December 9, 1969

To the Graduate Council:

I am submitting herewith a thesis written by Kadhim Abdul Ruhman Khalil entitled "Performance of Feeder Heifers Fed Corn Silages Treated with 10, 15 and 20 Pounds of Urea Per Ton." I recommend that it be accepted for nine quarter hours of credit in partial fulfillment of the requirements for the degree Master of Science, with a major in Animal Husbandry.

James A. Couch, Jr.
Major Professor

We have read this thesis and
recommend its acceptance:

Charles S. Hoff

C. O. Chamberlain

Accepted for the Council:

Sutton A. Smith
Vice Chancellor for
Graduate Studies and Research

PERFORMANCE OF FEEDER HEIFERS FED CORN SILAGES TREATED WITH 10, 15 AND 20 POUNDS OF UREA PER TON

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

Kadhim Abdul Ruhman Khalil

December 1969

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ABSTRACT

The purpose of this experiment was to determine if the amount of urea could be increased above 10 pounds per ton of corn silage without adversely affecting the acceptability of the silage or the feedlot performance of feeder heifers.

One hundred and eight feeder heifers with an average weight of 450-500 pounds were involved in a two-year experiment conducted at the University of Tennessee's Blount Farm, Knoxville. Three treatments with 10, 15 and 20 pounds per ton of urea treated corn silage were used in this two-year study.

In both trials, there were three replications (pens) per treatment with six feeder heifers per pen. At the beginning of both trials, 24 mg. of diethylstilbestrol was implanted per head.

The results showed that all three levels of urea were equally acceptable, and that feedlot performance and carcass characteristics were not significantly ($P > .05$) affected, either positively or negatively, by the addition of 10, 15 or 20 pounds of urea per ton of corn silage. Therefore, it was concluded that, when desirable, up to 20 pounds of urea could be added per ton of corn silage without adverse effects.

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CHAPTER I

INTRODUCTION

Corn silage has been recognized as an excellent beef cattle feed for many years. Besides the stalks and leaves, the 30 to 35 percent dry matter content of typical corn silage contains up to 40 percent corn grain. Thus, it is not surprising that silage has come to be recognized as a basic forage-concentrate feed for beef cattle in many parts of the United States.

The addition of urea to corn silage at the time of ensiling is a convenient, safe and economical method of increasing the crude protein equivalent of this important beef cattle feed. Further, the addition of ground limestone tends to have a favorable effect upon fermentation in the silo and increases the feeding value of the silage.

Urea, a good source of non-protein nitrogen (NPN), has been used for a number of years as a protein extender for replacing the more expensive organic supplement such as cottonseed meal or soybean meal. In experiments at the University of Tennessee's Blount Farm, Knoxville, the addition of urea-limestone (10 pounds each) per ton of corn silage eliminated the need for protein supplementation and resulted in marked savings in feed costs of feeding slaughter heifers.

The objective of these experiments was to see if the amount of urea could be increased above the 10 pounds per ton of silage without adversely affecting the acceptability of the silage or the feedlot performance of the animals.

CHAPTER II

REVIEW OF LITERATURE

I. CORN SILAGE

Corn silage in the ration of beef cattle is receiving much attention from researchers. Cattle feeders have also become increasingly aware of the excellent forage characteristics of corn silage and its value in the ruminant ration. From 1947 to 1967, the corn acreage in the United States utilized for the production of silage nearly doubled; the tons of corn silage produced nearly trippled. In the Southeast area where corn is well adapted, its use as whole plant silage results in a total energy yield unsurpassed by any other crop. Perennial forages commonly harvested as hay or hay crop silage decline in digestibility with advancing maturity, and cows voluntarily consume less dry matter from them (Stone et al., 1960). Contrary to previously cited evidence, Perry (1968) noted that maturity did not have much effect on acceptance by animals. However, Geasler et al. (1967) found consumption of the later-harvested silage (mid-November) to be greater. Chamberlain et al. (1968) and Huber et al. (1967) showed that animals fed silage harvested in the late dent stage has lower dry matter intakes than those fed silages harvested earlier. Conversely, the corn plant harvested for silage over a broad range in maturity exhibits little change in dry matter digestibility (Johnson and McClure, 1968); moreover, an increase in dry matter intake occurs through the range of 25 to 35 percent dry matter (Huber et al., 1965).

