	1000	1000	1000

[a]Provides an addition to the ration of 1000 ppm of Mu, 1 ppm Ca, 100 ppm Fe, 10 ppm Cu, and 100 ppm Zn.

[b]Contains 10 gm chlorotetracycline and 100 gm neomycin sulfate per pound.

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

III. MANAGEMENT

After weaning, 40 Duroc pigs were randomly allotted to pens with two barrows and two gilts per pen. Treatments were then randomly allotted to pens. All pigs were wormed at the start of the test and again at about 60 kg body weight. The pigs were weighed at 14-day intervals initially, and at 7-day intervals as the pigs approached slaughter weight. Average daily gain and feed efficiency ratios were calculated after each weighing and at the end of the test. At the end of the experiment, the pigs were probed for backfat and a final weight was taken.

IV. DIGESTION TRIALS

Fixed collection digestion trials were conducted with 6 Duroc and 6 crossbred barrows at 45 kg mean body weight and again at 68 kg mean body weight. The pigs used in these trials were not taken from those used in the feeding experiment to prevent possible adverse effects on gain and feed efficiency due to stress during confinement. Only three of the five rations (100 percent corn, 50 percent grain sorghum, and 100 percent grain sorghum) were used in the digestion trials so that more replications could be used, thus representing more reliable data. During the trials, the pigs were confined to individual metabolism crates based on a design by Welch, Cordts, and Vander Noot (1964). Total daily dietary feed allowance within each trial was determined by taking 4 percent of the body weight of each pig and adjusting the amount fed based on voluntary intake. Equal parts of the total intake were fed twice daily and water

was provided ad libitum. Four-day preliminary and 4-day collection periods were used. Feces were collected daily, composited for each animal, and refrigerated at 5° C in jars containing thymol until analyzed.

V. LABORATORY ANALYSES

Fecal collections from each animal were thoroughly mixed after each trial and a 300 g wet sample was dried for 72 hours in a forced-air oven at 65° C. The samples were allowed to air-equilibrate for 24 hours, reweighed, ground through the medium mesh (2 mm) of a Wiley Mill, and placed in air-tight glass jars until analyzed. Ration and feces samples were analyzed in duplicate for moisture, ash, crude protein, crude fiber, and ether extract according to A.O.A.C. (1965) methods. From these data, the following calculations were made: digestion coefficients of dry matter, crude protein, organic matter, crude fiber, and ether extract.

The determination of tannin in the grain sorghum was according to the Folin-Denis Method of A.O.A.C. (1960) as modified by Burns (1963). The Folin-Denis reagent is a mixture of compounds which produce a blue color with reducing substances and is non-specific for any group of tannins. The procedure called for refluxing of a 500 mg sample for 5 hours. A 2 ml aliquot of extract was mixed with 2 ml of Folin-Denis reagent and 5 ml of a sodium carbonate saturated solution and then diluted to 100 ml by the addition of distilled water. After 40 minutes, absorbance was determined at 725 mμ. The reading was compared to a commercial tannic acid standard, and the results expressed as tannic acid equivalents. However, for brevity in this thesis the results of this analysis will be hereafter expressed as percent tannin.

VI. SLAUGHTER PROCEDURE

As the pigs reached slaughter weight, they were slaughtered and processed packer style using the procedures outlined by the National Livestock and Meat Board (1952). After slaughter, carcass length, backfat thickness, and hot carcass weight was recorded. The value reported for backfat thickness was the mean of individual fat depth measurements over the first rib, last rib, and last lumbar vertebra. Carcass length was measured from the first rib to the aitch bone. The carcasses were then chilled at 33° F for 24 hours before final measurements were taken. At 24 hours post mortem, loin eye area at the tenth rib was traced and the area determined with a compensating planimeter. Ham and loin weights were taken, and loin color and marbling scores at the tenth rib were observed and scored on each carcass. These loin qualities were scored according to Pork Quality Standards, Special Bulletin 9, University of Wisconsin (1963).

VII. STATISTICAL ANALYSIS

Live performance and carcass data were analyzed by least squares procedures as outlined by Harvey and orthogonal polynomials using the following models:

$$Y_{ijk} = \mu + r_i + pen_j/r_i + e_{ijk}$$

where, Y_{ijk} is the kth observation in the jth subgroup of the ith group,

μ is Mμ, the overall mean

r_i is ration 1 through 5 in the ith group,

pen_j/r_i the jth pen within the ith ration,

e_{ijk} the error term.

