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THE EFFECTS OF WHOLE WHEAT IN COMBINATION WITH WHOLE SHELLED CORN AS A FINISHING RATION FOR BEEF CATTLE

A Thesis

Presented for the

Master of Science

Degree

The University of Tennessee, Knoxville

James Travis Fain

June 1979

ACKNOWLEDGMENTS

The author wishes to express his most sincere appreciation and gratitude to the following persons for their contributions to this graduate study:

Dr. William R. Backus, major professor and thesis adviser, for his guidance and counseling, for his diligent efforts in data collection, analysis and interpretation, for his encouragement, advice and genuine interest, for reviewing the manuscript, for his faith and friendship, and for his invaluable aid throughout this graduate program.

Dr. J. B. McLaren for his guidance and counsel, for his aid in analyzing and interpreting the data, for reviewing the manuscript, for serving on the graduate committee, for his personal and professional advice and for his friendship.

Dr. H. M. Jamison for his continuous encouragement, friendship and advice, for reviewing the manuscript, for serving on the graduate committee and for his genuine concern and interest.

Dr. N. W. Robinson for his aid in data collection, for reviewing the manuscript, for serving on the graduate committee and for his counsel and cooperation.

Dr. W. L. Sanders for his assistance in data analysis and interpretation.

J. M. Bryan, J. M. Anderson and Mike Winneger at Ames Plantation for their aid in carrying out the research and data collection.

To Domain Industries, New Richmond, Wisconsin, and Tennessee Farmer's Co-op for their financial support of the research project.

To the University of Tennessee Institute of Agriculture for financial assistance which made this graduate study possible.

To the entire Animal Science Department, secretaries and fellow students, for their assistance and associations.

To my special friends whose associations, friendships and patience made this graduate study more enjoyable and rewarding.

To my brothers, Steve and Alan, for their continued support and encouragement.

And foremost to my mother and father for their never-ending support and encouragement and for their inspiration, faith and love.

ABSTRACT

Three trials involving 96 and 160 Angus steers and 64 Hereford steers, respectively, fed all-grain finishing rations were conducted to determine the effects of varying levels of corn and wheat on performance and carcass variables. Basal rations consisted of (1) 100% whole shelled corn (WSC), (2) 80% WSC and 20% whole wheat (WW), (3) 60% WSC and 40% WW and (4) 40% WSC and 60% WW. All rations were supplemented with .5 kg Tend-R-Leen^{R} (36% CP) per head per day.

There were no significant differences among the variables in Trials 1 and 3 when they were analyzed separately. Trial 2 and a composite analysis gave the following results: Average daily gain was lower ($p < .05$) for rations containing 60% WW than for those containing 100% WSC or 60% WSC and 40% WW or 80% WSC and 20% WW. Feed effieiency tended to decline as the percentage of wheat in the ration increased. Rations with 100% WSC or 80% WSC and 20% WW had a more favorable feed efficiency ($p < .05$) than those containing 40% or 60% WW.

Carcass variable variations were in general agreement with differences shown in rate of gain. Rations which gave faster gains also produced carcasses with greater fatness and therefore higher yield grades when finished on a time constant basis. No differences were shown for marbling, quality grade or rib-eye area.

The results of this study indicate that WW in combination with WSC can be fed effectively to beef cattle as a finishing ration. However, performance decreased when the WW exceeded 40% of the ration.

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CHAPTER I

INTRODUCTION

Continued feeder calf production and the increase in the practice of backgrounding in Tennessee have made the process of finishing cattle within the state a more viable alternative. Keeping cattle within the state and especially on the original producer's farm retains the profits from the entire cattle production cycle in the state and saves the animals the further losses entailed in marketing and transporting calves to distant points for growth and/or finishing.

The use of whole shelled corn in a ration for finishing forage-grown, feedlot-ready yearling cattle has proven to be a logical alternative for many cattlemen. Using wheat as a substitute for part of the corn in finishing rations has been popular when wheat was in oversupply and its price competitive with corn. It is generally accepted, however, that wheat must be processed, coarsely ground or rolled, to be fed to beef cattle. The lack of wheat processing facilities in Tennessee prevents this cereal grain from being used as a ration constituent for finishing rations for cattle in this state. The possibilities of beef production, from conception to consumption, would be greatly enhanced if finishing rations could be formulated, fed and utilized without processing.