The corn plant requires less water than several other commonly grown forages. The amount of water transpired per 2.2 lb. of aboveground dry matter produced has been reported by Peters (1964) as 1887.6 lb for alfalfa, 1397 lb. for oats, 818.4 lb. for corn, and 596.2 lb. for sorghum.

With increasing beef production, limited land resources and greater emphasis on mechanization, the trend toward increased reliance on corn silage forage is expected to continue.

II. THE ADDITION OF UREA TO CORN SILAGE

The addition of urea at ensiling was first reported by Brigle and Windhenser (1931) who studied its effect on the quality of corn silage and sugar beet silage. Early experiments to correct the protein deficiency of corn silage with urea additions had varying degrees of success (Cullison, 1944; Davis et al., 1944; Mitchell et al., 1945; Woodward and Shepherd, 1944). Bentley et al. (1955) showed that high-quality corn silage could be made with urea additions with little loss of nitrogen. Recent work by Klosterman et al. (1964) indicated that urea is more efficiently utilized as a nitrogen source by ruminants when mixed with corn and silage at feeding time. Klosterman et al. (1961) fed corn silage treated by 0.5 percent each of ground limestone (high calcium) and urea to whole plant green-chopped corn at the time of ensiling. The treated corn silage promoted faster gains and greater feed efficiencies than untreated silage.

Hastings (1944) appraised the urease activity of various silages including corn by ensiling them with urea in jars and determining the release of ammonia. At 37°C., ammonia was detected within a few hours, but

at room temperature, it was several days before ammonia was released. Bentley et al.(1956) added urea at the rate of 0.85 to 1.25 percent of the weight of green corn and found that the large part of the urea was hydrolyzed during ensiling. It was suggested that the ammonia released combined with the silage acids to form ammonium salts. Karr et al. (1965) noted that from 28 to 57 percent of the urea added to corn at ensiling was hydrolized.

Johnson et al. (1961) showed that there is a considerable breakdown of plant proteins to non-protein forms during the ensiling process, except at a relatively late stage of maturity. During early states of maturity, more than 50 percent of the nitrogen in untreated whole-plant corn silage was in the non-protein form. Additions of urea and limestone, however, decreased the amount of true protein nitrogen in corn silate harvested at early stages of maturity, but increased the amount of true protein nitrogen at later stages of maturity.

Bentley et al. (1955) ensiled urea-corn silage in upright silos at the maturity level at which seepage was unlikely and reported an apparent urea recover of 94, 112 and 82 percent for 3 years. "The rather high dry matter content of the second year silage might be a source of possible error."

In a recent study by Schmutz (1966), NPN as 0.5, 0.75 percent urea or 1 percent diamonium phosphate was added to corn at ensiling and recovery values were calculated. Based on the crude protein content in the DM of the control silage and the theoretical amount of NPN added, the percentage of NPN crude protein equivalent recovered ranged from 55 to 68. The DM

of the silage was about 28 percent, which suggests that there was some seepage. It was pointed out that these values reflect not only sampling errors, but the possibility that all of the NPN added to the loads of green-chopped corn did not become ensiled.

Stenberg et al. (1968) showed that the differences were non-significant between gain when urea was added to corn silage at ensiling or at feeding time. Henderson et al. (1968) demonstrated that adding 20 pounds per ton at ensiling time was superior to 10 pounds addition. In another experiment Henderson and Purses (1968) found that cattle receiving corn silage treated with 0.5 percent urea at filling time, 1 percent urea at feeding time, 0.5 percent urea at filling and 0.5 percent urea at feeding all equalled or surpassed the performance of cattle receiving silage not treated with urea but supplemented with soybean meal.

III. LEVEL OF UREA ADDED AT TIME OF ENSILING

Early work of Cullison (1944) at Mississippi included the addition to 10 pounds of urea per ton to sweet sorghum which appeared to increase its feeding value for beef cows. Woodward and Shepherd (1944) added a similar amount of urea to corn silage fed dairy cows and obtained favorable results. Davis et al. (1944) in Florida treated sorghum silage with 10, 30 or 50 pounds of urea per ton of silage made in experimental silos. Acceptance tests indicated that the silage with 10 pounds of urea was satisfactory while the 50 pounds per ton of silage was rejected. The 30 pounds level was intermediate in acceptability. Bentley et al. (1955) added urea to corn silage at levels of 17 pounds, 25 pounds and 20 pounds.

