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August 29, 1972

To the Graduate Council:

I am submitting herewith a thesis written by Phillip Michael Smith entitled "The Effects on Performance, Economy of Gain and Carcass Quality of Slaughter Heifers Fed Three Levels of Crude Protein Using Two Sources of Additional Supplementation." I recommend that it be accepted for nine quarter hours of credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Animal Husbandry.

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THE EFFECTS ON PERFORMANCE, ECONOMY OF GAIN AND CARCASS QUALITY OF SLAUGHTER HEIFERS FED THREE LEVELS OF CRUDE PROTEIN USING TWO SOURCES OF ADDITIONAL SUPPLEMENTATION

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

Phillip Michael Smith

December 1972

ACKNOWLEDGEMENTS

The author wishes to express his sincere appreciation to the following persons for their contributions to this thesis:

To the late Dr. C. S. Hobbs for his encouragement, guidance and the opportunity for graduate study.

To Dr. J. A. Corrick, Jr., major professor, for his guidance in the author's graduate training and his encouragement and assistance in collection of the data.

To Dr. W. R. Backus for serving on the graduate committee and reviewing the manuscript.

To Dr. J. D. Smalling for serving on the graduate committee and reviewing the manuscript.

To Jim Neel, Richard Clarissee and Milton Southall for their assistant in collecting the data.

To Jim Neel, Dennis Onks and Jim Warren for assistance in analyzing the data.

To the author's fellow graduate students for their friendship and assistance.

To Miss Nancy Huffstetler for her untiring efforts and assistance in preparation and typing of this thesis.

To the author's family for their encouragement and aid during the course of this study.

1060274

ABSTRACT

The purpose of this experiment was to test the effects on performance, economy of gain and carcass quality of slaughter heifers when grown and fattened on a urea-limestone treated corn-silage ration in which the daily crude protein intake per head was 1.7 to 1.8, 1.9 to 2.0 and 2.1 to 2.2 lbs. and to test for any difference between cottonseed meal and urea as an additional supplemental source.

In addition to corn silage ad libitum each animal received 6.0 lbs. of concentrate per day during a 140-day roughage phase to provide three different levels of protein. Ration 1 consisted of only corn and provided 1.7 to 1.8 lbs. of crude protein per head per day. Rations 2 and 4 consisted of corn plus cottonseed meal and provided 1.9 to 2.0 and 2.1 to 2.2 lbs. of crude protein per head per day, respectively. Rations 3 and 5 consisted of corn plus urea and provided 1.9 to 2.0 and 2.1 to 2.2 lbs. of crude protein per head per day, respectively. After 140 days the heifers were full fed a concentrate ration of eight parts ground shelled corn to one part cottonseed meal. Animals were finished to a designated ultrasonically measured fat thickness of 10 or 8 mm.

The results of this study showed no significant ($P > .05$) differences were produced in feedlot performance or carcass characteristics by these levels or sources of dietary nitrogen.

TABLE OF CONTENTS

CHAPTER		PAGE
I.	INTRODUCTION	1
II.	LITERATURE REVIEW	3
	Protein Levels	3
	Urea as a Source of Protein for Ruminants	6
	Urea vs Natural Protein	7
	Initial Fat	10
	Ultrasonic Measurements	12
III.	EXPERIMENTAL PROCEDURE	14
	Experimental Animals	14
	Management and Feeding	14
	Collection of Data	16
	Statistical Analysis	17
IV.	RESULTS AND DISCUSSION	18
	Feedlot Performance	18
	Average total gains	18
	Average daily gain	18
	Average fat thickness	18
	Average condition scores	23
	Days on test and feed consumption	23
	Financial returns	27
	Carcass Characteristics	27
	USDA quality grade	27

CHAPTER PAGE

IV. (continued)

Carcass fat 27

Dressing percent. 31

Marbling scores 31

Ribeye area 31

Yield grade and percent retail yield. 31

V. SUMMARY AND CONCLUSIONS. 33

LITERATURE CITED. 35

APPENDIX. 40

VITA. 44

LIST OF TABLES

TABLE		PAGE
I.	Overall Means and Standard Deviations for Selected Variables	19
II.	Feedlot Performance of Feeder Heifers Fed Three Levels of Protein Using Two Sources of Additional Protein Supplementation	20
III.	Analysis of Variance for the Effects of Ration and Initial Subcutaneous Fat on Feedlot Performance of Feeder Heifers During Roughage Phase	21
IV.	Analysis of Variance for the Effects of Ration and Initial Subcutaneous Fat on Overall Feedlot Performance of Feeder Heifers	22
V.	Days on Test and Dry Matter Consumption of Feeder Heifers Fed Three Levels of Crude Protein Using Two Sources of Additional Supplementation	24
VI.	Analysis of Variance for Dry Matter Consumption and Economy of Gain During the Roughage Phase	25
VII.	Analysis of Variance for Overall Average Dry Matter Consumption, Economy of Gain and Average Return Per Head Above Initial and Feed Cost	26
VIII.	Financial Returns for Feeder Heifers Fed Three Different Crude Protein Levels from Two Sources of Additional Supplementation	28

TABLE PAGE

IX. Carcass Characteristics of Feeder Heifers Fed Three Levels of Protein Using Two Sources of Additional Supplementation 29

X. Analysis of Variance for the Effects of Ration and Initial Subcutaneous Fat on Carcass Traits. 30

XI. Analysis of Variance for the Effects of Ration and Initial Subcutaneous Fat on Yield Grade and Percent Retail Yield. 32

XII. Least Square Means of Feedlot Performance of Feeder Heifers Fed Three Levels of Protein Using Two Sources of Additional Supplementation 41

XIII. Least Square Means of Carcass Traits for Feedlot Performance of Feeder Heifers Fed Three Levels of Protein Using Two Sources of Additional Supplementation . . 42

XIV. Feed Cost 43

CHAPTER I

INTRODUCTION

Increasing the efficiency of beef cattle in Southeastern feedlots could greatly increase the feeding enterprises in this section and provide additional income to the beef industry. Urea-limestone treated corn silage with the addition of readily digestible carbohydrates such as shelled crushed corn has been demonstrated to be an acceptable growing-finishing ration for beef cattle in Tennessee.

