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Evaluation of protein supplement available to Tennessee farmers fed with whole shelled corn in finishing long yearling cattle

James C. Godfrey

To the Graduate Council:

I am submitting herewith a thesis written by James C. Godfrey entitled "Evaluation of protein supplement available to Tennessee farmers fed with whole shelled corn in finishing long yearling cattle." 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 Science.

Haley M. Jamison, Major Professor

We have read this thesis and recommend its acceptance:

William R. Backus, Joseph W. Holloway, Karl M. Barth

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

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

To the Graduate Council:

I am submitting herewith a thesis written by James C. Godfrey, Jr. entitled "Evaluation of Protein Supplement Available to Tennessee Farmers Fed with Whole Shelled Corn in Finishing Long Yearling Cattle." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Animal Science.

Haley M. Jamison
Haley M. Jamison, Major Professor

We have read this thesis
and recommend its acceptance:

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EVALUATION OF PROTEIN SUPPLEMENT AVAILABLE TO TENNESSEE FARMERS FED WITH WHOLE SHELLED CORN IN FINISHING LONG YEARLING CATTLE

A Thesis

Presented for the

Master of Science

Degree

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James C. Godfrey, Jr.

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ABSTRACT

The data used in this study were obtained from 160 long yearling feeder steers weighing between 600 and 750 lbs. and fed whole shelled corn finishing rations supplemented with four different protein sources as to comprise the finishing rations. The variables, frame size, increase in fat thickness, average daily gain, total gain per pen, average daily corn consumption, average corn conversion, carcass weight, rib eye area, fat thickness, percent kidney, pelvic, and heart fat, yield grade, marbling, and quality grade were subjected to a least squares regression analysis as dependent variables to detect significant differences between the treatments.

The variables, average daily gain, total gain per pen, average daily corn consumption, average corn conversion, carcass weight, and yield grade were found to be ($P < .05$) different for treatment. Duncan's Multiple Range Test was conducted to rank the treatments for these variables.

Previous workers have not made such comparisons as these but from these data one could conclude that the ($P < .05$) differences in average daily gain were due to the protein supplements. The relationship of carcass weight, rib eye area, and percent kidney, pelvic, and heart fat in replication effects, according to these data, would appear to be that the heavier carcasses had larger rib eye areas with less kidney, pelvic, and heart fat.

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CHAPTER I

INTRODUCTION

In recent years, Tennessee has become one of the major producers of feeder or stocker cattle. The reason for this is undoubtedly the forage production capabilities of the entire state. Corn production in Tennessee has also been on the increase and since corn is the primary feed grain used to finish cattle, it would appear that the possibility now exists for Tennessee farmers to produce beef from conception to consumption, to an even greater extent. In addition, with greater forage and lesser grain inputs in growing-finishing operations, it may be more feasible to ship grain to cattle rather than shipping cattle to grain. From a practical viewpoint, the possibilities of complete beef production in Tennessee could be greatly enhanced if finishing rations could be easily formulated, fed, and utilized under conditions that now prevail on Tennessee farms.

Consequently, a research project was initiated by the University of Tennessee to investigate the feeding of what is probably the least sophisticated and most easily fed of all beef finishing rations, whole shelled corn plus a protein supplement. The data collected as a result of that research provided the basis for this thesis.

The data consists of the live performance of 160 black, predominately Angus, steers fed at two different periods as well as the carcass characteristics of those steers.

It was the objective of this study to compare four protein supplements available to Tennessee farmers when fed with whole shelled corn in finishing long yearling steers.

CHAPTER II

REVIEW OF LITERATURE

In a never ending effort to improve the efficiency and quality of beef production, researchers have explored an almost infinite number of rations for finishing cattle. Recent years have led workers to investigate all-concentrate rations for the ruminant animal; heretofore, a more conventional ration of forage supplemented with a concentrate to provide the necessary nutrients was utilized in finishing ruminant meat animals.

Research by Wise et al. (1961) allowed them to conclude that satisfactory performance could be expected from calves on all-concentrate rations if the essential nutrients were contained therein. In an effort to compare an all-concentrate ration to a concentrate fortified ration, Davis et al. (1963) made comparisons between a ration of corn and cob and one with ground shelled corn. They subsequently stated that even though the consumption of the ground shelled corn ration was significantly lower there was no significant difference in the daily gains and carcass characteristics.

I. PRODUCTION ASPECTS

Probably the two most important factors involved in production are gains in body weight and the quantity of feed necessary to produce those gains.

In a system of feeding corn silage followed by corn, as compared to feeding corn silage throughout, Young et al. (1962) noted no real differences in total gain nor feed efficiency. After an extensive review of the literature, Ellis (1965) concluded that even with varying reports from different workers, concentrate rations with small amounts of roughage compared to all-concentrate rations, showed that rate of gain was generally constant with fewer number of pounds of feed per pound of gain needed in the all-concentrate rations. Wise et al. (1968) were in full agreement with Ellis (1965) but further observed that an all-concentrate ration lends itself to mechanization and, since the quantity of ration consumed per pound of gain is reduced, the quantity of mixing and handling is also reduced.

Further investigation of adding roughage to an all-concentrate ration led Tillman et al. (1969) to find that either raw or ammoniated rice hulls could be added to an all-concentrate ration of ground grain sorghum up to a level of 9 percent with no apparent effects in feed efficiency or average daily gain.

Hixon et al. (1969) in an endeavor to determine if cracked corn had an advantage over whole shelled corn compared the two rations. The quantity of the cracked corn ration needed to produce a pound of gain was greater than that of the whole shelled corn ration but not significantly so. However, the average daily gain for steers on whole shelled corn of 3.98 lbs. as compared to that of 3.43 lbs. for the steers on cracked corn was ($P < .05$) different. Further investigation into possible ways to process corn and get improved responses in steers were researched by Burkhardt et al. (1969). They used five different rations: (1) dry and unprocessed, (2) dry and rolled, (3) reconstituted high moisture, (4) reconstituted high moisture and rolled, and (5) steam processed and flaked. The results yielded no advantage in processing the corn. Weichenthal et al. (1972) found that whole shelled corn and cracked corn compared similarly for weight gain and feed conversion. However, both were improved with the addition of 5 percent soybean meal to the ration.