The feeding value of urea compared favorably with corn silage and soybean oil meal. The authors recommended 20 pounds per ton of silage for fattening cattle. Henderson and Purser (1968) added 20 pounds per ton of silage. Thus, when all supplemental protein was derived from urea, a calculated 16 percent crude protein ration on a DM basis was superior to a 12 percent crude protein ration. In the experiment they indicated that urea addition to corn silage did not reduce daily consumption of silage or total dry matter below values shown for the no urea-soybean oil meal lot. With the exception of the lot receiving silage treated with 20 pounds of urea at filling time, daily consumption of silage was improved by adding urea at filling time over adding the same quantity of urea at feeding time. In another experiment Henderson and Purser (1968) fed post-frost harvested 43 percent dry matter corn silage treated with 15 pounds of urea added at ensiling in a gas tight silo. Two lots of cattle were fed the same silage stored in an identical gas tight silo but not treated with urea. Both groups of cattle received one pound of 64 percent protein supplement per head daily. Thus, the calculated crude protein content of the total ration on a dry matter basis was 14 percent for the urea treated silage fed group and 12 percent for the groups receiving untreated silage. The results were almost identical for the two groups with exception of a slight improvement in feed efficiency for the urea treated silage fed group. The urea treated silage was equal in palatibility to the control silage and the smell of ammonia was not detected at any time while feeding and handling the urea treated silage. Klosterman et al. (1969) reported that a combination of whole plant corn silage treated with 20 pounds of urea, 10 pounds of

pulverized limestone, and 20 pounds of defluorinated phosphate per ton and approximately a half full-feed of untreated, dry shelled corn made a satisfactory ration for finishing yearling steers and heifers. This ration was not consistently improved by adding additional protein from dehydrated alfalfa meal, soybean meal, or mixed 64 percent protein supplement, all of which increased the cost of the ration. On the other hand, no harmful effects were noted from feeding the high urea supplement along with corn silage which had an added 20 pounds of urea per ton. Newland and Henderson (1965) found that the yearling Hereford heifers receiving silage treated with 10 pounds of urea and limestone gained 8 percent faster (1.99 vs. 1.84 lbs. per day), were more efficient in feed conversion, and made cheaper gains than those on regular corn silage. Also in the same experiments, the use of a urea-containing protein supplement (64 percent) had no significant depressing effect when fed to cattle receiving urea treated corn silage. Klosterman et al. (1965) noted increased efficiency and economy of gain by the addition of limestone, urea, and phosphorus to chopped corn at the time of ensiling. Doubling the normal ear content of silage treated in this manner made it a complete ration.

Most researchers have added urea in the range of 0.5-1.0 percent of the green matter ensiled. Essig (1968) indicated that addition of 0.5-1.0 percent urea to corn material at the time of ensiling increased the dry matter lost. The authors recommended that 0.5 percent urea and 0.5 percent limestone per ton be added to corn material at the time of ensiling. For sweet sorghum material being ensiled, the addition of 0.75 percent urea and 0.5 percent limestone was recommended in order to produce a

silage with a sufficiently high crude protein content.

Based on average figures for crude protein content of well matured corn silage and sweet sorghum silage of 2.3 and 1.6 percent crude protein, respectively (National Research Council, 1958), the addition of 0.5 percent urea would substantially increase the nitrogen content while maintaining acceptability at a level comparable with untreated silage.

IV. EFFECT OF ADDING UREA ON SILAGE QUALITY

Silage quality is generally judged by its acceptability by animals, the pH, lactic and acetic acid concentration, odor and color.

Acceptability by animals. Many studies have demonstrated that silage treated with 0.5 percent urea is readily eaten by animals, and comparable intakes have been recorded when untreated and urea treated silages have been fed ad lib. with other ration components. However, Cullison (1944) showed that cows consumed their urea treated silage in approximately half the time taken by a group receiving the same amount of untreated silage. Wise et al. (1944) demonstrated a reduced dry matter consumption of 15.5 pounds in cattle receiving 0.5 percent urea treated silage compared with 16.9 pounds in those fed untreated silage. Davis et al.(1944) reported complete rejection of silage with additions of higher levels of urea (2.5 percent) until much of the free ammonia had disappeared.