Urea has been used for a number of years as a protein supplement for replacing the more expensive organic supplements such as cottonseed meal or soybean meal. However, the optimum level of urea which may be used in a feeding ration has not been definitely determined.

Previous research at the University of Tennessee has indicated that increasing the protein content of a low protein ration, such as corn silage, will result in an improved feedlot performance for feeder cattle. The type of cattle produced, shorter feeding periods and consumer demands may influence the protein requirement and possibly increase recommended requirements.

Comparisons of non-protein nitrogen to natural sources of protein have produced conflicting results. Addition of urea to a ration would be profitable because of its lower cost compared to natural protein sources.

Requirements given by the National Research Council and previous trials by the University of Tennessee have indicated that 1.7 to 1.8 lbs.

of crude protein per head per day have produced satisfactory results in growing and finishing slaughter heifers.

The objectives of this experiment were:

1. To study the effects of three levels of dietary protein for growing and finishing feeder heifers of similar grade and fat thickness.

2. To evaluate two sources of dietary nitrogen (urea vs. cottonseed meal) for growing and finishing feeder heifers of similar grade and fat thickness.

CHAPTER II

LITERATURE REVIEW

I. PROTEIN LEVELS

Data summarized by Preston (1966) indicated that the protein requirements of growing-finishing cattle and lambs were a function of body weight, body weight gain and digestibility of the protein in the ration. Daily digestible protein requirements were expressed by the following equation:

$$\text{Cattle DP} = 2.79\ Wkg^{0.75}\ (1 + 1.905G)$$

$$\text{Lambs DP} = 2.79\ Wkg^{0.75}\ (1 + 6.02\ G)$$

where,

DP is the amount of digestible protein, (g.) $Wkg^{0.75}$ is the metabolic mass and G is the daily gain (kg.).

Kay, Bowers and McKiddie (1968) fed diets containing 11, 14 or 17 percent protein to 54 steers reared in individual pens. There were no significant differences in either dry-matter intake or live-weight gain by the steers on diets containing 14 or 17 percent crude protein. Dry matter intake was lower for the steers given the diet containing 11 percent crude protein and their live-weight gain was lower up to 250 kg. live weight. Above 250 kg., live weight gain was similar to steers on the other two treatments. Both dry matter digestibility and apparent nitrogen digestibility were lowest for those steers given the diet containing 11 percent crude protein.

Stobo, Roy and Gaston (1967) reported that calves given a concentrate containing 20 percent crude protein gained weight significantly faster from 3 to 12 weeks of age than those given concentrates containing either 12 percent crude protein or 18 percent crude protein of which 33 percent was in the form of urea.

Browers et al. (1965) fed all concentrate diets ad libitum, containing different levels of fish meal and varying in crude protein content from 16 to 22 percent of the dry matter, to 8 Frierian steers from 150 kg. to 240 kg. live weight. At 150 kg. the retention of nitrogen increased significantly to a maximum of 40.5 g. per day for the diet having 22 percent crude protein. At 240 kg. the maximum retention of 37 g. per day was achieved at 20 percent crude protein. Fecal nitrogen excretion per unit of metabolic body weight was approximately constant at all protein levels and at both live weights. Urinary nitrogen excretion per unit of metabolic body weight increased with increased crude protein level and was highest at 240 kg. live weight.

Elliott (1963) reported that live weight gain improved significantly as the protein content of the ration increased from 6 to 10 percent, but a further increase to 14 percent produced only a small subsequent improvement in growth.

Goodrich et al. (1961) fed 200 Hereford steers using protein levels of 9.5, 10.6, 12.0 and 12.7 percent. Gain and feed efficiency were 2.42 and 925, 2.55 and 878, 2.46 and 885 and 2.39 and 903 lbs., respectively. Martin et al. (1970) fed protein supplements which analyzed 10.1 and 34.6 percent crude protein and furnished 0.15 and 0.52 lbs. crude protein per steer daily, respectively. The higher

level of protein supplementation improved rate of gain with both whole-reconstituted ground and steam flaked milo, but not with ground-reconstituted grain. Because of a greater intake of the ground-reconstituted grain there resulted an increased daily protein intake (0.55 to 0.58 lbs.) which was actually higher than the greater amount received supplementally by the high-protein supplemented cattle. Feed efficiency was markedly improved by protein supplementation within all processing methods.

Perry, Beeson and Mohler (1967) fed two types of silage, three levels of corn and three levels of supplemented protein (0, 454 and 908 g. per head daily). Cattle fed the two types of silage gained at similar rates regardless of the level of corn or of supplemental protein fed.

Williams and Taylor (1961) fed three rations to test levels of cottonseed meal for fattening yearling steers. When an oat and Johnson grass hay ration was fed there was an increase in rate of daily gain when the cottonseed meal increased up to 1.5 lbs. per day. When one pound of alfalfa hay was fed with oat and Johnson grass hay, the protein did not appear to be a limiting factor as measured by rate of average daily gain. Steers with no cottonseed meal gained as well as those receiving it. When a corn and Johnson grass hay ration was fed, the average daily gain and dressing percent increased slightly as the level of cottonseed meal was increased to 3.0 lbs. However, this increase was not significant. The most economical gains were made by steers receiving 1.0 lbs. of cottonseed meal (based on current prices).

Freitag, Smith and Beeson (1968) reported that both reducing the crude protein from 11 to 7 percent and substituting urea for soybean meal caused reduced average daily gain. Haskings et al. (1967) reported that an increase from 11 to 14 percent protein level in rations fed 80 steers significantly increased gains. Raleigh and Wallace (1963), in feeding meadow hay plus a protein supplement to steers, reported that body weight gain, feed intake and feed efficiency were significantly greater from 9 and 12 percent protein diets than from a 6 percent diet.