Treatment sum of squares were then partitioned by orthogonal polynomials using the following model:

$$Y = a + b_1X + b_2X^2 + b_3X^3$$

Digestion trial data were analyzed using a two-level analysis of variance with the following model:

$$Y_{ijk} = \mu + r_i + t_j + (rt)_{ij} + e_{ijk}$$

where, Y_{ijk} is the kth observation in the jth subgroup of the ith group

μ is Mu, the overall mean,

r_i is the random contribution for the ith ration

t_j is the random contribution for the j^{th} time

$(rt)_{ij}$ is the interaction of ration and time of the ith and jth group

e_{ijk} the error term.

Significant differences between means were determined by significant F values (Steele and Torrie, 1960) or Duncan's (1955) multiple range test.

CHAPTER IV

RESULTS AND DISCUSSION

I. EFFECT OF GRAIN SORGHUM ON GAINS

The effect of grain sorghum on average daily gains (ADG) is shown in Table 2. In the periods from 140 to 190 pounds and 40 pounds to market, the highest ADG was made by pigs fed the 100 percent corn and the 25 percent grain sorghum rations. However, the difference was not significant. In the periods from 40 to 90 pounds and 90 to 140 pounds, the rations appeared to be equal in producing gain, and again no significant differences were noted. This supports the results of Fletcher (1953), Peo and Rudman (1958), Jensen et al. (1969), and Van Spaendonk et al. (1964) who reported that grain sorghum and corn produced approximately the same ADG in fattening swine. In contrast, Cole et al. (1969) reported that rate of gain of pigs fed grain sorghum was significantly higher ($P < .05$) than those fed corn. During the entire period from 40 pounds to market weight, grain sorghum had from 90 to 98 percent the value of corn. This is in agreement with the results of Baker and Reinmiller (1939) and Hiller et al. (1954) who found that grain sorghum was from 89 to 98 percent as efficient as corn in producing gain.

II. EFFECT OF GRAIN SORGHUM ON FEED CONVERSION

The effect of grain sorghum levels on feed conversion is shown in Table 2 with the analysis of variance for this variable shown in Table 3. There were significant differences in several comparisons made in feed conversion from 40 pounds to market weight. In a comparison between the

TABLE 2. FEEDLOT PERFORMANCE OF PIGS FED VARIOUS LEVELS OF GRAIN SORGHUM TO MARKET WEIGHT

	Percent grain sorghum				
	0[a]	25	50	75	100
No. of pigs	8	8	8	8	8
Avg. initial wt., lb.	50.50	47.75	53.75	47.88	45.38
Avg. final wt., lb.	220.00	224.00	220.38	219.88	223.63
Avg. daily gain, lb.					
40 to 90 lb.	1.53	1.43	1.59	1.27	1.42
90 to 140 lb.	1.93	1.84	1.83	1.76	1.89
140 to 190 lb.	1.81	1.81	1.61	1.64	1.60
40 lb. to market	1.75	1.76	1.70	1.61	1.73
Feed per lb. gain, lb.	3.02	3.12	3.27	3.19	3.29

[a]100 percent corn.

TABLE 3. ANALYSIS OF VARIANCE OF FEED CONVERSION

Source	df	Mean Squares	F
Total	9		
Treatment	4	947.00	7.52*
Linear	1	2832.20	22.48**
Quadratic	1	289.29	2.30
Cubic	1	145.80	1.16
Lack of fit	1	520.71	4.13
Error	5	126.00	

*P<.05.

**P<.01.

control ration and rations containing 50 and 100 percent grain sorghum, there was a significant difference ($P < .01$) in favor of the control ration. There was also a significant difference ($P < .05$) in favor of the control when compared against the 75 percent grain sorghum ration. Examination of these data further revealed that there was a significant difference ($P < .05$) in favor of the 25 percent grain sorghum ration versus the rations containing 50 and 100 percent grain sorghum. There was no significant difference between the 25 percent grain sorghum ration and the 75 percent grain sorghum ration. When comparisons were made among the 50, 75, and 100 percent grain sorghum rations, no significant differences were noted. There was also no significant difference in feed conversion between the control and 25 percent grain sorghum rations, indicating that the ration containing the lowest percentage of grain sorghum approached the control ration in efficiency of gain.