This research project was initiated by The University of Tennessee to study the performance of yearling steers on a whole shelled corn ration to those fed varying levels of whole wheat in combination with the whole shelled corn. The data were collected from 256 Angus and 64 Hereford steers fed at three different times and two different locations.

Carcass data were obtained in two packing plants from two USDA graders.

It was the objective of this study to compare the effectiveness of feeding varying levels of whole wheat to replace whole shelled corn in an all-concentrate finishing ration for yearling beef cattle.

CHAPTER II

REVIEW OF LITERATURE

The price of almost every commodity is on the rise. In an effort to improve the efficiency and quality of beef production, researchers have explored a great variety of cattle-finishing rations. Recently, workers have explored all-concentrate rations for ruminants. Historically, rations have consisted of forage supplementation with a concentrate to provide the necessary nutrients.

Meade and Regan (1931) were the first workers to conclude that roughage or bulk per se was not necessary in the diet of calves. Research by Davis et al. (1963) made comparisons between a ration of corn and cob and one of ground shelled corn. They stated that even though the consumption of a ground shelled corn ration was significantly lower there were no significant differences in the daily gains and carcass characteristics. This research agrees with more recent work by Ellis (1965) and Tietz (1969) which indicated that steers can be finished more quickly and efficiently on all-concentrate rations than on roughage-containing rations. To further this point, Wise et al. (1968) stated that little doubt remains that beef cattle may be finished successfully on all-concentrate rations. Studies by Bowling et al. (1977) showed that grain-finished beef carcasses were more tender and more flavorful than forage-finished carcasses. In an extensive literature review, Ellis (1965) stated that some advantages of all-concentrate rations are: Less total feed is required; storage, labor and equipment needs are reduced; costs per unit of gain may be very favorable in areas

with abundant supplies of feed grains and feed handling and processing can be easily mechanized.

According to Fowler (1969), corn is unsurpassed as a finishing ration. He also recommended rolling, cracking or coarsely grinding the corn unless the cattle were followed by hogs. However, spiraling labor, equipment and fuel costs have led researchers to explore the possibilities of feeding corn whole and unprocessed to beef cattle. This has been done with varying degrees of success. Research by Adeeb et al. (1971) indicated that the maximum digestibility for corn in cattle is obtained when the grain is ground to a fineness of 4.85 to 3.0 mm. However, Burkhardt et al. (1969) and Hixon et al. (1969) stated that there was no advantage to processing corn. Vance et al. (1971) showed that whole shelled corn as a finishing ration for cattle was well utilized as long as the roughage level did not exceed 17% of the total ration. Similar findings were reported by Cole et al. (1972). Tennessee workers (Backus et al., 1977, and Godfrey et al., 1977) reported excellent results when finishing heavy yearling cattle on rations consisting entirely of whole shelled corn and a protein supplement. Some researchers have reported advantages to finishing cattle using whole shelled corn: Gerken et al. (1971) reported less incidence of parakeratosis for whole corn than with ground; Martin et al. (1971) indicated that feeding whole corn was cheaper than feeding ground or rolled corn; and Vance et al. (1972) found that in all concentrate rations steers fed whole corn gained faster than when fed crimped corn.

During times of oversupply and when it is competitive in price, wheat has been said to be a good substitute for corn or barley in

feeding cattle (Morrison, 1948). According to Baker and Baker (1960), feeding wheat in the U.S. is not new and at times has been fed widely to all classes of livestock. As early as 1906 ground wheat was being fed to cattle (Haney and Elling, 1906). Wheat has been fed in many forms. Some researchers indicate wheat should be coarsely ground or dry rolled (Baker, 1935; Seiden et al., 1957; Brethour, 1966; Fowler, 1969; Arnett, 1971; Cornett et al., 1971 and Wagner et al., 1971). Other researchers recommend micronizing, crushing or steam flaking (Martin, 1974; Toland, 1976 and Aimione, 1977). Still others stated that wheat can be fed whole to beef cattle (Pryor and Laws, 1972, and Toland, 1978). Much controversy also has arisen over the maximum amount of wheat that can be included in a diet. Brethour (1966) indicated that wheat should be limited to not more than 50% of the total grain in the ration. Fowler (1969) and Nichols (1970) also recommended that wheat should make up 30-50% of the grain in the diet. Wagner et al. (1971) indicated that higher levels of wheat could be fed to beef cattle than the 50% limit recommended by some researchers. Baker (1960) stated that wheat could replace all or part of the corn in a finishing ration.