II. UREA AS A SOURCE OF PROTEIN FOR RUMINANTS

The ruminant animal, because of the anatomy of its stomach, can utilize urea as a nitrogen source. Billions of bacteria and protozoa which live in the reticula-ruminal area are capable of converting cellulose to soluble products which are utilized by the host in synthesizing certain vitamins and converting non-protein nitrogen compounds to protein (Tillman, 1967).

In rations containing sufficient energy urea can replace, on a nitrogen basis, up to one third of the protein in rations of dairy cows, beef cattle and lambs. However, there is a limit to what can be fed without decreasing appetite or even inducing a toxicity because of excessive amounts of ammonia formed and absorbed from the rumen (Maynard and Loosli, 1969).

Many reviews deal with the use of urea by the ruminant animal (Reid, 1953; Gross, 1942; Barnett and Reid, 1961 and Blackburn, 1965). Stangel, Johnson and Spellman (1963) compiled a large number of abstracts and titles of research papers dealing with the use of urea and other

non-protein nitrogen compounds in ruminant rations. Information concerning these sources can be obtained from these reviews.

III. UREA VS. NATURAL PROTEIN

Harris et al. (1943) reported that the average apparent digestion coefficient of urea nitrogen was 74 and that of soybean meal was 78 while the true digestibility averaged 94 for both sources of nitrogen.

Haskings et al. (1967), in a study using 80 steers to compare the effects of urea vs. soybean meal, found that the performance of steers fed rations containing urea was comparable to steers fed soybean meal.

Hammack and Marion (1970) conducted a trial to compare castor meal, starea, cottonseed meal and urea as a source of supplemental protein. During the first half of the study, cattle receiving castor meal made the highest gains and most efficient dry matter conversion. However, dry matter consumption was lowest in the castor meal groups. Animals fed the other three protein supplements compared closely in daily gain and conversion throughout the test.

Raleigh and Wallace (1963) used urea in amounts to provide one half and all the nitrogen supplementation in 6, 9 and 12 percent protein rations to compare with an all cottonseed meal supplement in a wintering ration for steer calves fed a low quality native meadow hay. The results showed that source of protein had no significant effect on feed intake, feed efficiency or gains when comparing all levels of protein. However, at the 9 and 12 percent protein levels, daily gains were significantly greater for the cottonseed meal diets.

Anderson et al. (1959) conducted digestion and nitrogen metabolism trials to compare uramite, a urea formaldehyde condensation compound, crude biuret, biuret, purified soybean protein and creatine with urea or sources of nitrogen for lambs. Nutrient digestibility was greater when purified soybean protein or a nitrogen equivalent mixture of urea and creatine replaced urea as a source of supplemental nitrogen.

Baker (1944) studied the response of beef heifers to various protein supplements. The basal diet consisted of corn silage, corn grain and mineral supplements. In addition to 29.17 lbs. of corn silage, the four rations consisted of 1.97 lbs. of corn plus 0.99 lbs. soybean meal, 1.65 lbs. corn plus 1.32 lbs. wheat distillers dried grains with solubles, 0.99 lbs. corn plus 1.97 lbs. wheat distillers dried grain with solubles and 2.85 lbs. corn and 0.11 lbs. urea. Urea nitrogen was inferior to that of soybean meal and was equivalent to that of wheat distillers dried grain for wintering beef calves.

Bartellt and Cotton (1938) reported that animals receiving the same quantity of additional nitrogen in the form of natural proteins showed slightly better live weight gains than those receiving urea. Although the difference was not significant, it seemed probable that the natural protein was a more efficient nitrogen supplement than urea.

Freitag, Smith and Beeson (1968) conducted two trials in which soybean meal and urea were compared as sources of protein. In the first trial, urea supplied 30 and 70 percent of total nitrogen in the control and test diets. The diets were calculated for a 10 percent crude protein level. In trial two, two nitrogen sources (soybean meal and urea plus corn) and two levels of protein were used. Only free plasma amino acids

were affected by the substitution of urea for soybean meal in trial one. In trial two, average daily gain, free plasma amino acids, ruminal ammonia, ruminal volatile fatty acids and plasma urea nitrogen were all affected by substituting urea for soybean meal in the diet.

O'Donovan (1967) reported cottonseed meal to be superior to urea when urea was used to make up one half of the supplementary nitrogen in roughage-based diets for cattle. The difference, however, was not statistically significant.

Williams, Whiteman and Tillman (1969) made a study with urea and cottonseed meal as a protein supplement, using 190 pregnant lactating grade Angus cows. These cows were allowed to graze dead range grasses during the winter seasons. One half of the cattle were fed a 21 percent crude protein equivalent supplement containing 4.0 percent urea; the remaining were fed cottonseed meal at a level isonitrogenous with the urea. Cows fed the urea-containing supplement lost more weight than those fed cottonseed meal. Birth and weaning weights of the calves were not affected significantly by treatment, but trends apparently favored those fed cottonseed meal.

Nelson and Waller (1962) summarized 16 experiments involving 879 cows under winter range conditions in Oklahoma and found that urea-containing supplements were always inferior to isonitrogenous ones containing cottonseed meal as the supplemental nitrogen source.

Perry, Beeson and Mohler (1967) compared high levels of urea in beef cattle supplements with a standard protein supplement. They concluded that properly formulated high urea supplements could replace at least 90 percent of natural protein of supplements for high-energy

fattening rations for beef cattle. However, in growing type rations, which consisted primarily of roughage materials, the higher urea supplements were not as satisfactory as those containing a preponderance of natural proteins.