The pH. Adding urea to the corn silage at the time of ensiling would theoretically result in some increase alkalinity of the silage produced. Thomas (1966) indicated that urea acts as a buffer during the ensiling

process and results in formation of higher levels of organic acid. Austin (1967) reported that in urea treated silages pH and ammonia concentration were highly correlated (r = -.66) but not in untreated silages (r = -.39).

Usually the increase in pH has been greater at the higher levels of urea addition. Owens et al. (1967) showed that the addition to corn silage of both limestone and 0.5 percent urea resulted in a higher pH than in untreated silage. Schmutz et al. (1966) studied corn silage of 27 to 29 percent DM ensiled alone, with additions of limestone, urea or diammonium phosphate. The authors indicated a slight increase in pH over control values with single chemical additives; any combination of two or more additives increased the pH more than did a single chemical additive. Langston et al. (1958) reported that most corn silage, after fermentation has been completed, has a pH of about 3.8. The addition of limestone or urea or a combination of urea and limestone increased the pH to 4.0-5.1, depending on the quantity of neutralizing material added.

Lactic and acetic acid concentration. Several researchers have reported varying effects of the addition of urea on the lactic acid contents of corn silage. Klosterman et al. (1963), Schmutz (1966), Austin (1967) and Essig (1968) indicated an increase in the lactic acid content from corn silage treated by urea and limestone compared with untreated silage.

In most reports an increase in acetic acid concentration was recorded following the addition of urea. Johnson et al. (1967) studied the effects on silage ensiled with and without urea and limestone additions (0.5 percent each) on seven stages of maturity from blister to post-frost stage (20 to 55 percent DM). Material harvested at the glaze stage was

ensiled with various combinations of urea, limestone, and diammonium phosphate (DAP). Lactic and acetic acid production was highest at the early stages of maturity and decreased with maturity. The research demonstrated that acid production was increased appreciably by limestone-urea treatments but only slightly by DAP treatments. Huber et al. (1967a) fed lactating cows corn silage containing 0.0 (I), 0.5 (II) or 0.75 (III) percent urea ad lib. as the only forage. The rumen acetate was significantly increased ($P < .05$) and propionate significantly decreased ($P < .05$) in Group III compared with I and II. Rumen butyrate, isobutyrate and valerate significantly decreased ($P < .05$) in Group III compared to I.

Odor and color. As might be expected, the odor most frequently detected in urea treated silage is that of ammonia. The presence of this odor is dependent to some degree on the level of urea addition, but may also be influenced by the extent to which the ammonia formed in the silage has been combined with organic acids to form ammonia salts.

Wise et al. (1944) treated corn silage with urea in an aqueous solution of two pounds of crystals (46 percent nitrogen) per gallon of solution. This was added at the cutter at the rate of five gallons per ton of fresh ensilage material. The experiment showed that urea corn silage was of fair quality, possessing a slightly caramelized odor and a brownish color. There was no free ammonia as detected by the sense of smell, except in the spoiled surface layer at the top of the silo. Harvey et al. (1962) detected a stronger odor in treated silage than was detected in untreated silage. Bentley et al. (1955) noted that the odor of ammonia was rarely detected in silage made with 1.0 percent addition of urea, but in a corn silage of high dry matter content and pH of 7.6 to which 1.25

percent of urea had been added, a distinct odor of ammonia was present, especially after exposure to air for several hours. Owens et al. (1967) showed that the addition of both limestone and 0.5 percent urea increased the ammonia concentration in silage. Davis et al. (1944) noted a marked smell of ammonia with a 2.5 percent addition of urea.