In comparing wheat to corn as a finishing ration, the first criterion noted is that wheat is 2.5-3.0% higher in protein than corn (Nichols, 1970). In an experiment feeding diets containing 0, 30%, 60% and 90% wheat mixed with corn, Oltjen et al. (1965) indicated that gains were significantly lower for animals fed the 60 and 90% levels of wheat. However, there were no significant differences in carcass traits. Another study by Oltjen et al. (1966) where high levels of wheat were fed showed no carcass trait differences, but the incidence of liver abscess was higher for the high-wheat diets.

CHAPTER III

EXPERIMENTAL PROCEDURE

I. SOURCE OF DATA

Data were collected during three separate feeding trials between September 1977 and September 1978. Trials 1 and 2 were conducted at Ames Plantation, Grand Junction, Tennessee, and Trial 3 was conducted at The University of Tennessee, Martin, Tennessee. Angus (256) and Hereford (64) steers ranging in weight from 191 to 429 kg were used. In Trials 1 and 2 the steers were from either the herd at Ames Plantation or were purchased at the Tri-County Feeder Calf Sale in Brownsville, Tennessee. The 96 Angus steers on Trial 1 were first used on a grazing trial at Ames Plantation and subsequently used in the feeding trial. In Trial 2, the 160 Angus steers were purchased in the fall and wintered on available forage. The 64 Hereford steers used in Trial 3 were all purchased through order buyers in the Martin, Tennessee, area.

Previous to the feeding trial, all the animals were weighed, stratified by weight and divided into a heavier and a lighter one-half. These constituted replicates 1 and 2 of each trial, respectively. Each steer was treated for internal and external parasites, implanted with 36 mg Ralgro and injected intramuscularly with 1,000,000 IU of Vitamin A. Steers were randomly assigned to four pens per replication and pens were randomly assigned to treatments (whole shelled corn:whole wheat rations, Table 1). Steers were gradually accustomed to their respective ration over a 14-day adjustment period. At the outset of this period, long hay was fed ad lib plus 1% of their body weight of the

Table 1. Experimental rations.

Treatment	Ration
1	100% whole shelled corn + .5 kg Tend-R-Leen/head/day*
2	80% whole shelled corn + 20% whole wheat + .5 kg Tend-R-Leen/head/day
3	60% whole shelled corn + 40% whole wheat + .5 kg Tend-R-Leen/head/day
4	40% whole shelled corn + 60% whole wheat + .5 kg Tend-R-Leen/head/day

*Tend-R-Leen is a 36% protein supplement designed to feed with whole shelled corn.

Note. Active drug ingredient: Monensin (as sodium Monensin), 300 g/ton. Guaranteed analysis: Crude protein not less than 36%. This includes not more than 12% equivalent protein from nonprotein nitrogen. Crude fat not less than 1.25%. Crude fiber not more than 12%.

respective grain diet plus .5 kg Tend-R-Leen^{R} per head per day. The grain portion was increased at the rate of .46 kg per head per day, and the hay gradually decreased. By the 14th day, no hay was fed, and the experimental ration was fed ad lib.

Initial weights were an average of 2 weights taken on 2 consecutive days following the 14-day adjustment period with intermediate weights taken at 28-day intervals. All weights were taken with no withdrawal of feed or water. Daily feed records were kept for each pen. The experiment was terminated and the steers were slaughtered when it was estimated that at least 75% had attained the choice grade.

Response variables consisted of performance variables (final weight, average daily gain and feed efficiency) and carcass data (carcass weight, carcass fat, percent kidney fat, marbling, quality grade, rib-eye area and yield grade). Definitions and procedures used to calculate these variables are listed in Table 2.

II. METHODS OF ANALYSIS

A preliminary analysis was performed on each trial separately to evaluate treatment by replication interaction. These analyses indicated that response to ration differences were similar in both the heavy- and light-steer group within each trial. In addition, a preliminary analysis was performed on all three trials combined to evaluate treatment by trial interaction. These analyses indicated that response to ration differences were similar in all trials. These analyses suggested that the data could be pooled across trials and evaluated in a single analysis of variance.