Barth, McConnell and Wang (1968), in comparing urea with cottonseed meal in digestion and metabolism experiments, found that the total digestible nutrient values were higher in the urea ration, but that nitrogen utilization was approximately the same when a high-concentrate ration was fed. When a high-silage ration was fed, the steers fed high-urea rations retained less of the absorbed nitrogen than those fed cottonseed-meal rations.

Bell, Odom and Reynolds (1957) found that cattle fed a fattening ration supplemented with cottonseed meal gained 0.29 lbs. more per day than cattle fed an identical ration but supplemented with urea.

IV. INITIAL FAT

Corrick and Hobbs (1969), in a study comparing the feedlot performance of Light and Medium heifers, found significant differences in carcass characteristics ($P < .05$) in favor of the heavier cattle except for dressing percent and ribeye area. There was no significant difference for overall average daily gain. The higher group had a somewhat better overall economy of gain, but the heavier group returned more money per head.

Corrick and Hobbs (1970), in comparing the feedlot performance of Good and Medium grade heifers, found that the average gains and economy of gain were about equal. The Good heifers returned more money

per head. However, the financial returns from the Medium grade heifers were considered comparable to those from the Good grade heifers.

Anderson, High and Chapman (1964) found from a three-year study involving 149 heifers and 120 steers of Choice, Good and Medium feeder grades, that there were no significant ($P > .05$) differences in average daily gain of the steers regardless of grade or initial weight. Good grade heifers had significantly ($P < .01$) higher average daily gains than Medium grade heifers.

McLaren, High and Hobbs (1971) conducted feeding trials comparing the performance of nine different weights and grades of Hereford feeder steers and heifers. Within each weight and sex group, the Good and Medium grade cattle gained at a similar rate, and the Choice grade cattle gained at a slightly slower rate. Return per head over feed and initial cost were highest for Medium grade cattle and lowest for Choice cattle.

Backus et al. (1967) studied minimum fatness for beef production. Eighty-four weanling Hereford steers were used in a two-year study of the effects of three predetermined subcutaneous fat thickness levels upon the production efficiency and organoleptic properties of beef. The steers in trial one had a greater initial subcutaneous fat thickness, made slower daily gains and had higher costs of gain. Gains made by trial two steers had a more favorable lean to fat ratio than those in trial one. Cattle fed to 3 to 5 mm. of fat thickness produced beef with eating quality comparable to that from fatter cattle, and feed costs per kg. gain were lower. However, cattle with greater fat thickness produced higher value beef, resulting in greater profit to the producer.

Harrell (1971) reported that Medium grade heifers were superior to Choice in average daily gain, but no difference in average daily gain of Good and Choice, and Medium and Good heifers were found. Initial fat thickness did not affect average daily gain, but did significantly ($P < .05$) affect yield grade and percent retail yield.

Minish et al. (1967) conducted a study using 128 Choice and Standard grade steers fed four levels of concentrate plus a full-feed of corn silage. The Standard grade steers had a significantly ($P < .05$) higher average daily gain than did the Choice grade steers.

V. ULTRASONIC MEASUREMENTS

Ultrasonics appear to have potential for a nondestructive and accurate method for determining muscle and adipose tissue development in the live animal (Stouffer et al., 1961 and Hedrick et al., 1962).

Backus (1968) found that ultrasonic readings taken on consecutive dates were highly related. Readings taken near the end of the trial were progressively higher in their relationship to carcass fat thickness. The last ultrasonic measurement of fat thickness taken in trial one in a two year study was highly significant in its relationship to actual fat thickness ($r = 0.88$). The correlation coefficient between the ultrasonic estimate of fatness made on the day prior to slaughter and actual carcass fat thickness in trial two was 0.84.

Walkins, Sherritt and Ziegler (1967) found highly significant ($P < .01$) over-all correlation coefficients of 0.90 and 0.56 between the estimated and actual values for subcutaneous fat thickness and longissimus dorsi muscle area, respectively.

Ramsey et al. (1965) used 25 beef animals of varying breeding, age and weight to determine effect of slaughter and chilling treatments on muscle and fat configuration. Ultrasonic estimates were highly associated with the actual values for fat thickness (r = 0.9), longissimus dorsi area (r = 0.9) and biceps femoris area (r = 0.9).

Temple, Ramsey and Patterson (1965) reported errors in ultrasonic evaluation of live cattle. Decreased accuracy in predicting lean and fat were found to be due to: (1) animal variation, (2) tissue change during slaughter, (3) interpretation and (4) machine manipulation.

Stouffer et al. (1961) developed an ultrasonic technique for producing cross sectional outline of the longissimus dorsi muscle and associated fat layers at the thirteenth ribs of live cattle and hogs. A comparison of ultrasonic estimates of longissimus dorsi area with actual areas gave significant but low associations. Problems of measurements in this study were positioned variation of longissimus dorsi area and fat thickness between the twelfth and thirteenth ribs, changes in shape and size of the muscle due to slaughtering and hanging, and variability in pressure of the transducer on the hide during ultrasonic measuring.

CHAPTER III

EXPERIMENTAL PROCEDURE

Data for this study were collected between November 4, 1971, and July 12, 1972, from an experiment conducted at the University of Tennessee's Blount Farm, Knoxville, Tennessee.

I. EXPERIMENTAL ANIMALS

One hundred and eighty feeder heifers, ranging in weight from 320 to 385 lbs., were purchased through graded feeder calf sales in East Tennessee and used in this experiment. One hundred and seventy-seven heifers completed the experiment; three were removed due to illness. The breeds represented were 150 Hereford and 30 Angus.

II. MANAGEMENT AND FEEDING

A short period was allowed before going on test for the heifers to adjust to the environment and recover from the stress of weaning and sale. After the adjustment period, the heifers were weighed, graded for condition and type, sonorayed for fat thickness and implanted with 24 mg. of diethystilbestrol. Heifers were allotted according to initial fat thickness of 1 to 2, 3 and 4 mm. plus. Five Herefords and one Angus were randomly assigned by their fat thickness to each of the 30 pens.