There was a significant ($P < .01$) linear relationship between the percentage of grain sorghum in the ration and the amount of feed required per pound of gain. (See Table 3). As the percentage of grain sorghum in the ration increased, the amount of feed required per pound of gain also increased. (See Figure 1). This increase in the amount of feed required by pigs fed the grain sorghum rations above that required by those fed the control ranged from 3 to 8 percent. Similar results were reported by Fletcher (1953), Loeffel (1957), Peo and Hudman (1958), Handlin et al. (1961), and Jensen (1969) who stated that 8 to 20 percent more feed was required per pound of gain with grain sorghum as compared to corn.

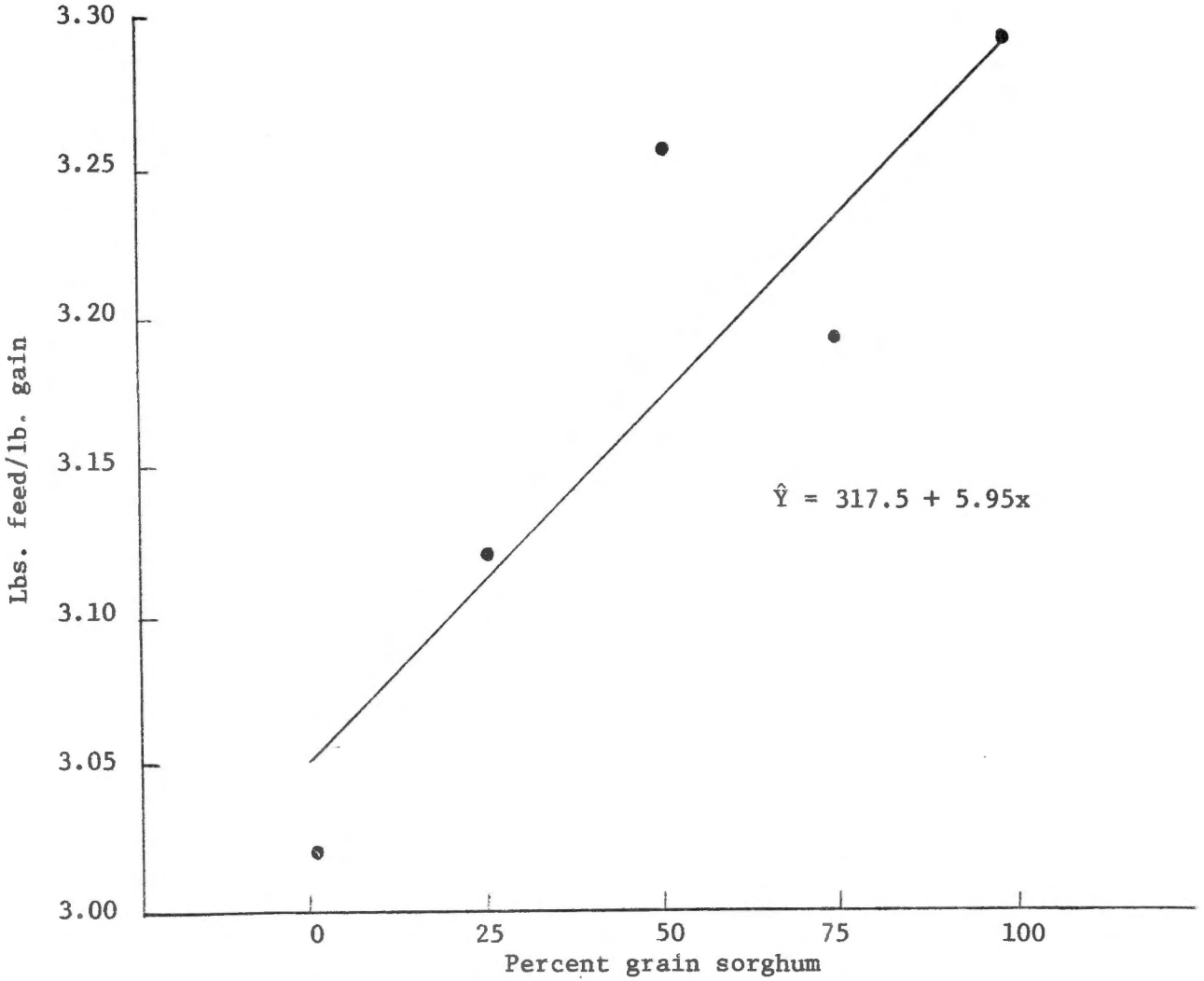

Figure 1. Relationship of mean feed conversion figures to percentage of grain sorghum in the ration.