In consideration of the type of protein sources, Gerken (1971) noted that steers fed an all-concentrate ration of whole shelled corn with ad libitum liquid (30 percent C.P.) supplement consisting of molasses and non-protein nitrogen tended to have larger gains and greater feed consumption as compared to steers fed dry non-protein nitrogen mixed with dry molasses (44 percent C.P.) and fed at the rate of 10 percent of the ration. White et al. (1975) explored the area of feeding soybean meal and urea in rations of whole and ground shelled corn. They further substantiated previous workers in stating that average daily gains were better in the whole shelled corn rations. They further went on to state that liquid urea supplement improved intake and daily gains over dry urea supplement but that there was no significant difference between the urea supplements and the soybean meal supplement.

II. CARCASS ASPECTS

Carcass quality and yield are undoubtedly major factors in any feeding system for finishing beef cattle. In the comparisons of all-concentrate rations to those containing forage or roughage as well as those all-concentrates compared to each other, the general agreement among the researchers is the same. The carcass quality and yield of one against the other shows no significant difference (Young et al., 1962; Davis et al., 1963; Kercher and Bishop, 1963; Ellis, 1965; Harvey et al., 1968; Tillman et al., 1969; Haskins et al., 1969; Gerken, 1971; and White et al., 1975).

The one negative factor, that has been associated with all-concentrate rations in most research, is liver abcess as reported by Ellis (1965). According to Foster and Woods (1970), after data collection on 2,522 animals, "Incidence of liver abcess was found to be higher for cattle fed all-concentrate rations as compared to those fed rations containing added roughage. The percentage reduction in the incidence of liver abcess was greatest from all-concentrate to 5 percent hay equivalent in the ration." Harvey et al. (1968) noted that 75 to 85 mg. of chlortetracycline per head per day decreased the incidence of liver abcess from 33 percent to 3 percent in steers fed an all-concentrate ration or a ration containing a small quantity of roughage.

CHAPTER III

EXPERIMENTAL PROCEDURE

I. SOURCE OF DATA

The data used in this study were collected between the fall of 1975 and the summer of 1976 at The University of Tennessee, Middle Tennessee Experiment Station. The data were collected on 160 black, predominately Angus, long yearling steers ranging in initial weight from 600 to 750 lbs. The 160 animals had two different origins. The first group of 140 animals was purchased as good and choice feeder calves at the Brownsville, Tennessee Feeder Calf Sale in the fall of 1974. They were then used in an experiment at Ames Plantation dealing with different cuttings of Bermuda grass hay. After the completion of that research, the heaviest and the lightest animals were culled until the 140 animals had been reduced in number to 80. These 80 animals were then pastured together for approximately 60 days prior to this research. The second group of 80 animals was purchased by an order buyer at various sales across the state of Tennessee in the spring of 1976.

Previous to the feeding trial, all animals were treated for internal and external parasites. At the same time, the growth stimulant Synovex-S was administered as an ear implant.

It was predetermined that the steers would be removed from the trial and slaughtered at 120 days or five tenths inch fat thickness, whichever occurred first. The first 79 reached approximately five tenths (0.5) inch fat thickness at approximately the same time, after 110 days on feed, at which time they were slaughtered. The second 80 did not follow the same pattern and consequently, 40 of these animals were removed from feed and slaughtered after 90 days on feed, with the final 40 being slaughtered after 110 days on feed. The removal of the 40 after 90 days was evenly distributed across the trial. Two pens from each treatment were removed.

Each feeding trial consisted of four treatments with four pens per treatment and five steers per pen. In assigning the animals to pens and treatments, they were stratified by weight and then randomly assigned to pen. The pens were then randomly assigned to treatment. Treatment specifications and codes can be found in Table I. The differences in quantity of protein supplement per steer per day were due to the quantity of crude protein between the supplements. The basis for the quantity fed was to supply each animal with an additional four tenths (0.4) pound crude protein per day in addition to the assumed 8 percent crude protein in the whole shelled corn and in accordance with N.R.C. requirements. Since treatments were all-concentrate rations, a 21 day adjustment period was allowed to convert the animals from a roughage ration to those used in the feeding trial.

The data resulting from the feeding trials consisted of two basic segments. The first segment was the production aspects to include frame size, increase in fat, average daily gain, total gain per pen, average daily corn consumption, and average corn conversion. The second segment was the carcass data including carcass weight, fat thickness, percent kidney, pelvic, and heart fat, rib eye area, yield

TABLE I

TREATMENT CODES

Code		Treatment
1	-	Two (2) pounds of Purina Steer Fatena BIR 4 per day per steer plus whole shelled yellow corn <u>ad libitum</u>. The contents of the protein supplement premix as described by the manufacturer were:
		Active Drug Ingredient
		Chlortetracycline - 35 g/T
		Guaranteed Analysis
		Crude protein not less than - 22.0%
		Includes not more than 13.4% equivalent protein from non-protein nitrogen
		Crude fat not less than - 0.5%
		Crude fiber not more than - 27.0%
		Calcium (Ca) not less than - 1.5%
		Calcium (Ca) not more than - 2.5%
		Phosphorus (P) not less than - 0.4%
		Iodine (I) not less than - 0.0003%
		Salt (NaCl) not less than - 1.5%
		Salt (NaCl) not more than - 2.5%
2	-	One and one tenth (1.1) pounds of Co-op Tend-R-Leen Beef Finisher Concentrate per day per steer plus whole shelled yellow corn <u>ad libitum</u>. The contents of the protein supplement premix as described by the manufacturer were:
		Active Drug Ingredient
		Chlortetracycline - 133.4 g/T
		Guaranteed Analysis
		Crude protein (min.) - 36.00%
		This includes not more than 12.0% equivalent crude protein from non-protein nitrogen.
		Crude fat (min.) - 1.25%
		Crude fiber (max.) - 12.00%
		Calcium (Ca) (min.) - 2.75%