The feedlot period consisted of two phases: (1) a 140-day roughage phase during which the heifers were fed corn silage ad libitum

plus 6.0 lbs. of concentrate per head per day and (2) a full-fed phase in which the heifers were given a full feed of concentrate of corn-cottonseed meal in an 8 to 1 ratio plus 4.0 lbs. of hay per head per day.

During the roughage phase two pens of each designated fat thickness were allotted to one of five treatments to provide a specific amount of crude protein per head per day. These rations were as follows during the 140-day roughage phase:

1. Ration 1 consisted of urea-limestone treated corn silage ad libitum plus 6.0 lbs. corn per head per day (crude protein of 1.7 to 1.8 lbs. per head per day).

2. Ration 2 consisted of urea-limestone treated corn silage ad libitum plus 5.4 lbs. of corn and 0.6 lbs. of cottonseed meal per head per day (crude protein of 1.9 to 2.0 lbs. per head per day).

3. Ration 3 consisted of urea-limestone treated corn silage ad libitum plus 5.9 lbs. of corn and 0.1 lbs. of urea per head per day (crude protein of 1.9 to 2.0 lbs. per head per day).

4. Ration 4 consisted of urea-limestone treated corn silage ad libitum plus 4.75 lbs. of corn and 1.25 lbs. of cottonseed meal per head per day (crude protein of 2.1 to 2.2 lbs. per head per day).

5. Ration 5 consisted of urea-limestone treated corn silage ad libitum plus 5.8 lbs. of corn and 0.2 lbs. of urea per head per day (crude protein of 2.1 to 2.2 lbs. per head per day).

One pen of each fat thickness on each ration was designated to be removed from test and slaughtered when the heifers obtained 8 mm.

of fat as estimated by ultrasonic measurements; the second pen was slaughtered when the heifers reached 10 mm. of fat.

The cattle were fed twice daily and feed weights were recorded at each feeding.

III. COLLECTION OF DATA

During the first 28 days on test the heifers were weighed and sonorayed at 14-day intervals and then at 28-day intervals until the end of the 140-day roughage phase.

At the end of 140 days those that had reached their designated fat thickness (10 or 8 mm.) were removed from test and sent to slaughter. After the animals went on the fullfeed phase they were weighed and sonorayed at 14-day intervals, and when an animal reached its designated fat thickness it was removed from test and slaughtered.

Packer's weights and hot carcass weights were obtained to calculate dressing percent.

After a 48-hour chilling period, United States Department of Agriculture (USDA) grades, maturity scores, kidney fat, conformation and marbling scores were assigned each carcass by a USDA meat grader. ribeye area and fat thickness over the twelfth rib were determined following the procedures outlined by the American Meat Science Association (Schoonover et al., 1967).

Yield grades on percent retail yield were also calculated using the procedures outline by Murphey et al. (1960). The yield grade equation he used was: Yield grade = 2.5 + 2.5 x carcass fat (ins.) - 0.462 x kidney fat - 0.0093 x hot carcass weight - 0.32 x ribeye area.

IV. STATISTICAL ANALYSIS

These data were analyzed by the method of least squares outlined by Harvey (1968). Unless otherwise stated, testing was at the conventional 5 percent level probability of chance occurrence ($P > .05$). When range testing was required, Duncan's Multiple Range Test, as outlined by Steele and Torrie (1961) was used.

The analysis was based on the following model:

$$Y_{ijk} = \mu + t_j + f_k + (yf)_{jk} + e_{ijkl}$$

where, Y_{ijk} = the observed value of given performance trait,

μ = the mean.

t_j = the effect of the jth protein level,

f_k = the effect of the kth initial fat classification,

$(yf)_{jk}$ = the interaction between protein levels and the initial fat classification,

e_{ijkl} = the random error associated with the $ijkl^{th}$ individual.

CHAPTER IV

RESULTS AND DISCUSSION

This study involved 177 heifers, purchased from feeder-calf sales in East Tennessee, which ranged from 320 to 585 lbs. Initial fat thickness was from 1.0 to 7.5 mm. and condition scores were from 5.0 to 12.0. The overall means and standard deviations for selected variables are illustrated in Table I.

I. FEEDLOT PERFORMANCE

Average Total Gains

The total gains per head for both the roughage and overall period for heifers are shown in Table II. The average total gains during both periods were not significantly affected by either the level of protein or the source of supplemental protein (Tables III and IV).

Average Daily Gain

The average daily gain for both roughage and overall periods is shown in Table II. Although the heifers which received the 2.1 to 2.2 lbs. of supplemental crude protein per head per day, using cotton-seed meal as an additional supplemental protein source, had a slightly higher average daily gain, no significant differences were found in average daily gain due to source or level of protein (Tables III and IV).

Average Fat Thickness

The average fat thickness measured at the onset of the test, at the end of the roughage phase and at the end of test for the heifers

TABLE I

OVERALL MEANS AND STANDARD DEVIATIONS FOR SELECTED VARIABLES

Variable	Mean	Standard Deviation
Number of animals	177	
Initial observations		
Weight, lbs.	472.59	±51.04
Fat thickness, mm.	3.05	± 1.29
Condition	8.19	± 1.36
Performance measurements		
Avg. daily gain, roughage lb.	1.89	± 0.31
Avg. daily gain, overall lb.	1.77	± 0.28
Roughage weight, lb.	738.02	±67.30
Final weight, lb.	389.15	±61.23
Roughage fat thickness, mm.	6.58	± 2.15
Final fat thickness, mm.	9.71	± 1.46
Roughage condition[a]	9.72	± 1.39
Final condition[a]	11.31	± 1.06
Days on feed	182.83	±33.16
Carcass characteristics		
USDA grade	10.91	± 1.39
Carcass fat, mm.	11.06	± 2.40
Dressing percent	59.51	± 2.34
Marbling score	4.34	± 1.33
Ribeye area, sq. in.	10.19	± 1.26
Yield grade	2.42	± 0.43
Percent retail yield	50.35	± 1.37

[a]Condition scores: 9 = low good, 10 = average good, 11 = high good and 12 = low choice.