III. EFFECT OF GRAIN SORGHUM ON CARCASS CHARACTERISTICS

The effect of grain sorghum levels on carcass characteristics is shown in Table 4. Examination of these data show that the average backfat thickness of pigs fed the various rations approach a linear response. As the percentage of grain sorghum in the ration increased, the average BF tended to decrease slightly. However, this linear response was not significant. The control ration and the 25 percent grain sorghum ration had the highest average BF, but there was no significant difference. This is in agreement with Lawrence (1969) who reported that fat thickness at the shoulder, middle, and loin was greater for carcasses of hogs fed corn. Analysis of the data for the remaining carcass traits (carcass length, dressing percentage, loin eye area, percent ham-loin, loin quality scores, and loin marbling quality scores) revealed no significant differences nor did they approach significance. Results of the analyses of these data support the findings of others that grain sorghum produces carcasses of equal value to those of corn-fed pigs. Van Spaendonk (1964), Cole et al. (1969), and Howell et al. (1971) reported no significant differences in any of the previously mentioned carcass characteristics when used in the comparison of corn and grain sorghum. Baker and Reinmiller (1939) also reported that grain sorghum produced carcasses apparently equal to those of pigs fed corn in yield, finish, firmness, and grade.

IV. DIGESTIBILITY OF THE RATION

Effect of Age

The apparent digestibilities of dry matter (DM), organic matter (OM), crude protein (CP), ether extract (EE), and crude fiber (CF) are presented

TABLE 4. FINAL WEIGHTS AND CARCASS MEASUREMENTS FROM PIGS FED VARIOUS LEVELS OF GRAIN SORGHUM TO MARKET WEIGHT

	Percent grain sorghum				
	0[a]	25	50	75	100
No. of pigs	8	8	8	8	8
Avg. final wt., lb.	220.00	224.00	220.38	219.88	223.63
Avg. percent ham and loin, %	42.74	42.80	41.88	42.76	43.51
Avg. length, in.	31.23	30.70	30.55	30.94	31.00
Avg. dressing percent, %	71.51	70.20	72.15	70.02	71.55
Avg. backfat, in.	1.49	1.54	1.43	1.42	1.42
Avg. loin eye area, sq. in.	5.16	5.23	5.47	5.25	5.47
Avg. loin quality score[b]	2.31	3.00	2.25	2.94	2.75
Avg. loin eye marbling[c]	4.75	6.88	5.25	7.25	5.50

[a]100 percent corn.

[b]Scored from 1 through 4 with 1 = pale, soft, and watery and 4 = dark, firm.

[c]Scored from 1 through 10 with 1 = devoid and 10 = abundant.

in Table 5, with the analysis of variance for these data following in Table 6. In the experiment, the apparent digestibilities of the ration components increased several percentage units as the animals became older. The digestibility of DM, OM, CP, EE, and CF in Trial 2 were significantly higher ($P < .01$) than in Trial 1. These data are in agreement with Dammers (1965) and McConnell (1970) who concluded that the digestibility of most nutrients increased as animals become older.

Effects of Grain Sorghum Level

Insofar as the digestibility of the rations are concerned, excluding the age interaction, the level of grain sorghum had a significant effect. The apparent digestibilities of DM and OM in the control ration (100 percent corn) were significantly higher ($P < .01$) than those of the rations containing 50 and 100 percent grain sorghum. There was no significant difference in digestibility of DM and OM in the latter two rations. CP digestibility was significantly higher ($P < .05$) in the control ration than in the rations containing grain sorghum, and again no significant difference was noted in the digestibility among the grain sorghum rations. There was no significant difference in EE and CF digestibility of the control and 50 percent grain sorghum rations. However, the digestibility of these two ration components was significantly higher ($P < .05$) in the control than in the 100 percent grain sorghum ration. In all instances, the digestibility of the control ration was higher than the grain sorghum rations, with the 50 percent grain sorghum ration being more digestible than the ration containing 100 percent grain sorghum. Lawrence (1968, 1969) found similar results when comparing the digestibility of corn and grain sorghum in pigs weighing 60 and 130 pounds.

TABLE 5. MEAN APPARENT DIGESTIBILITY COEFFICIENTS OF RATION COMPONENTS

Percent grain sorghum	0[a]	50	100
Number of barrows	4	4	4
Dry matter digestibility, %			
Trial 1	82.42	81.65	76.13
Trial 2	88.73	79.57	83.09
Organic matter digestibility, %			
Trial 1	84.26	83.04	78.15
Trial 2	89.76	81.34	84.40
Crude protein digestibility, %			
Trial 1	73.64	76.52	68.78
Trial 2	85.32	74.40	78.14
Ether extract digestibility, %			
Trial 1	55.62	60.97	40.30
Trial 2	75.81	58.17	69.25
Crude fiber digestibility, %			
Trial 1	31.72	44.35	16.33
Trial 2	61.73	40.54	44.28

[a]100 percent corn.