Table 2. Definitions and procedures used to calculate values.

Term	Definition or Procedure
Final weight	Weight of the steers in kilograms that was arrived at by taking two weights 24 hours apart and averaging them at the end of the trial.
Average daily gain (ADG)	Total increase in body weight (kg) during the feeding trial divided by the number of days in the trial.
Feed efficiency	Total amount of feed consumed by a pen of animals during the trial divided by the total amount of gain.
Carcass weight	Weight of the hot carcass (kg) taken immediately after slaughter.
Carcass fat cover	A single measure of fat thickness (mm) taken three-fourths of the way up the rib-eye muscle at the 12th rib.
Percent kidney fat	The percentage of total carcass weight represented by the fat around the heart, pelvic area and the kidney subjectively estimated by a USDA grader.
Marbling	Quantity of intramuscular fat as determined by a USDA grader.
Quality grade	The USDA quality grade assigned to each carcass by a USDA grader.
Rib-eye area	Area of the rib-eye muscle (cm^2) between the 12th and 13th ribs measured with a grid.
Yield grade	A value expressed in tenths and derived from the USDA equation of yield grade = 2.5 + 2.5 X fat thickness (in inches) + 0.20 X percent kidney fat + 0.0038 X carcass weight - .32 X rib-eye area (Schoonover et al., 1967).

Therefore, the data from the three trials were combined and analyzed by least-squares procedures to determine the effect of the independent variables (trial, replication, treatment) and various interactions among these independent variables on the dependent variables (performance and carcass traits). When the F-ratio indicated differences in a response variable due to the effect of various levels of an independent variable, mean separation was accomplished by the Student-Newman-Kuel multiple range test (Steel and Torrie, 1960). Orthogonal polynomial procedures were used to determine deviation from linearity of the change in the response variable as the percentage of wheat in the grain mixture increased.

CHAPTER IV

RESULTS AND DISCUSSION

I. PERFORMANCE VARIABLES

As the percentage of wheat in the ration increased, average daily gain (ADG) tended to decrease (Table 3). The ADG for the whole shelled corn ration was slightly greater than those reported by Godfrey et al. Oltjen et al. (1965) also reported lower gains in steers fed 60% and 90% wheat rations than those fed all-corn rations. The decrease in ADG observed in this experiment tended to be cubic in nature. However, the fact that the decrease in ADG due to including 20% wheat in the ration was greater than when including 40% wheat in the ration could be due to the greater average daily intake of the 40% wheat ration. Daily feed consumption tended to decrease when 20% wheat was included in the ration, then increase for the 40 and 60% wheat rations. This increase in intake coupled with the decrease in ADG resulted in significantly poorer feed efficiency values for the high-wheat rations. Units of feed per unit of gain tended to increase linearly with the addition of wheat to the ration, and all feed conversion values were higher than those reported by Godfrey et al. This trend of increased feed per unit of gain as wheat increased agrees with the results reported by Oltjen et al. (1965). All these feed conversion values fall within the acceptable range used by most feedlots. Final weight remained constant across treatments. These trends were observed in the individual trials when they were analyzed separately (Tables 5, 6, 7, Appendix).

Table 3. Least squares means of performance and carcass variables during three trials.

Variable	% Wheat in Corn-Wheat Mixture 0	20	40	60
Performance Variables				
No. of animals	80	80	80	80
Initial weight (kg)	307[a]	310[a]	310[a]	310[a]
Final weight (kg)	480[a]	473[a]	477[a]	468[a]
Average daily gain (kg/day)	1.47[a]	1.40[ab]	1.44[a]	1.35[b]
Feed efficiency	6.65[a]	6.96[a]	7.35[b]	7.92[b]
Daily feed consumption (kg)	10.1	9.6	10.4	10.5
Carcass Variables				
Carcass weight (kg)	284[a]	280[ab]	281[ab]	274[b]
Carcass fat (mm)	14.4[a]	13.4[a]	13.5[a]	12.2[b]
Percent kidney fat	2.69[a]	2.60[a]	2.51[ab]	2.38[b]
Marbling[d]	51[a]	50[a]	49[a]	50[a]
Rib-eye area (cm^2)	70.1[a]	70.0[a]	70.8[a]	69.8[a]
Quality grade[e]	12.0[a]	11.9[a]	11.7[a]	11.7[a]
Yield grade	3.3[a]	3.2[a]	3.1[a]	3.0[a]

[a,b,c]Means within a row with differing superscripts are significantly different ($p < .05$).