TABLE I (continued)

Code		Treatment
		Calcium (Ca) (max.) - 3.50% Phosphorus (P) (min.) - 1.00% Iodine (I) (min.) - 0.0006% Salt (NaCl) (min.) - 2.00% (NaCl) (max.) - 3.00% Vitamin A (min.) - 30,000 USP units/lb. Vitamin D-3 (min.) - 6,000 USP units/lb.
3	-	One half (0.5) pound of Moorman's Beef-Trate 80 AU medicated per day per steer plus whole shelled yellow corn <u>ad libitum</u>. The contents of the protein supplement premix as described by the manufacturer were:
		Active Drug Ingredient
		Chlortetracycline - 280 g/T (140 milligrams/lb.)
		Guaranteed Analysis
		Crude protein not less than - 80.0% This includes not more than 66% equivalent protein from biuret, triuret, cyanuric acid and urea, of which not more than 35% is from urea. Crude fat not less than - 1.0% Crude fiber not more than - 6.0% Calcium (Ca) not less than - 7.8% (Ca) not more than - 9.4% Phosphorus (P) not less than - 1.2% Salt (NaCl) - 0.0% Iodine (I) not less than - 0.0025% Vitamin A not less than 44,000 USP units/lb.
4	-	Nine tenths (0.9) pound of 44% Protein, Solvent Extracted, Soybean Meal per day per steer plus whole shelled yellow corn <u>ad libitum</u>. The contents of the protein supplement premix as described by the manufacturer were:
		Protein not less than - 44.00% Fat not less than - 0.50% Fiber not more than - 7.00% Nitrogen free extracts not less than 29.00% Ash not more than - 6.00%

grade, marbling, and quality grade. Definitions of the aforementioned data and coding systems for marbling and quality grade can be found in Tables II and III, respectively.

II. METHODS OF ANALYSIS

A least squares regression analysis was conducted on the data with a series of the following models being fitted where applicable.

$$Y = a + b_1X_1 + b_2X_2 + e$$

or

$$Y = a + b_1X_1 + e$$

where:

Y = frame size; increase in fat thickness; average daily gain; total gain per pen; average daily corn consumption; average corn conversion; carcass weight; fat thickness; percent kidney, pelvic, and heart fat; rib eye area; yield grade; marbling; quality grade.

and where:

a = intercept;

b_1X_1 = effects of replication;

b_2X_2 = effects of treatment;

e = residual effects.

A visual inspection of the raw means indicated that there was no need for an interaction term in the model containing replication and treatment.

TABLE II

DEFINITIONS

Term		Definition
FRAME SIZE	-	A subjective measure ranging from two (2) to six (6), with two being the smallest possible and six being the largest, and subdivided into tenths (i.e. 2.4, 3.1, 5.6).
INCREASE IN FAT	-	The difference between an Ultrasonic estimate, taken at the beginning of the feeding trial and the carcass fat thickness at slaughter.
AVERAGE DAILY GAIN	-	Amount of increase in body weight (pounds) across the feeding trial divided by the number of days in the trial.
TOTAL GAIN PER PEN	-	Number of pounds increase in body weight for all animals within a pen during the course of the feeding trial.
AVERAGE DAILY CORN CONSUMPTION	-	The quantity of corn (pounds) each animal averaged in consumption on a daily basis.
AVERAGE CORN CONVERSION	-	The amount of corn utilized (pounds) in a pound of gain, averaged on a per animal basis.
CARCASS WEIGHT	-	Weight of the hot carcass (pounds) taken immediately after slaughter.
FAT THICKNESS	-	A single measure of fat thickness (millimeters) taken three-fourths the way up the rib eye muscle at the twelfth rib.

TABLE II (continued)

Term		Definition
PERCENT KIDNEY, PELVIC, AND HEART FAT	-	The percentage of total carcass weight found as fat around the heart, kidneys and in the pelvic area as estimated by a U.S.D.A. grader.
RIB EYE AREA	-	Area of the rib eye muscle (square inches) between the twelfth and thirteenth ribs.
YIELD GRADE	-	A value expressed in tenths and derived from the U.S.D.A. equation of yield grade = 2.5 + 2.5 X fat thickness (in inches) + 0.20 X percent kidney, pelvic and heart fat + 0.0038 X carcass weight - .32 X rib eye area.
MARBLING	-	Quantity of intra muscular fat as determined by a U.S.D.A. grader.
QUALITY GRADE	-	The U.S.D.A. quality grade as determined by a U.S.D.A. grader.

TABLE III

MARBLING AND CARCASS QUALITY GRADE CODING SYSTEMS

Code		Marbling	Code		Carcass quality grade
100	-	Abundant	17	-	Prime (+)
97	-	Abundant (-)	16	-	Prime
93	-	Moderately abundant (+)	15	-	Prime (-)
90	-	Moderately abundant	14	-	Choice (+)
87	-	Moderately abundant (-)	13	-	Choice
83	-	Slightly abundant (+)	12	-	Choice (-)
80	-	Slightly abundant	11	-	Good (+)
77	-	Slightly abundant (-)	10	-	Good
73	-	Moderate (+)	9	-	Good (-)
70	-	Moderate	8	-	Standard (+)
67	-	Moderate (-)	7	-	Standard
63	-	Modest (+)	6	-	Standard (-)
60	-	Modest			
57	-	Modest (-)			
53	-	Small (+)			
50	-	Small			
47	-	Small (-)			
43	-	Slight (+)			
40	-	Slight			
37	-	Slight (-)			
33	-	Traces (+)			
30	-	Traces			
27	-	Traces (-)			
23	-	Practically devoid (+)			
20	-	Practically devoid			
17	-	Practically devoid (-)			
13	-	Devoid (+)			
10	-	Devoid			

or

a = intercept;

b_1X_1 = effects of treatment;

e = residual effects.