TABLE 6. ANALYSIS OF VARIANCE FOR DIGESTION COEFFICIENTS

Source	df	Mean Squares				
		Dry Matter	Organic Matter	Crude Protein	Ether Extract	Crude Fiber
Total	23					
Rations (R)	2	81.60**	76.00**	75.15**	240.55	580.44**
Trials (T)	1	83.48**	67.27**	238.64**	1431.44**	1954.63**
T X R	2	50.85**	38.51**	109.15*	538.03**	719.19**
Error	18					
anim. (ration)	9	2.47	2.78	8.67	81.04	48.83
time X animal (ration)	9	1.33	.86	16.29	41.93	31.04

*P<.05.

**P<.01.

When considering the interaction between ration and trial, or age of the animals, it was found that the digestibility of all the ration components in the control and 100 percent grain sorghum rations were significantly higher ($P < .05$) in Trial 2. However, the digestibility of these ration components in the 50 percent grain sorghum ration was higher in Trial 1, indicating increased digestibility at a younger age. This decreased digestibility of DM and OM in Trial 2, or at an older age was significant ($P < .05$). The CP, EE, and CF digestibility of the 50 percent grain sorghum ration was also lower in Trial 2, but the difference was not significant. This phenomenon cannot be explained by research conducted within the scope of this thesis.

Effect of Tannin on the Digestibility of Grain Sorghum

The decreased digestibility of the rations containing grain sorghum can be explained by the presence of tannins. The variety of grain sorghum used in this experiment was McNair 546, a brown-seeded bird resistant hybrid containing 1.63 percent tannin. As the amount of grain sorghum in the ration increased, the digestibility of the ration decreased. (See Figure 2). This is due to an increased amount of tannin in the 100 percent grain sorghum ration (12.24 lbs/1000 lbs of ration) as compared to the amount of tannin in the 50 percent grain sorghum ration (6.12 lbs/1000 lbs of ration). This is in agreement with McGinty (1969) who found that brown sorghum grain was lower in DM digestibility than white, red, or yellow grain. Donnelly and Anthony (1970) and Harris et al. (1970) reported that the seed of high tannin hybrids were not digested as efficiently as those having lower tannin content. The decreased digestibility