[d]Marbling: 47 = small minus; 50 = small; 53 = small plus.

[e]Quality grade: 11.0 = high good (G+); 12.0 = low choice (C-).

II. CARCASS VARIABLES

Carcass weight tended to decrease linearly with any increase in wheat in the ration and decreased significantly from the control ration when the amount of wheat in the ration reached 60% of the total grain in the ration (Table 3). Carcass fat and percent kidney fat decreased linearly with the increase of wheat in the ration, and these decreases were significant ($p < .05$) when the wheat was increased to 60% of the grain mixture. However, these two variables are a function of time and rate of gain, and if the cattle were fed to a fat-constant basis (rations with high levels of wheat stay on feed longer), this difference would be alleviated. Marbling and rib-eye area were similar in all groups and highly acceptable values. Quality grade, which is based mainly on marbling, is relatively unaffected by treatment and was not significant for any treatment level. Yield grade was significantly better for the 60-40 wheat-to-corn mixture; however, this reflected the lower carcass fat of steers fed wheat. Differences in carcass yield grades due to treatment effect would have been alleviated by feeding to a constant fat thickness. All trends observed in this analysis were also observed in each individual trial, except Trials 1 and 3 showed no significant differences ($p < .05$) for any of the variables (Tables 5, 6, 7, Appendix). Results reported by Oltjen et al. (1965) agree with this study, except they found no significant differences for carcass fat.

CHAPTER V

SUMMARY

Three trials involving 96 and 160 Angus steers and 64 Hereford steers, respectively, fed all-grain finishing rations were conducted to determine the effects of varying levels of corn and wheat on performance and carcass variables. Basal rations consisted of (1) 100% whole shelled corn (WSC), (2) 80% WSC and 20% whole wheat (WW), (3) 60% WSC and 40% WW and (4) 40% WSC and 60% WW. All rations were supplemented with .5 kg Tend-R-Leen^{R} (36% CP) per head per day.

Average daily gain was lower ($p < .05$) for rations containing 60% WW than for those containing 100% WSC, 60% WSC and 40% WW or 80% WSC and 20% WW. Feed efficiency tended to decline as the percentage of wheat in the ration increased. Rations with 100% WSC or 80% WSC and 20% WW had a more favorable feed efficiency ($p < .05$) than those containing 40% or 60% WW.

Carcass variable variations reflected the differences observed in rate of gain. Rations which resulted in faster gains also produced carcasses with greater fatness and therefore higher yield grades when finished on a time constant basis. No differences were observed in the effect of the percentage of wheat in the ration on marbling, quality grade or rib-eye area.

The results of this study indicate that WW in combination with WSC can be fed effectively to beef cattle as a finishing ration. However, performance decreased when the WW exceeded 40% of the ration.

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APPENDIX

Table 4. Analysis of variance for the effects of experimental ration.

Source	df	ADG	Feed Efficiency	Carcass Fat	Marbling	Quality Grade
Trial	2	9.0610***	1.0417	1481.6258***	1842.5281***	40.9826***
Rep (trial)	3	7.2181***	1.9984	127.3929*	1095.4079**	13.1856*
Ration	3	3.3056**	5.3594**	190.9509***	244.5846	5.3593
Linear	1	2.1259**	5.2513***	161.6198***	156.5013	4.3414
Quadratic	1	0.0127**	0.1044	2.2708	87.0246	0.2269
Cubic	1	1.1670*	0.0037	27.0603	1.0586	0.7910

*$p < .05$

**$p < .01$

***$p < .001$

Table 5. Least squares means of performance and carcass variables for Trial 1.