If significant difference was determined, a Duncan's Multiple Range Test for unequal subclasses as described by Kramer (1957) was conducted to separate those significant differences for each respective model.

CHAPTER IV

RESULTS AND DISCUSSION

The dependent variables used in this study were as follows: the production aspects of frame size, increase in fat thickness, average daily gain, total gain per pen, average daily corn consumption, and average corn conversion; the carcass aspects of carcass weight, fat thickness, rib eye area, percent kidney, pelvic, and heart fat, yield grade, marbling, and quality grade. Since all of these variables are measurements, estimations of values calculated from those measurements and estimations, there must be many sources of variation. However, for the purpose of this study those sources were considered to be random and were therefore not considered. It should be noted that if these protein supplements had been fed as per the manufacturers' recommendations the results might have been different.

To simplify the discussion, the 79 steers and the 40 steers fed for 110 days and comprising a total of 119 will be hereafter referred to as Analysis 1 and the 40 steers fed for 90 days will hereafter be referred to as Analysis 2.

I. PRODUCTION ASPECTS

It was found that there was a difference ($P < .05$) in frame size between replications in Analysis 1 (Table IV), but there was no ($P < .05$) difference between treatments as depicted in the ANOVA

TABLE IV

ANALYSIS OF VARIANCE OF FRAME SIZE, INCREASE IN FAT THICKNESS OVER THE TWELFTH RIB, AND AVERAGE DAILY GAIN (119 STEERS) (ANALYSIS 1)

Source	Degrees of freedom	Mean Square		
		Frame size	Increase in fat	Average daily gain
Replication	1	1.974***	4.017	0.011
Treatment	3	0.101	22.675	1.337**
Residual	114	0.426	12.806	0.216
R^2		.04	.05	.14

***P < .01.

**P < .05.

in Tables IV and V for Analyses 1 and 2, respectively. The overall arithmetic means for frame size in Analyses 1 and 2 were 4.108 and 4.150. Replications 1 and 2 differed from the overall mean by 0.137 and -0.137 units, respectively. Treatments 1, 2, 3, and 4 varied -0.063, -0.036, 0.050 and 0.049 units, respectively, in Analysis 1 (Table VI). In Analysis 2 Treatments 1, 2, 3, and 4 varied -0.040, 0.090, -0.090, and 0.040 units, respectively (Table VII). The least squares estimates, for the ($P < .05$) difference in replications, are given in Table VI, with replication 2 having the smaller animals. The ANOVA for increase in fat thickness in Analysis 1 and 2 is presented in Tables IV and V, even though no significant difference occurred. The overall arithmetic mean for increase in fat thickness was 9.983 mm. in Analysis 1. The replications differed by 0.189 and -0.189 mm. and Treatments 1, 2, 3, and 4 varied by -0.276, 1.157, 0.057, and -0.938 mm., respectively from the overall arithmetic mean (Table VIII). In Analysis 2 the overall arithmetic mean for fat thickness increase was 7.150 mm., with treatment variations of -1.050, -0.250, 0.850, and 0.450 mm. for Treatments 1, 2, 3, and 4, respectively (Table VII).

Average daily gain showed a ($P < .05$) difference between treatments in Analysis 1 as presented in Table IV with corresponding least squares estimates in Table IX. The overall arithmetic mean for average daily gain in Analysis 1 was 3.043 lbs. per day. The replications differed by -0.011 and 0.011 lbs. per day for Replication 1 and 2, respectively. Treatments 1, 2, 3, and 4 varied -0.172, 0.277, 0.054, and -0.159 lb. per day from the overall arithmetic mean, respectively (Table IX). Analysis 2 did not, however, yield any significant

TABLE V

ANALYSIS OF VARIANCE OF FRAME SIZE, INCREASE IN FAT THICKNESS OVER THE TWELFTH RIB, AND AVERAGE DAILY GAIN (40 STEERS) (ANALYSIS 2)

		Mean Square		
Source	Degrees of freedom	Frame size	Increase in fat	Average daily gain
Treatment	3	0.065	5.586	0.598
Residual	36	0.588	5.313	0.566
R^2		.01	.18	.08

TABLE VI

LEAST SQUARES ESTIMATES[1] OF FRAME SIZE
(ANALYSIS 1)

Variable	Number of steers	Frame size (units)
Intercept		3.974±0.063
Replication		
1	79	0.137±0.063[a]
2	40	-0.137±0.063[b]
Treatment		
1	30	-0.036±0.103[a]
2	30	-0.063±0.103[a]
3	30	0.050±0.103[a]
4	29	0.049±0.103[a]

[1]Estimates are deviations from the overall means adjusted for unequal numbers per subclass. The overall arithmetic mean for frame size was 4.108.

[a,b]Those estimates followed by the same letter within a column within subclass do not differ significantly at the 0.05 level of probability.

TABLE VII

LEAST SQUARES ESTIMATES[1] FOR FRAME SIZE, INCREASE IN FAT THICKNESS OVER THE TWELFTH RIB, AND AVERAGE DAILY GAIN (ANALYSIS 2)

Variable	Number of steers	Frame size (units)	Increase in fat (mm.)	Average daily gain (lbs.)
Intercept		4.150 ± 0.121	7.150 ± 0.362	3.040 ± 0.119
Treatment				
1	10	-0.040 ± 0.210^a	-1.050 ± 0.626^a	-0.234 ± 0.206^a
2	10	0.090 ± 0.210^a	-0.250 ± 0.626^a	0.339 ± 0.206^a
3	10	-0.090 ± 0.210^a	0.850 ± 0.626^a	-0.007 ± 0.206^a
4	10	0.040 ± 0.210^a	0.450 ± 0.626^a	-0.098 ± 0.206^a

[1]Estimates are deviations from the overall means. The overall arithmetic means for frame size, increase in fat, and average daily gain were 4.150, 7.150, and 3.040, respectively.