V. DIGESTION AND NITROGEN RETENTION

Digestibility studies with sheep have recently been reported. Bentley (1955), using lambs in metabolism trials, indicated that the apparent digestibility of the dry matter and non-protein nitrogen in urea-corn silage and corn compared favorably with that obtained for corn silage supplemented with corn and soybeal meal or corn and urea. Cellulose digestibility appeared to be slightly lower for urea-corn silage. Klosterman et al. (1963) showed in digestion experiments with wether lambs that the addition of limestone did not decrease the digestibility of cellulose, organic matter, crude fiber, protein or ether extract of the whole plant, or ground ear corn silage. Goodrich and Meiske (1966), in digestion trials using lambs, suggested that the crude fiber in a complete ration was more available than the crude fiber in the ration composed of silage and corn-urea supplement at the time of feeding. Nitrogen retention was significantly less for lambs fed complete ensiled ration. These studies suggested that much of the nitrogen was present as ammonia. Schmutz (1966) compared the digestibility of corn silage by using wethers in which 0.5, 0.75 percent urea, or combination of 0.5 percent urea and 0.5 percent $CaCO_3$ had been added at filling. Crude protein and TDN intakes were equalized with corn starch and soybean meal. Urea addition caused a slight but non-significant

depression in digestibility of DM, crude protein (N x 6.25), and ash, with a significant depression in crude fiber at the 0.5 percent level of urea addition. Johnson et al. (1966) found that urea limestone addition (0.5 percent each) had no consistent effect on the digestibility of DM in sheep, although there was a slight reduction in digestibility of crude protein. Shumway and Barth (1969) utilized steers in a digestion and nitrogen metabolism trial by feeding three levels of urea (0.5, 0.75 and 1.0 percent) with 0.5 limestone corn silage. Results indicated that nitrogen in the 1.0 percent urea silage ration was utilized significantly less ($P < .05$) than that in the 0.5 urea silage ration. This was not comparable to feeding with added corn.

VI. UREA SILAGE FEEDING

Dairy Cattle

Early work of Wise et al. (1944) compared corn silage treated with 0.5 percent urea and untreated corn silage. Concentrates were fed at the same level in both groups and were adjusted according to milk production. The silages were fed ad lib. Consumption of the treated silage was lower than that of the untreated silage. Milk production was comparable in both groups; average daily production for the group fed urea-silage being 24.7 pounds of 4 percent fat corrected milk per head compared with 24.5 pounds for the group fed untreated silage. The authors concluded that the treatment of corn silage with urea did not improve the overall feeding value of the resulting silage. Their data indicated that cows and yearling heifers preferred the urea treated silage without extra protein. Hillman et al.

(1966) suggested that silage treated with urea should contain a minimum of 30 percent dry matter so that the silage may contain more protein on a dry matter basis. These studies revealed that samples of corn silage which contained 30 percent dry matter averaged 2.5 percentage points more protein than samples which contained less than 30 percent dry matter. Van Horn et al. (1969) concluded that high-dry matter urea-silage was not as satisfactory as lower dry matter urea-silage for lactating dairy cows. Schmutz et al. (1969) indicated that milk production for cows fed urea treated silage was similar to that for cows fed control silage. The author's recommendations concerning the use of 0.75 percent urea advised waiting for further definitive research. It was also recommended that the level might be entirely satisfactory with a more mature silage of ± 37 percent dry matter.

In general, it has not been fully determined which level of urea gives optimum benefits for milk production. However, urea treated corn silage has been proved to be a very inexpensive ration for feeding dairy cattle and adequate for maintaining sufficient milk production.

Sheep

Feeding urea treated corn silage to sheep resulted in a much higher body-weight gain and increased wool production compared with the untreated corn silage. Kozmanishvili (1959) compared the body weight gain and wool production of sheep fed a ration based on untreated corn silage (Group I) with similar groups receiving either 0.75 percent urea-corn silage (Group II or untreated corn silage and a supplement of sunflower oil cake (Group III). All groups were fed similar amounts of lucerne hay, millet

straw and silage. Groups I and II received an additional mixture of oats and barley, while Group III, a portion of the oats and barley mixture was replaced with sunflower oil cake to obtain a crude protein content comparable with the ration fed to Group II. The average daily body-weight gains over a period of 123 days for Groups I, II and III, respectively, were 44, 80 and 88 g., while average wood growth during the experimental period was 2.9, 3.3, and 3.5 cm., respectively.

Beef Cattle

Since corn silage is generally considered to be an economical source of available energy but low in protein, calcium and phosphorous, a good approach to producing a balanced winter feed for beef cattle would be to incorporate urea, limestone and a phosphorus source into the silage at the time of ensiling.