Variable	% Wheat in Corn-Wheat Mixture 0	20	40	60
Performance Variables				
No. of animals	24	24	24	24
Initial weight (kg)	300[a]	302[a]	300[a]	305[a]
Final weight (kg)	454[a]	447[a]	446[a]	452[a]
Average daily gain (kg/day)	1.58[a]	1.49[a]	1.53[a]	1.50[a]
Feed efficiency	6.59	6.40	7.10	7.71
Daily feed consumption (kg)	10.5	9.5	10.9	11.6
Carcass Variables				
Carcass weight (kg)	264[a]	258[a]	257[a]	262[a]
Carcass fat (mm)	11.1[a]	9.9[a]	10.6[a]	9.7[a]
Percent kidney fat	2.69[a]	2.51[a]	2.58[a]	2.63[a]
Marbling[d]	53[a]	50[a]	50[a]	53[a]
Rib-eye area (cm^2)	70.4[a]	70.7[a]	68.4[a]	70.9[a]
Quality grade[e]	12.1[a]	12.2[a]	11.9[a]	12.2[a]
Yield grade	2.8[a]	2.6[a]	2.8[a]	2.7[a]

[a,b,c]Means in a row with differing superscripts are significantly different ($p < .05$).

[d]Marbling: 47 = small minus; 50 = small; 53 = small plus.

[e]Quality grade: 11.0 = high good (G+); 12.0 = low choice (C-).

Table 6. Least squares means of performance and carcass variables for Trial 2.

Variable	% Wheat in Corn-Wheat Mixture 0	20	40	60
Performance Variables				
No. of animals	40	40	40	40
Initial weight (kg)	273[a]	276[a]	277[a]	275[a]
Final weight (kg)	451[a]	445[a]	451[a]	438[a]
Average daily gain (kg/day)	1.42[a]	1.35[ab]	1.38[ab]	1.30[b]
Feed efficiency	6.85	7.39	7.62	7.96
Daily feed consumption (kg)	9.4	10.0	10.5	10.4
Carcass Variables				
Carcass weight (kg)	273[a]	268[ab]	271[a]	261[b]
Carcass fat (mm)	14.7[a]	13.5[ab]	13.4[ab]	12.0[b]
Percent kidney fat	3.14[a]	3.05[a]	2.89[ab]	2.60[b]
Marbling[d]	54[a]	52[a]	52[a]	51[a]
Rib-eye area (cm^2)	71.3[a]	70.5[a]	72.7[a]	70.4[a]
Quality grade[e]	12.3[a]	12.2[a]	12.0[a]	11.9[a]
Yield grade	3.3[a]	3.2[a]	3.0[a]	2.9[b]

[a,b,c]Means in a row with differing superscripts are significantly different ($p < .05$).

[d]Marbling: 50 = small; 53 = small plus; 57 = modest minus.

[e]Quality grade: 11.0 = high good (G+); 12.0 = low choice (C-); 13.0 = high choice (C+).

Table 7. Least squares means for performance and carcass variables for Trial 3.

Variable	% Wheat in Corn-Wheat Mixture 0	20	40	60
Performance Variables				
No. of animals	16	16	16	16
Initial weight (kg)	349[a]	354[a]	352[a]	352[a]
Final weight (kg)	535[a]	529[a]	532[a]	510[a]
Average daily gain (kg/day)	1.43[a]	1.35[a]	1.41[a]	1.22[a]
Feed efficiency	6.51	7.10	7.32	8.09
Daily feed consumption (kg)	10.3	9.3	9.8	9.5
Carcass Variables				
Carcass weight (kg)	313[a]	318[a]	316[a]	299[a]
Carcass fat (mm)	17.0[a]	16.9[a]	16.9[a]	15.1[a]
Percent kidney fat	2.17[a]	2.19[a]	2.03[a]	2.06[a]
Marbling[d]	47[a]	47[a]	45[a]	45[a]
Rib-eye area (cm^2)	68.4[a]	69.2[a]	70.9[a]	68.2[a]
Quality grade	11.4[a]	11.3[a]	10.9[a]	11.1[a]
Yield grade	3.8[a]	3.8[a]	3.6[a]	3.5[a]

[a,b,c]Means in a row with differing superscripts are significantly different ($p < .05$).

[d]Marbling: 43 = slight plus; 47 = small minus; 50 = small.

[e]Quality grade: 11.0 = high good (G+); 12.0 = low choice (C-).

VITA

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In September of 1972, he entered Middle Georgia College in Cochran, Georgia, as an undergraduate in Industrial Engineering. Four quarters and three changes of major later found the author at Fort Valley State College in Fort Valley, Georgia. At Fort Valley State College, he majored in Animal Science and received his Bachelor of Science degree in this field in June of 1977.

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