[a]Those estimates followed by the same letter within a column within subclass do not differ significantly at the 0.05 level of probability.

TABLE VIII

LEAST SQUARES ESTIMATES[1] FOR INCREASE IN FAT THICKNESS OVER THE TWELFTH RIB (ANALYSIS 1)

Variable	Number of steers	Increase in fat (mm.)
Intercept		9.914±0.347
Replication		
1	79	0.189±0.347[a]
2	40	-0.189±0.347[a]
Treatment		
1	30	-0.276±0.567[a]
2	30	1.157±0.567[a]
3	30	0.057±0.567[a]
4	29	-0.938±0.567[a]

[1]Estimates are deviations from the overall means adjusted for unequal numbers per subclass. The overall arithmetic mean for increase in fat was 9.983.

[a]Those estimates followed by the same letter within a column within subclass do not differ significantly at the 0.05 level of probability.

TABLE IX

LEAST SQUARES ESTIMATES[1] OF AVERAGE DAILY GAIN (ANALYSIS 1)

Variable	Number of steers	Average daily gain (lbs.)
Intercept		3.046±0.045
Replication		
1	79	-0.011±0.045[a]
2	40	0.011±0.045[a]
Treatment		
1	30	-0.172±0.074[b]
2	30	0.277±0.074[a]
3	30	0.054±0.074[a,b]
4	29	-0.159±0.074[b]

[1]Estimates are deviations from the overall means adjusted for unequal numbers per subclass. The overall arithmetic mean for average daily gain was 3.043.

[a,b]Those estimates followed by the same letter within a column within subclass do not differ significantly at the 0.05 level of probability.

difference for treatment. Analysis 2 had an overall arithmetic mean of 3.040 lbs. per day for average daily gain, with Treatments 1, 2, 3, and 4 varying -0.234, 0.339, -0.007, and -0.098 lb. per day, respectively, from the mean (Table VII). Previous workers have not made such comparisons as these but from these data one could conclude that the ($P < .05$) differences in average daily gain were due to the protein supplements.

The ANOVA tables for total gain per pen are presented in Tables X and XI for Analyses 1 and 2, respectively. The least squares estimates for the ($P < .05$) difference in total gain per pen are in Table XII. The overall arithmetic mean for total gain per pen in Analysis 1 was 1659.708 lbs. Replications 1 and 2 differed from the mean by -16.063 and 16.063 lbs., respectively. Treatments 1, 2, 3, and 4 in Analysis 1 varied -81.542, 165.792, 42.292, and -126.542 lbs., respectively, from the mean (Table XII). In Analysis 2 the overall arithmetic mean for total gain per pen was 1368.000 lbs. Treatments 1, 2, 3, and 4 varied -105.500, 152.500, -3.000, and -44.000 lbs., respectively, from the mean (Table XIII). As normally would be anticipated, they follow the pattern of average daily gain identically.

Average daily corn consumption and average corn conversion were found to be ($P < .01$) different for replication and ($P < .05$) different for treatment in Analysis 1 (Table X). No ($P < .05$) difference was detected in Analysis 2 (Table XI). In Analysis 1 average daily corn consumption had an overall arithmetic mean of 18.035 lbs. per day. Replications 1 and 2 differed by 1.323 and -1.323 lbs. per day, respectively. Treatments 1, 2, 3, and 4 varied 0.257, 0.522, -0.007 and -0.772 lbs. per day, respectively, from the mean (Table XIV). In

TABLE X

ANALYSIS OF VARIANCE OF TOTAL GAIN PER PEN, AVERAGE DAILY CORN CONSUMPTION PER STEER, AND AVERAGE CORN CONVERSION (119 STEERS) (ANALYSIS 1)

Source	Degrees of freedom	Mean Square		
		Gain per pen	Corn consumption	Corn conversion
Replication	1	5504.083	37.334***	4.008***
Treatment	3	103874.597**	1.866**	0.713**
Residual	19	25780.057	0.526	0.157
R^2		.39	.81	.67

***P < .01.

**P < .05.

TABLE XI

ANALYSIS OF VARIANCE OF TOTAL GAIN PER PEN, AVERAGE DAILY CORN CONSUMPTION PER STEER, AND AVERAGE CORN CONVERSION (40 STEERS) (ANALYSIS 2)

Source	Degrees of freedom	Mean Square		
		Gain per pen	Corn consumption	Corn conversion
Treatment	3	24221.000	0.411	0.197
Residual	4	3796.250	0.168	0.086
R^2		.83	.64	.63

TABLE XII

LEAST SQUARES ESTIMATES[1] OF TOTAL GAIN PER PEN (ANALYSIS 1)

Variable	Number of pens	Gain per pen (lbs.)
Intercept		1665.063 ± 34.763
Replication		
1	16	-16.063 ± 34.763^{a}
2	8	16.063 ± 34.763^{a}
Treatment		
1	6	-81.542 ± 56.767^{b}
2	6	165.792 ± 56.767^{a}
3	6	$42.292 \pm 56.767^{a,b}$
4	6	-126.542 ± 56.767^{b}

[1]Estimates are deviations from the overall means adjusted for unequal numbers per subclass. The overall arithmetic mean for gain per pen was 1659.708.

[a,b]Those estimates followed by the same letter within a column within subclass do not differ significantly at the 0.05 level of probability.