A comprehensive series of studies on feeding urea-silage was reported by Bentley et al. (1955). In the main experiment, five groups of seven steers replicated three times were fed for a period of 112 days. The average daily rations fed to the groups were:

1. corn silage + 4 lb. corn and cobmeal per head
2. corn silage + 4 lb. corn and cobmeal + 0.2 lb. urea per head
3. corn silage + 2.5 lb. corn and cobmeal + 1.5 lb. soybeal oil meal per head.
4. urea-corn silage (20 lb. urea per ton) + 4 lb. corn and cobmeal per head.
5. urea-corn silage (20 lb. urea per ton + 2 lb. dicalcium phosphate per ton) + 4 lb. corn and cobmeal per head.

The rations also contained salt and mineral mix. The amount of silage fed to all groups was similar; the mean daily consumptions (average of three replicates) varied from 19.3 to 19.9 pounds per head in the various groups. The average daily gain (average of three replicates) were: Group I, 1.82 lb.; Group II, 1.73 lb.; Group III, 1.87 lb.; Group IV, 1.82 lb.; Group V, 1.83 lb. The difference between Groups I and II, III, IV and V was significant ($P < .05$). There were no significant differences ($P > .05$) between Groups III, IV and V. Thus for fattening purposes, the feeding value of the urea-corn silage compared favorably with that of the silage plus soybean oil meal. Newland and Henderson (1967) fullfed short yearling Hereford heifers either limestone treated corn silage (0.5 percent) or urea-limestone treated corn silage (0.5 percent urea and 0.5 percent total concentrate). Differences in daily gains between the urea and non-urea treated silages were non-significant ($P > .05$) with feed intake slightly lower for the urea treated silage. Klosterman et al. (1960) found that calves which were fed 0.5 percent urea and ground limestone treated corn silage gained 11 percent faster and required 8.5 percent less feed per cwt. gain than did those animals fed untreated silage. Goodrich and Meiske (1966) indicated that cattle fed a corn silage ration with urea added at ensiling performed better than beef cattle fed equivalent untreated corn silage plus a corn-urea ration supplement. Edwards et al. (1968) reported that corn silage was fed successfully as the only roughage in producing steers whose carcass grade was good to choice. They also indicated that both corn silage and urea can be used effectively to reduce feed costs for finishing cattle. The steers finished on treatments of urea

treated corn silage produced carcasses which had grades of top to low choice.

In summary, research has demonstrated that urea added to silage, or silage plus cereal grains, provides a satisfactory growing-finishing ration for beef cattle. The optimum level of urea added at the time of ensiling for maximum nitrogen utilization has not been accurately determined. There seems to be many factors which affect nitrogen utilization such as the amount of readily available energy, the amount of dry matter in the corn silage and available minerals.

CHAPTER III

I. EXPERIMENTAL PROCEDURE

Corn silages treated with 10, 15 and 20 pounds of urea per ton were used in this two-year study. The first experiment (Trial I) was conducted during the fall and winter of 1967-1968; the second experiment (Trial II) was conducted during the fall and winter of 1968-1969. Both experiments were conducted at the University of Tennessee's Blount Farm, Knoxville. There were three replications per treatment with six feeder heifers per pen. At the beginning of both trials, each animal was implanted with 24 mg. of diethylstilbestrol. Heifers were fed their respective treatment silages ad lib. for the first 140 days (called the roughage phase), then fed a fullfeed of concentrate (called the fullfeed phase) until a condition grade of high-good/low choice was reached. After the fullfeed phase all animals were sent to slaughter, and carcass data was obtained.

II. TREATMENTS

The experimental silage treatments were as follows:

Treatment I. During the roughage phase, animals were fed corn silage, treated with 10 pounds each of urea and limestone per ton, ad lib. plus six pounds of corn per head per day. A fullfeed of ground, shelled corn and cottonseed meal in a ratio of 8:1 plus four pounds of alfalfa hay per head per day were fed during the fullfeed phase.

Treatment II. Treatment II was the same as Treatment I except the urea was at a level of 15 pounds per ton of silage. The level of limestone remained at 10 pounds per ton of silage.

Treatment III. Treatment III was the same as Treatment I except the urea was at a level of 20 pounds per ton of silage. The level of limestone remained at 10 pounds per ton of silage.