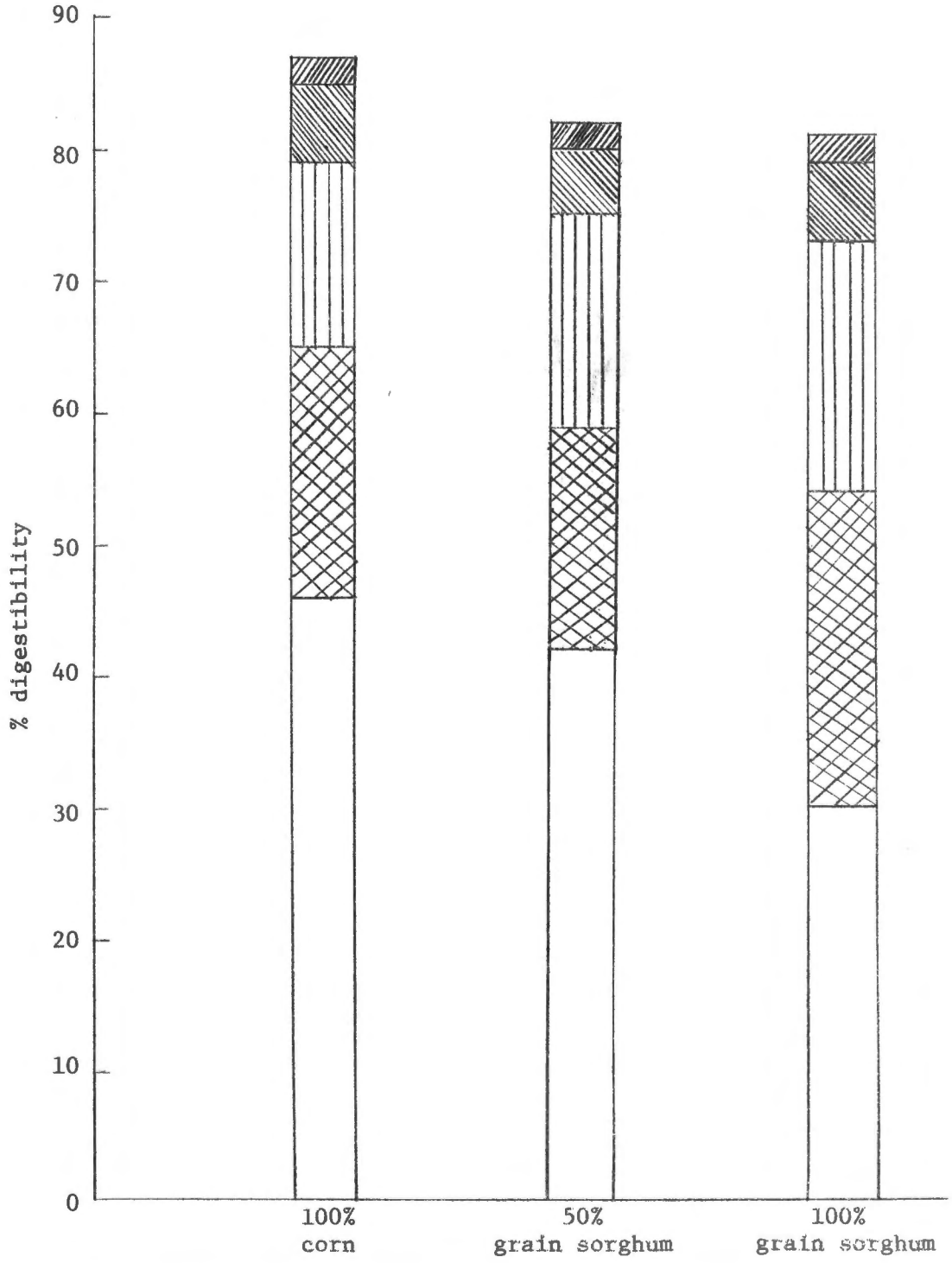

Figure 2. Mean apparent digestibility coefficients of ration components for the control and 50 and 100 percent grain sorghum rations.

of the grain sorghum rations is possibly responsible for the poor feed conversion of the animals fed these rations as shown by the feeding trials.

V. SOME GENERAL OBSERVATIONS ON FEEDING GRAIN SORGHUM

A cost analysis of feeding grain sorghum in this experiment is shown in Table 7. As expected, the total feed required for the amount of gain among the various rations is higher for the grain sorghum rations. However, the feed cost per pound decreases with these rations as compared to the control ration. The total feed cost per pig was lowest with the 50 percent grain sorghum ration, but this is explained by the fact that the pigs on this ration were the heaviest, and therefore required less total gain to reach market weight. When considering the cost per pound of gain, it appears that any level of grain sorghum can be fed as cheaply as a 100 percent corn ration based on the prices paid for the grain sorghum and corn in this experiment. It is also important to note that due to the almost negligible difference in cost per pound of gain among the rations, it appears that the price paid for the grain sorghum was near the maximum affordable based on the price of corn.

The drying, storing, and handling of sorghum grain are important steps between production or purchase of the grain and feeding operations. Inadequate and/or improper drying and storage facilities and procedures contribute to a loss in grain quality and a decrease in the feeding value of the grain. For best results, the grain should be ground fine to moderately fine to obtain maximum digestibility. Finely ground grain also requires "tighter" feeders to prevent waste. However, grinding too fine increases dustiness and may cause a decrease in consumption.

TABLE 7. COST ANALYSIS OF FEEDING GRAIN SORGHUM

	Percent grain sorghum				
	0[a]	25	50	75	100
Final wt., lbs.	220.00	224.00	220.38	219.88	223.63
Starting wt., lbs.	51.00	47.75	56.25	47.88	45.38
Total gain, lbs.	169.00	176.25	164.13	172.00	178.25
Feed efficiency	3.02	3.12	3.27	3.19	3.29
Total feed, lbs.	510.38	548.90	536.71	548.68	586.44
Feed cost/lb., $	0.06	0.06	0.065	0.053	0.052
Total feed cost/pig, $	29.09	30.24	28.98	29.08	30.49
Cost/lb. gain, $	0.1721	0.1716	0.1766	0.1691	0.1711

[a]100 percent corn.

CHAPTER V

SUMMARY

Data were collected on 40 Duroc hogs at the University of Tennesse-Agricultural Experiment Station, Knoxville, Tennessee to determine the effect of various levels of bird resistant grain sorghum on live performance and carcass characteristics in meat type swine. Rations containing 25, 50, 75, or 100 percent grain sorghum in the grain portion of the ration were compared with a control ration consisting of 100 percent corn. The protein level (16 percent) remained constant throughout the experiment.