TABLE XIII

LEAST SQUARES ESTIMATES[1] FOR TOTAL GAIN PER PEN, AVERAGE DAILY CORN CONSUMPTION, AND AVERAGE CORN CONVERSION (ANALYSIS 2)

Variable	Number of pens	Gain per pen (lbs.)	Corn consumption (lbs.)	Corn conversion (lbs.)
Intercept		1368.000±21.784	17.467±0.145	5.770±0.104
Treatment				
1	2	-105.500±37.731[a]	-0.472±0.251[a]	0.293±0.179[a]
2	2	152.500±37.731[a]	0.517±0.251[a]	-0.445±0.179[a]
3	2	-3.000±37.731[a]	0.228±0.251[a]	0.006±0.179[a]
4	2	-44.000±37.731[a]	-0.273±0.251[a]	0.086±0.179[a]

[1]Estimates are deviations from the overall means. The overall arithmetic means for gain per pen, corn consumption, and corn conversion were 1368.000, 17.467, and 5.770, respectively.

[a]Those estimates followed by the same letter within a column within subclass do not differ significantly at the 0.05 level of probability.

TABLE XIV

LEAST SQUARES ESTIMATES[1] OF AVERAGE DAILY CORN CONSUMPTION AND AVERAGE CORN CONVERSION (ANALYSIS 1)

Variable	Number of pens	Corn consumption (lbs.)	Corn conversion (lbs.)
Intercept		18.035±0.157	5.990±0.085
Replication			
1	16	1.323±0.157[a]	0.433±0.085[a]
2	8	-1.323±0.157[b]	-0.433±0.085[b]
Treatment			
1	6	0.257±0.256[a]	0.442±0.256[a]
2	6	0.522±0.256[a]	-0.372±0.140[b]
3	6	-0.007±0.256[a,b]	-0.137±0.140[b]
4	6	-0.772±0.256[b]	0.067±0.140[a,b]

[1]Estimates are deviations from the overall means adjusted for unequal numbers per subclass. The overall arithmetic means for corn consumption and corn conversion were respectively 18.476 and 6.135.

[a,b]Those estimates followed by the same letter within a column within subclass do not differ significantly at the 0.05 level of probability.

Analysis 2 average daily corn conversion had an overall arithmetic mean of 17.467 lbs. per day with Treatments 1, 2, 3, and 4 varying -0.472, 0.517, 0.228, and -0.273 lbs. per day, respectively (Table XIII). In Analysis 1 corn conversion had an overall arithmetic mean of 5.990 lbs. corn per lb. gain. Replications 1 and 2 differed in conversion by 0.433 and -0.433 lbs. corn per lb. gain, respectively, from the mean. Treatments 1, 2, 3, and 4 varied 0.442, -0.372, -0.137, and 0.067 lbs. corn per lb. gain, respectively, from the overall mean (Table XIV). In Analysis 2 the overall arithmetic mean was 5.770 lbs. corn per lb. gain. Treatments 1, 2, 3, and 4 varied from the mean by 0.293, -0.445, 0.066, and 0.086 lb. corn per lb. gain, respectively (Table XIII). The lowest corn consumption aligned with lowest corn conversion on a replication basis. However, this did not hold true on a treatment basis.

II. CARCASS ASPECTS

In Analysis 2 no ($P < .05$) difference occurred for any of the variables analyzed to include carcass weight, rib eye area, fat thickness, percent kidney, pelvic, and heart fat, yield grade, marbling, and quality grade (Tables XV and XVI). The overall arithmetic means, in Analysis 2, for carcass weight, rib eye area, fat thickness, percent kidney, pelvic, and heart fat, yield grade, marbling and quality grade were, respectively, 579.625 lbs., 10.845 sq. in., 9.475 mm., 1.763 percent, 2.523 units, 48.575 units, and 11.500 units. The variations from those means for Treatments 1, 2, 3, and 4 were -14.025, -0.285, -1.175, -0.113, -0.103, -3.575, -0.500; 8.975, -0.095, -0.175, 0.038,

TABLE XV

ANALYSIS OF VARIANCE OF CARCASS WEIGHT, RIB EYE AREA, FAT THICKNESS OVER THE TWELFTH RIB, AND PERCENT KIDNEY, PELVIC, AND HEART FAT (40 STEERS) (ANALYSIS 2)

Source	Degrees of freedom	Mean Square			
		Carcass weight	Rib eye area	Fat thickness	Percent KPH fat
Treatment	3	1104.692	1.430	9.092	0.206
Residual	36	1561.256	0.735	4.908	0.122
R^2		.06	.14	.13	.12

TABLE XVI

ANALYSIS OF VARIANCE OF YIELD GRADE, MARBLING AND QUALITY GRADE (40 STEERS) (ANALYSIS 2)

Source	Degrees of freedom	Mean Square		
		Yield grade	Marbling	Quality grade
Treatment	3	0.210	89.625	1.133
Residual	36	0.100	85.247	2.406
R^2		.15	.08	.04

0.058, 1.825, 0.200; 7.075, -0.175, 1.125, -0.113, 0.178, 3.025, 0.200; and -2.025, 0.555, 0.225, 0.188, -0.133, -1.275, 0.100, respectively (Tables XVII and XVIII). This is in general agreement with results from Kercher and Bishop (1963).