TABLE II

FEEDLOT PERFORMANCE OF FEEDER HEIFERS FED THREE LEVELS OF PROTEIN USING TWO SOURCES OF ADDITIONAL PROTEIN SUPPLEMENTATION[a]

	Pounds of Crude Protein Consumer Per Head Per Day				
	1.7 - 1.8	1.9 - 2.0		2.1 - 2.2	
Ration	1	2	3	4	5
Source of supplemental protein	---	CSM	Urea	CSM	Urea
Weight, lb.					
Initial	477	471	469	471	473
End of roughage	747	734	738	742	729
Final	794	781	791	800	791
Fat thickness					
Initial	3.2	3.1	3.1	2.9	3.0
End of roughage	6.6	7.1	6.7	6.3	6.1
Final	9.8	9.6	9.7	10.0	9.5
Condition score[b]					
Initial	8.3	8.3	8.1	8.2	7.9
End of roughage	9.4	10.0	9.8	9.8	9.3
Final	11.6	11.0	11.5	11.5	11.3
Gain					
End of roughage	270.0	261.0	269.0	271.0	256.0
Final	317.4	307.9	322.0	329.6	317.2
Average daily gain					
End of roughage	1.93	1.86	1.92	1.94	1.84
Final	1.71	1.75	1.77	1.80	1.66

[a]In addition to the supplemental protein provided in the concentrate, the heifers were fed corn silage free choice which had been treated with 10 lbs. of urea per ton during ensiling.

[b]Condition scores: 7 = average medium, 8 = high medium, 9 = low good, 10 = average good, 11 = high good and 12 = low choice.

TABLE III

ANALYSIS OF VARIANCE FOR THE EFFECTS OF RATION AND INITIAL SUBCUTANEOUS FAT ON FEEDLOT PERFORMANCE OF FEEDER HEIFERS DURING ROUGHAGE PHASE

		Means Square				
		Roughage Traits				
Source	d.f.	Wt.	F.T.	Cond.	Gain	ADG
Ration	4	1599.76	1.63	1.79	1382.64	2.70
Int. F.T.	2	7601.04	90.80**	3.32	9570.41**	0.49**
Tmt. X F.T.	8	1515.38	7.10*	1.49	1246.36	0.71
Residual	162	4708.86	3.45	1.95	1831.93	0.10

*P < .05.

**P < .001.

TABLE IV

ANALYSIS OF VARIANCE FOR THE EFFECTS OF RATION AND INITIAL SUBCUTANEOUS FAT ON OVERALL FEEDLOT PERFORMANCE OF FEEDER HEIFERS

	Means Square					
	Final Traits					
Source	Wt.	F.T.	Cond.	Gain	ADG	Days on test
Ration	1123.43	1.38	1.39	1644.71	0.06	1019.89
Int. F.T.	15611.13*	0.50	0.90	72331.59	0.05**	17900.06**
Tmt. X F.T.	2651.76	1.74	1.78	3070.88	0.04	1253.21
Residual	3721.89	2.20	1.09	2482.43	0.08	886.54

*P < .05.

**P < .001.

allotted to the different rations are shown in Table II, page 20. The fat thickness was not significantly affected by any level or source of protein tested (Table III, page 21).

Average Condition Scores

The condition scores made at the onset, at the end of the roughage phase and at the completion of the test were not significantly affected by the level of protein or the source of supplemental crude protein (Tables III and IV). The average condition scores for each ration are illustrated in Table II, page 20.

Days on Test and Feed Consumption

Although no significant differences were found between days on test for any ration (Table IV), there was a trend for animals which received CSM as a supplemental protein source to require fewer days to reach the same condition as those which received urea. The average total days on test for each ration are shown in Table V.

Dry matter per hundred pound gain and average dry matter consumed per head per day for each ration are shown in Table V. Animals which received the urea as a source of supplemental protein tended to consume less feed than animals on other rations during the roughage phase. However, there was no significant difference in dry matter consumption during the roughage phase (Table VI).

There was a significant difference ($P < .05$) between average dry matter consumed per head per day between animals on Ration 4 and animals on Ration 1, 2 and 3 for total dry matter consumed per head per day (Tables V and VII). The possible reason for a higher dry matter

TABLE V

DAYS ON TEST AND DRY MATTER CONSUMPTION OF FEEDER HEIFERS FED THREE LEVELS OF CRUDE PROTEIN USING TWO SOURCES OF ADDITIONAL SUPPLEMENTATION[1]

	Pounds of Crude Protein Consumed Per Head Per Day				
	1.7 - 1.8	1.9 - 2.0		2.1 - 2.2	
Ration	1	2	3	4	5
Source of supplemental protein	---	CSM	Urea	CSM	Urea
Avg. animal days					
Roughage	140	140	140	140	140
Fullfeed	45.3	39.5	42.2	42.2	50.4
Overall	185.3	175.6	181.1	182.2	190.3
Avg. dry matter consumer per cwt. gain					
Roughage	628.2	662.5	605.1	651.6	640.4
Fullfeed	1340.5	936.3	1130.4	866.3	772.3
Overall	750.5	702.6	714.6	686.1	776.9
Avg. dry matter consumer per head per day					
Roughage	12.11	12.32	11.85	12.52	11.72
Fullfeed	14.25	12.39	14.88	14.81	14.53
Overall	12.59[a]	12.34[a]	12.45[a]	13.14[b]	12.78[ab]

[1]In addition to the supplemental protein provided in the concentrate, the heifers were fed corn silage free choice which had been treated with 10 lbs. of urea per ton during ensiling.

[a,b]Means on the same line bearing different superscript letters differ significantly ($P < .05$).