There were no significant differences between any of the rations for average daily gains (ADG) during the periods from 40 to 90 pounds, 90 to 140 pounds, 140 to 190 pounds, or 40 pounds to market weight. However, the highest ADG resulted when pigs were fed the 100 percent corn or 25 percent grain sorghum rations. In the periods from 40 to 140 pounds, all of the rations appeared to be equal in producing gain.

In a comparison of feed conversion from 40 pounds to market weight between the control ration and rations containing 50, 75, and 100 percent grain sorghum, there was a significant difference ($P < .05$) in favor of the control. There was also a significant difference ($P < .05$) in favor of the 25 percent grain sorghum ration when compared to the 50 and 100 percent grain sorghum rations. No significant differences were noted in comparisons of the 25 and 75 percent grain sorghum rations, the 50, 75, and 100 percent grain sorghum rations, nor between the 25 percent grain sorghum ration and the control. There was a significant ($P < .01$) linear relationship between the percentage of grain sorghum in the ration and the amount

of feed required per pound of gain. As the percentage of grain sorghum in the ration increased, the amount of feed required per pound of gain also increased. The increased amount of feed required per pound of gain for the pigs fed the grain sorghum rations ranged from 3 to 8 percent above that amount required by pigs fed the control ration.

As the percentage of grain sorghum in the rations increased, a non-significant decrease in backfat (BF) was noted. The control ration and the 25 percent grain sorghum ration had the highest average BF. There were no significant differences for any of the comparisons for carcass length, dressing percentage, loin eye area, percent ham and loin, loin color scores, or loin marbling scores.

Digestion trials were conducted at two stages of growth with 6 Duroc and 6 Duroc-Yorkshire crossbred pigs using the 50 and 100 percent grain sorghum rations and the control ration. Nutrient digestibility increased significantly ($P < .01$) with age. The grain sorghum had a significant effect on digestibility. Dry matter (DM), organic matter (OM), and crude protein (CP) digestibility was significantly higher ($P < .05$) in the control ration than in the rations containing 50 and 100 percent grain sorghum. There was no significant difference in ether extract (EE) and crude fiber (CF) digestibility of the control and 50 percent grain sorghum ration. However, the digestibility of these two ration components was significantly higher ($P < .05$) in the control than in the 100 percent grain sorghum ration. In all instances, the digestibility of the control ration was higher than the grain sorghum rations, with the 50 percent grain sorghum ration being more digestible than the 100 percent grain sorghum ration. This decreased digestibility of the rations containing grain

sorghum is a result of the presence of tannic acid which is associated with bird resistant varieties of grain sorghum. As the amount of grain sorghum in the ration increases, so does the percentage of tannin, thereby causing decreased digestibility. The decreased digestibility of the grain sorghum rations is possibly responsible for the poor feed conversion of the animals fed these rations as shown by the feeding trials.

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APPENDIX

TABLE 8. OVERALL MEANS AND STANDARD ERRORS

	Overall mean	Standard error
Average daily gain		
40 to 90 lbs.	1.45	.034
90 to 140 lbs.	1.85	.036
140 to 190 lbs.	1.69	.051
40 lbs. to market wt.	1.71	.029
Feed efficiency	317.50	.671
Dressing percent	71.29	.342
Carcass length	30.88	.076
Backfat	1.46	.020
Loin eye area (10th rib)	5.32	.150
Percent ham and loin	42.74	.377
Color score (loin)	2.65	.108
Marbling (loin)	5.93	.410

TABLE 9. ANALYSIS OF VARIANCE FOR ADG 1,[a] ADG 2,[b] ADG 3[c] AND FADG[d]

Source	df	ADG 1	ADG 2	ADG 3	FADG
Total	39				
Treatment	4	0.122	0.032	0.090	0.030
Linear	1	0.109	0.023	0.269	0.032
Quadratic	1	0.000	0.076	0.015	0.023
Cubic	1	0.041	0.012	0.015	0.059
Lack of fit	1	0.338	0.018	0.060	0.005
Error	35	0.046	0.051	0.105	0.034

[a]40 to 90 lbs.

[b]90 to 140 lbs.

[c]140 to 190 lbs.

[d]40 lbs to market wt.