Analysis 1, however, yielded ($P < .01$) differences for replication in carcass weight, rib eye area, and percent kidney, pelvic, and heart fat (Table XIX). The only ($P < .05$) differences between treatments were in carcass weight and yield grade (Tables XIX and XX). In Analysis 1 overall arithmetic means were 612.958 lbs., 11.544 sq. in., 12.185 mm., 2.336 percent, 2.803 units, 52.932 units, and 12.118 units for carcass weight, rib eye area, fat thickness, percent kidney, pelvic, and heart fat, yield grade, marbling, and quality grade, respectively. Replications 1 and 2 differed from those means by 26.271, 0.348, 0.303, -0.133, -0.007, 1.147, 0.144; and -26.271, -0.348, -0.303, 0.133, 0.007, -1.147, 0.144, respectively. Treatments 1, 2, 3, and 4 varied from the overall arithmetic means by 1.948, 0.284, -0.213, -0.002, -0.108, 3.043, 0.417; 19.181, -0.226, 0.954, 0.082, 0.266, -1.797, -0.083; -2.952, -0.089, 0.121, -0.018, 0.022, -0.497, -0.117; and -18.177, 0.031, -0.862, -0.062, -0.180, -0.749, -0.217, respectively (Tables XXI, XXII, XXIII, and XXIV). The relationship of carcass weight, rib eye area, and percent kidney, pelvic, and heart fat in replication effects, according to these data, would appear to be that the heavier carcasses had larger rib eye areas with less kidney, pelvic, and heart fat (Tables XXI and XXIII). The ($P < .05$) differences in carcass weight and yield grade between treatments are not clear but from these data one could conclude that since

TABLE XVII

LEAST SQUARES ESTIMATES[1] FOR CARCASS WEIGHT, RIB EYE AREA, FAT THICKNESS OVER THE TWELFTH RIB, AND PERCENT KIDNEY, PELVIC AND HEART FAT (ANALYSIS 2)

Variable	Number of steers	Carcass weight (lbs.)	Rib eye area (sq. in.)	Fat thickness (mm.)	Percent KPH fat
Intercept		579.625±6.248	10.845±0.136	9.475±0.350	1.763±0.055
Treatment					
1	10	-14.025±10.821[a]	-0.285±0.235[a]	-1.175±0.607[a]	-0.113±0.095[a]
2	10	8.975±10.821[a]	-0.095±0.235[a]	-0.175±0.607[a]	0.038±0.095[a]
3	10	7.075±10.821[a]	-0.175±0.235[a]	1.125±0.607[a]	-0.113±0.095[a]
4	10	-2.025±10.821[a]	0.555±0.235[a]	0.225±0.607[a]	0.188±0.095[a]

[1]Estimates are deviations from the overall means. The overall arithmetic means for carcass weight, rib eye area, fat thickness, and percent kidney, pelvic, and heart fat were 579.625, 10.845, 9.475, and 1.763, respectively.

[a]Those estimates followed by the same letter within a column within subclass do not differ significantly at the 0.05 level of probability.

TABLE XVIII

LEAST SQUARES ESTIMATES[1] FOR YIELD GRADE, MARBLING, AND QUALITY GRADE (ANALYSIS 2)

Variable	Number of steers	Yield grade (units)	Marbling (units)	Quality grade (units)
Intercept		2.523±0.050	48.575±1.460	11.500±0.245
Treatment				
1	10	-0.103±0.087[a]	-3.575±2.529[a]	-0.500±0.425[a]
2	10	0.058±0.087[a]	1.825±2.529[a]	0.200±0.425[a]
3	10	0.178±0.087[a]	3.025±2.529[a]	0.200±0.425[a]
4	10	-0.133±0.087[a]	-1.275±2.529[a]	0.100±0.425[a]

[1]Estimates are deviations from the overall means. The overall arithmetic means for yield grade, marbling, and quality grade were 2.523, 48.575, and 11.500, respectively.

[a]Those estimates followed by the same letter within a column within subclass do not differ significantly at the 0.05 level of probability.

TABLE XIX

ANALYSIS OF VARIANCE OF CARCASS WEIGHT, RIB EYE AREA, FAT THICKNESS OVER THE TWELFTH RIB, AND PERCENT KIDNEY, PELVIC, AND HEART FAT (119 STEERS) (ANALYSIS 1)

Source	Degrees of freedom	Mean Square			
		Carcass weight	Rib eye area	Fat thickness	Percent KPH fat
Replication	1	73949.306***	12.816***	10.122	1.874***
Treatment	3	6996.356**	1.406	16.879	0.107
Residual	114	2240.530	0.823	15.344	0.191
R^2		.27	.15	.03	.09

***P < .01.

**P < .05.

TABLE XX

ANALYSIS OF VARIANCE OF YIELD GRADE, MARBLING, AND QUALITY GRADE (119 STEERS) (ANALYSIS 1)

Source	Degrees of freedom	Mean Square		
		Yield grade	Marbling	Quality grade
Replication	1	0.003	141.558	2.236
Treatment	3	1.141**	162.490	2.396
Residual	114	0.254	96.004	1.499
R^2		.11	.05	.05

**P < .01.

TABLE XXI

LEAST SQUARES ESTIMATES[1] OF RIB EYE AREA AND PERCENT KIDNEY, PELVIC, AND HEART FAT (ANALYSIS 1)

Variable	Number of steers	Rib eye area (sq. in.)	Percent Percent KPH fat
Intercept		11.430 ± 0.088	2.379 ± 0.042
Replication			
1	79	0.348 ± 0.088[a]	-0.133 ± 0.042[b]
2	40	-0.348 ± 0.088[b]	0.133 ± 0.042[a]
Treatment			
1	30	0.284 ± 0.144[a]	-0.002 ± 0.069[a]
2	30	-0.226 ± 0.144[a]	0.082 ± 0.069[a]
3	30	-0.089 ± 0.144[a]	-0.018 ± 0.069[a]
4	29	0.031 ± 0.144[a]	-0.062 ± 0.069[a]

[1]Estimates are deviations from the overall means adjusted for unequal numbers per subclass. The overall arithmetic means for rib eye area and percent kidney, pelvic, and heart fat were respectively 11.544 and 2.336.

[a,b]Those estimates followed by the same letter within a column within subclass do not differ significantly at the 0.05 level of probability.