TABLE VI

ANALYSIS OF VARIANCE FOR DRY MATTER CONSUMPTION AND ECONOMY OF GAIN DURING THE ROUGHAGE PHASE

Source	d.f.	Means Square		
		DM/head/ day, lbs.	DM/wt. gain	Feed cost/ cwt. gain
Ration	4	0.3350	402.6106	2.6725*
Int. F.T.	2	0.4759	16683.5848	5.4500**
Ration X F.T.	8	0.2175	1901.6009	0.9783
Residual	15	0.2267	8445.5848	1.0420

*P < .05.

**P < .01.

TABLE VII

ANALYSIS OF VARIANCE FOR OVERALL AVERAGE DRY MATTER CONSUMPTION, ECONOMY OF GAIN AND AVERAGE RETURN PER HEAD ABOVE INITIAL AND FEED COST

Source	d.f.	Means Square			
		DM/head/ day, lbs.	DM/cwt. gain	Feed Cost cwt. gain	Avg. Return
Ration	4	0.3800*	845.3050	2.9575	21.7207
Int. F.T.	2	0.1050	1502.6850	3.7950	456.1490**
Ration X F.T.	8	0.1675	1187.3388	2.3550	45.0055
Residual	15	0.1247	2685.7347	2.7980	58.3960

*P < .05.

**P < .001.

consumption with Ration 4 and 5 is that Ration 5 had more animal days on full feed than animals on Ration 1, 2, 3 or 4. Animals on Ration 4 received the high level of CSM supplement during the total roughage phase.

Financial Returns

The financial returns for the animals of the five rations are shown in Table VIII. There was no significant difference due to ration for return per head above initial and feed cost (Table VII). Ration 1, which received no additional supplementation, produced comparable returns to rations which received additional protein supplementation. The only differences observed were the lower returns for the urea supplemented ration which contained 2.1 to 2.2 lbs. of crude protein. This may be explained by the lower performance of the heifers which was not enough to offset the additional feed cost of Treatment 5.

II. CARCASS CHARACTERISTICS

USDA Quality Grade

Average USDA quality grades for animals on each ration are shown in Table IX. Quality grades were not significantly affected by level or source of crude protein (Table X).

Carcass Fat

Average carcass fat thickness for animals on each ration is in Table IX. As shown in Table IX, those rations which contained urea produced carcasses with slightly less fat than the other three rations. Carcass fat thickness was not significantly affected by either supplemental protein level or source of crude protein.

TABLE VIII

FINANCIAL RETURNS FOR FEEDER HEIFERS FED THREE DIFFERENT CRUDE PROTEIN LEVELS FROM TWO SOURCES OF ADDITIONAL SUPPLEMENTATION[a]

	Pounds of Protein Consumed Per Head Per Day				
	1.7 - 1.8	1.9 - 2.0		2.1 - 2.2	
Ration	1	2	3	4	5
Source of supplemental protein	---	CSM	Urea	CSM	Urea
Number of animals	35	36	35	36	35
Avg. purchase price per cwt., $	31.61	31.61	31.61	31.61	31.61
Avg. purchase price per head, $	150.78	148.88	148.25	148.88	149.52
Avg. selling price per cwt., $	33.10	32.99	32.98	33.39	33.07
Avg. selling price per head, $	262.81	257.65	260.87	267.12	261.58
Avg. feed cost per cwt., $	17.01	16.39	16.34	17.31	17.76
Avg. feed cost per head, $	54.00	50.46	52.62	57.06	56.35
Avg. return per head over initial and feed cost, $	58.03	58.31	60.00	61.18	55.71

[a]In addition to the supplemental protein provided in the concentrate, the heifers were fed corn silage free choice which had been treated with 10 lbs. of urea per ton during ensiling.

TABLE IX

CARCASS CHARACTERISTICS OF FEEDER HEIFERS FED THREE LEVELS OF PROTEIN USING TWO SOURCES OF ADDITIONAL SUPPLEMENTATION[a]

	Pounds of Crude Protein Consumed Per Head Per Day				
	1.7 - 1.8	1.9 - 2.0		2.1 - 2.2	
Ration	1	2	3	4	5
Source of supplemental protein	---	CSM	Urea	CSM	Urea
USDA grade	11.03	11.06	10.77	10.69	11.00
Carcass fat, mm.	11.11	11.33	10.66	11.31	10.87
Dressing percent	59.35	59.06	59.33	60.25	59.51
Marbling score	4.29	4.50	4.34	3.96	4.63
Ribeye area	9.93	10.57	10.01	10.36	10.11
Percent retail yield	50.12	50.60	50.20	50.33	50.33
Yield grade	2.47	2.32	2.44	2.38	2.43

[a]In addition to the supplemental protein provided in the concentrate, the heifers were fed corn silage free choice which had been treated with 10 lbs. of urea per ton during ensiling.

TABLE X

ANALYSIS OF VARIANCE FOR THE EFFECTS OF RATION AND INITIAL SUBCUTANEOUS FAT ON CARCASS TRAITS

		Means Square				
Source	d.f.	USDA Quality Grade	Carcass Fat	Dressing Percent	Marbling Score	Ribeye Area Sq. In.
Ration	4	0.9712	2.8048	6.6698	2.2189	2.3818
Int. F.T.	2	2.1648	42.5019*	9.0628	2.0602	0.9755
Ration X F.T.	8	0.5029	1.0854	3.0399	0.6506	1.2487
Residual	155	2.0279	5.6273	5.5024	1.8230	1.5919

*P < .001.

Dressing Percent

The dressing percents were all very similar, with no significant differences between any ration (Table X). Table IX, page 29, shows the average dressing percent for animals allotted to the various rations.

Marbling Scores

The average marbling scores for animals allotted to each ration are presented in Table IX. The marbling scores were not significantly affected (Table X).

Ribeye Area

No significant differences were found in ribeye due to rations (Table X). Table IX shows the average ribeye area for each ration.