TABLE 10. ANALYSIS OF VARIANCE FOR DRESSING PERCENT, CARCASS LENGTH, BACKFAT, AND LOIN EYE AREA

Source	df	Mean Squares			
		DR. PER.	CL	BF	LEA
Total	39				
Treatment	4	4.21	0.557	0.025	0.169
Linear	1	0.634	0.043	0.058	0.337
Quadratic	1	0.204	1.654	0.000	0.011
Cubic	1	2.029	0.406	0.025	0.054
Lack of fit	1	13.961	0.127	0.017	0.272
Error	35	4.67	0.229	0.016	0.900

TABLE 11. ANALYSIS OF VARIANCE FOR HAM-LOIN PERCENT, COLOR, AND MARBLING

Source	df	Mean Squares		
		Ham-loin[a]	Color[b]	Marbling[c]
Total	39			
Treatment	4	2.69	0.98	9.35
Linear	1	1.85	0.53	2.81
Quadratic	1	5.81	0.06	9.72
Cubic	1	0.58	0.25	0.00
Lack of fit	1	2.53	3.08	24.86
Error	35	5.68	0.46	6.73

[a]Percentage of carcass made up by ham and loin.

[b]Color score of loin at 10th rib.

[c]Marbling score of loin at 10th rib.

TABLE 12. DIGESTIBILITY FOR INDIVIDUAL PIGS DURING TRIALS 1 AND 2

Grain sorghum level and pig number	Digestibility coefficients, %				
	DM	OM	CP	EE	CF
	---------- Trial 1 ----------				
0[a]					
1	82.14	85.19	63.99	73.98	38.75
2	83.18	84.63	78.84	61.69	33.98
3	80.89	82.40	74.21	37.80	21.30
4	83.46	84.83	77.50	49.02	32.85
50%					
5	80.94	82.28	76.20	54.76	40.63
6	82.43	83.92	76.92	65.14	48.04
7	81.87	83.21	76.87	62.25	47.19
8	81.36	82.75	76.08	61.73	41.54
100%					
9	76.85	78.92	70.88	38.81	16.47
10	75.83	78.01	66.74	41.61	14.18
11	76.19	78.00	69.47	38.92	16.85
12	75.63	77.67	68.02	41.87	17.82
	---------- Trial 2 ----------				
0[a]					
1	90.73	91.46	88.20	78.84	67.58
2	87.34	88.60	83.02	75.58	59.52
3	86.88	88.08	82.58	66.84	55.27
4	89.95	90.90	87.46	81.99	64.56
50%					
5	78.97	80.62	72.36	55.61	40.56
6	79.88	81.77	76.13	52.23	38.21
7	79.64	81.48	73.20	63.44	44.24
8	79.79	81.49	75.91	61.38	39.13
100%					
9	85.37	86.70	80.81	74.01	56.43
10	84.87	86.14	81.92	74.19	51.60
11	81.03	82.40	75.18	63.09	33.28
12	81.08	82.35	74.63	65.73	35.81

[a]100 percent corn.

TABLE 13. FEED COSTS

Ingredient	Bulk price	Price/lb.
No. 2 Yellow Corn[a]	$3.45/cwt.	$0.345
Grain Sorghum	2.80/cwt.	0.280
SBOM[b]	260/T	0.130
Meat Scraps[c]	216/T	0.108
Dehy. Alf. Meal[d]	105/T	0.053
Dical. Phos.	110/T	0.055
Salt	42/T	0.021
Trace Min. Premix	---	1.00
Antibiotics	---	2.25
Vit. Premix	---	0.35

[a]Average of $3.43, 3.29, 3.61/cwt. on 3 purchases.

[b]Average of $235.45, 224.50, 320.00/T on 3 purchases.

[c]Average of $118.00, 210.00, 310.00/T on 3 purchases.

[d]Average of $98.00 and 113.00 on 2 purchases.

VITA

Calvin F. Prince, Jr. was born in Brownsville, Tennessee on August 14, 1948. He attended elementary and high school in Brownsville and graduated from Haywood County High School in 1966. In September, 1966, he entered the University of Tennessee at Martin and received a Bachelor of Science degree in Agricultural Education in 1970. While an undergraduate student, he was a member of Alpha Tau Omega Fraternity. Upon graduation he was commissioned a Second Lieutenant in the United States Army and completed two years of active duty in the Federal Republic of Germany.

In September, 1972, he entered the University of Tennessee in Knoxville and began study toward a Master of Science degree with a major in Animal Husbandry. He received the degree in March, 1974. He is a member of Gamma Sigma Delta Honorary Fraternity.

He is married to the former Mary Mullen of Brownsville, Tennessee.