TABLE XXII

LEAST SQUARES ESTIMATES[1] FOR FAT THICKNESS OVER THE TWELFTH RIB (ANALYSIS 1)

Variable	Number of steers	Fat thickness (mm.)
Intercept		12.078±0.380
Replication		
1	79	0.303±0.380[a]
2	40	-0.303±0.380[a]
Treatment		
1	30	-0.213±0.620[a]
2	30	0.954±0.620[a]
3	30	0.121±0.620[a]
4	29	-0.862±0.620[a]

[1]Estimates are deviations from the overall means adjusted for unequal numbers per subclass. The overall arithmetic mean for fat thickness was 12.185.

[a]Those estimates followed by the same letter within a column within subclass do not differ significantly at the 0.05 level of probability.

TABLE XXIII

LEAST SQUARES ESTIMATES[1] OF CARCASS WEIGHT AND YIELD GRADE (ANALYSIS 1)

Variable	Number of steers	Carcass weight (lbs.)	Yield grade (units)
Intercept		604.196±4.593	2.803±0.049
Replication			
1	79	26.271±4.593[a]	-0.007±0.049[a]
2	40	-26.271±4.593[b]	0.007±0.049[a]
Treatment			
1	30	1.948±7.495[a,b]	-0.108±0.080[b]
2	30	19.181±7.495[a]	0.266±0.080[a]
3	30	-2.952±7.495[a,b]	0.022±0.080[a,b]
4	29	-18.177±7.495[b]	-0.180±0.080[b]

[1]Estimates are deviations from the overall means adjusted for unequal numbers per subclass. The overall arithmetic means for carcass weight and yield grade were respectively 612.958 and 2.803.

[a,b]Those estimates followed by the same letter within a column within subclass do not differ significantly at the 0.05 level of probability.

TABLE XXIV

LEAST SQUARES ESTIMATES[1] FOR MARBLING AND QUALITY GRADE (ANALYSIS 1)

Variable	Number of steers	Marbling (units)	Quality grade (units)
Intercept		52.547±0.951	12.069±0.119
Replication			
1	79	1.147±0.951[a]	0.144±0.119[a]
2	40	-1.147±0.951[a]	-0.144±0.119[a]
Treatment			
1	30	3.043±1.551[a]	0.417±0.194[a]
2	30	-1.797±1.551[a]	-0.083±0.194[a]
3	30	-0.497±1.551[a]	-0.117±0.194[a]
4	29	-0.749±1.551[a]	-0.217±0.194[a]

[1]Estimates are deviations from the overall means adjusted for unequal numbers per subclass. The overall arithmetic means formarbling and quality grade were 52.932 and 12.118, respectively.

[a]Those estimates followed by the same letter within a column within subclass do not differ significantly at the 0.05 level of probability.

average daily gain was ($P < .05$) different for treatment, then carcass weight would also be ($P < .05$) different. It should be noted that carcass weight and yield grade have a part-whole relationship since carcass weight is a part of yield grade.

The incidence of liver abcess for this research is reported in Table XXV and is in general agreement with Harvey et al. (1968) except for Treatment 4 where the incidence was much lower than they reported.

The lack of significance encountered throughout Analysis 2 could be due to the small number of observations, especially since the trends of variation in both sets of data were generally the same.

TABLE XXV

LIVER ABCESS INCIDENCE

Treatment	Number of steers	Number of livers abcessed
1	30	2
2	30	0
3	30	2
4	29	2

CHAPTER V

SUMMARY

The data used in this study were obtained from 160 long yearling feeder steers weighing between 600 and 750 lbs. and fed whole shelled corn finishing rations supplemented with four different protein sources as to comprise the finishing rations. The variables, frame size, increase in fat thickness, average daily gain, total gain per pen, average daily corn consumption, average corn conversion, carcass weight, rib eye area, fat thickness, percent kidney, pelvic, and heart fat, yield grade, marbling and quality grade were subjected to a least squares regression analysis as dependent variables to detect significant differences between the treatments.

The variables, average daily gain, total gain per pen, average daily corn consumption, average corn conversion, carcass weight and yield grade were found to be ($P < .05$) different for treatment. Duncan's Multiple Range Test was conducted to rank the treatments for these variables.

Previous workers have not made such comparisons as these but from these data one could conclude that the ($P < .05$) differences in average daily gain were due to the protein supplements. The relationship of carcass weight, rib eye area, and percent kidney, pelvic, and heart fat in replication effects, according to these data, would appear to be that the heavier carcasses had larger rib eye areas with less kidney, pelvic, and heart fat.

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VITA

James C. Godfrey, Jr. was born August 18, 1948, in Jackson, Tennessee. He attended Alexander Elementary School, Tigrett Junior High School and graduated from North Side High School, Jackson, Tennessee, in 1966.

In September of 1966 he entered The University of Tennessee at Martin as an undergraduate in the field of agriculture. While attending The University of Tennessee at Martin, he was a member of Alpha Gamma Rho Fraternity and served as social chairman of that organization. In January of 1971 Mr. Godfrey enlisted in the United States Army for a tour of active duty.

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In June of 1972 Mr. Godfrey was employed by Eastern Airlines in Washington, D.C. until his return to The University of Tennessee at Martin where he was awarded a Bachelor of Science Degree in Animal Science in June of 1974. After completion of his undergraduate work, Mr. Godfrey was employed by the National Farmers Organization in Corning, Iowa.

September of 1975 led the author to The University of Tennessee to complete a Master of Science graduate program. While completing his graduate program he had the pleasure of working under the guidance and direction of Dr. Haley M. Jamison in the Animal Science-Beef Section of The University of Tennessee Extension Service. He and his wife were blessed with the birth of a son on October 23, 1975. He became a member of the American Society of Animal Science and was elected to Gamma Sigma Delta Honor Society of Agriculture.

He received the Master of Science Degree in Animal Science in August of 1977.