Yield Grade and Percent Retail Yield

The averages for yield grade and cutability for animals on each ration are given in Table IX. No significant differences were found between any rations for yield grade or percent retail yield (Table XI).

TABLE XI

ANALYSIS OF VARIANCE FOR THE EFFECTS OF RATION[a] AND INITIAL SUBCUTANEOUS FAT ON YIELD GRADE AND PERCENT RETAIL YIELD

Source	d.f.	Means Square	
		Yield Grade	Percent Retail Yield
Ration	4	0.0385	1.3538
Int. F.T.	2	0.9500*	2.4700
Ration X F.T.	8	0.1424	1.3836
Residual	155	0.1846	1.9379

[a]In addition to the supplemental protein provided in the concentrate, the heifers were fed corn silage free choice which had been treated with 10 lbs. of urea per ton during ensiling.

*P < .01.

CHAPTER V

SUMMARY AND CONCLUSIONS

The purpose of this experiment was to test the effects on performance, economy of gain and carcass quality of slaughter heifers when grown and finished on urea-limestone treated corn-silage rations in which the daily crude protein intake per head was 1.7 to 1.8, 1.9 to 2.0 and 2.1 to 2.2 lbs. and to test for any difference between cottonseed meal and urea as an additional supplemental source.

In addition to corn silage ad libitum each animal received 6 lbs. of concentrate per day during the 140-day roughage phase to provide three different levels of protein. Ration 1 consisted of only corn and provided 1.7 to 1.8 lbs. of crude protein per head per day. Rations 2 and 4 consisted of corn plus cottonseed meal and provided 1.9 to 2.0 and 2.1 to 2.2 lbs. of crude protein per head per day, respectively. Rations 3 and 5 consisted of corn plus urea and provided 1.9 to 2.0 and 2.1 to 2.2 lbs. of crude protein per head per day, respectively. After 140 days the heifers were full-fed a concentrate ration of eight parts ground shelled corn to one part cottonseed meal, and finished to a designated ultrasonically measured fat thickness of 10 or 8 mm.

Results showed that neither feedlot performance nor carcass characteristics were significantly affected by the levels or sources of protein fed. It was concluded that 1.7 to 1.8 lbs. of crude protein per head per day was as effective in growing and fattening feeder heifers

as either of the higher levels of protein. The rations containing the cottonseed meal tended to produce slightly improved feedlot performance over those which contained additional urea. No significant differences were found in the feedlot performance or carcass characteristics of heifers allotted to either cottonseed meal or urea supplementation. Feedlot performance and carcass characteristics of the heifers were not significantly affected by either level or source of crude protein supplementation.

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LITERATURE CITED

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APPENDIX

TABLE XII

LEAST SQUARE MEANS OF FEEDLOT PERFORMANCE OF FEEDER HEIFERS FED THREE LEVELS OF PROTEIN USING TWO SOURCES OF ADDITIONAL SUPPLEMENTATION[a]

	Pounds of Crude Protein Consumer Per Head Per Day				
	1.7 - 1.8	1.9 - 2.0		2.1 - 2.2	
Ration	1	2	3	4	5
Source of supplemental protein	---	CSM	Urea	CSM	Urea
Number of animals	35	36	35	36	35
Avg. weight					
Initial	476.63	472.64	469.57	470.81	473.62
End of roughage	746.84	733.75	738.61	741.67	729.51
Final	794.97	780.56	788.99	787.78	793.23
Avg. fat thickness					
Initial	3.22	3.11	3.05	2.92	2.96
End of roughage	6.57	7.08	6.77	6.33	6.17
Final	9.76	9.55	9.66	10.03	9.55
Avg. condition					
Initial	8.37	8.33	8.06	8.19	8.01
End of roughage	9.37	9.97	9.81	9.81	9.67
Final	9.76	11.00	11.46	11.50	11.28
Avg. gain					
End of roughage	270.21	263.89	269.04	270.86	255.88
End of fullfeed	73.72	69.03	86.92	63.81	72.44
Final	317.92	308.19	320.93	326.83	319.61
Avg. ADG					
End of roughage	1.92	1.87	1.92	1.93	1.83
End of fullfeed	0.97	1.41	1.31	1.43	1.31
Final	1.76	1.78	1.80	1.82	1.71

[a]In addition to the supplemental protein provided in the concentrate, the heifers were fed corn silage free choice which had been treated with 10 lbs. of urea per ton during ensiling.

TABLE XIII

LEAST SQUARE MEANS OF CARCASS TRAITS FOR FEEDLOT PERFORMANCE OF FEEDER HEIFERS FED THREE LEVELS OF PROTEIN USING TWO SOURCES OF ADDITIONAL SUPPLEMENTATION[a]

	Pounds of Crude Protein Consumed Per Head Per Day				
	1.7 - 1.8	1.9 - 2.0		2.1 - 2.2	
Ration	1	2	3	4	5
Source of supplemental protein	---	CSM	Urea	CSM	Urea
USDA grade	11.03	11.06	10.77	10.68	11.00
Carcass fat, mm.	11.08	11.33	10.68	11.33	10.86
Dressing percent	59.35	59.06	59.34	60.23	59.51
Marbling score	4.29	4.50	4.35	3.96	4.64
Ribeye area	9.93	10.57	10.00	10.35	10.11
Percent retail yield	50.11	50.52	50.16	50.52	50.23
Yield grade	2.46	2.37	2.43	2.41	2.40

[a]In addition to the supplemental protein provided in the concentrate, the heifers were fed corn silage free choice which had been treated with 10 lbs. of urea per ton during ensiling.

TABLE XIV

FEED COST

	Price Per Pound	
	Roughage Phase	Fullfeed Phase
10-10 urea-limestone treated corn silage	$ .00422	$ .00422
Ground shelled corn	.02424	.02524
Cottonseed meal	.04470	.04600
Feed grade urea	.03730	-----
Alfalfa hay	-----	.02710

VITA

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