III. EXPERIMENTAL ANIMALS

One hundred and eight feeder heifers were bought at feeder calf sales held in East Tennessee with an average body weight of 400-500 pounds. All animals graded medium (7) or good (10). When the heifers arrived at the Blount Farm, they were placed on a urea (0.5 percent) and limestone (0.5 percent) treated corn silage ration for approximately two weeks before being placed on experiment.

IV. COLLECTION OF DATA

Weights

Cattle were weighed at the beginning and end of each trial. During both experiments, cattle were weighed at the end of 14, 28, 42 and 56 days and at 28-day intervals thereafter until the conclusion of the experiment. Initial and final weights were taken at 7:00 a.m. before the morning feeding and with the water turned off by 8:00 p. m. the night before.

Carcass Data

Following a 48-hour chill period after slaughter, carcasses were

ribbed between the 12 and 13th ribs and were evaluated by a federal grader for USDA quality grade, marbling score, maturity, conformation grade and percent kidney fat. Fat thickness, ribeye area and dressing percent were also determined.

Feeding

Silage was fed twice a day in sufficient amounts, so that a small amount remained at the end of each day. This left-over silage was removed and weighed each day before the afternoon feeding during the first year but only on Tuesday, Thursday and Saturday of each week during the second year. One half of the corn supplement was poured over the silage at each feeding and mixed sufficiently by hand. A mineral box of two compartments were kept in each feed trough. Two parts by weight of dicalcium phosphate and one part of granulated loose salt were fed free choice and separately in these mineral boxes.

V. ADDING UREA TO CORN SILAGE

The proper amounts of urea and limestone were scattered over the top of each wagon load at the time the green chop was unloaded into the respective silos. No special attempt was made to mix the urea and limestone into the green chop since the unloading and blowing process did a very satisfactory and thorough job of mixing. Routine tests once a month showed that the percentage of crude protein remained relatively constant from top to bottom of the silo.

VI. STATISTICAL ANALYSIS

Statistical analyses were made and included the following dependent variables:

1. total gain per head
2. average daily gain, roughage phase
3. average daily gain, fullfeed phase
4. average daily gain, overall average
5. condition grade, roughage phase
6. final condition grade
7. carcall characteristics which includes USDA grade, dressing percentage, marbling score, ribeye area (sq. in.), fat thickness (in.), and percent kidney fat.

All statistical analyses were made at the 5 percent level of probability ($P < .05$). When the analyses of variance showed significances, a range test was made using Duncan's Multiple Range Test as outlined by Steele and Torrie (1960).

CHAPTER IV

RESULTS AND DISCUSSION

I. PERFORMANCE

Average Gains

Average total gain per head for heifers fed the various levels of urea in the years 1967-1968 and 1968-1969 are shown in Table I. The average total gain was not significantly affected by the levels of urea. The 1967-1968 data in Table II does show that numerically the lowest average total gain was for the 15 pounds urea level, but this was highest during 1968-1969, Table III.

Average Daily Gain

The average daily gain increased slightly as the level of urea increased for the roughage phase (Figure 1). However, the opposite was true for the fullfeed phase. Differences between treatments were not significant for either roughage or fullfeed phases or for the overall treatment averages. Since animals gaining the most during the roughage phase gained least during the fullfeed phase, the differences may be explained by the phenomenon of compensatory gain. The 1967-1968 data (Figure 2) as well as the 1968-1969 data (Figure 3) showed small differences between average daily gain for the roughage phase, but small decreases in average daily gain with increased levels of urea for the fullfeed phase were observed. Also, these differences were not significant.

TABLE I

PERFORMANCE AND FINANCIAL RETURNS FROM FEEDER HEIFERS
TWO-YEAR SUMMARY (1967-68, 1968-69)

Treatment	Level of Urea, Lb. Per Ton of Silage		
	10	15	20
Av. number of animals per year	18	18	18
Performance			
Av. initial wt., lb.	463.5	463.0	464.5
Av. wt., end roughage phase, lb.	712.0	719.5	726.5
Av. wt., end fullfeed phase, lb.	833.0	831.0	835.5
Av. gain, on roughage phase, lb.	248.5	256.5	262.0
Av. gain, on fullfeed phase, lb.	121.0	111.5	109.0
Overall av. gain, lb.	369.5	368.0	371.0
Financial returns			
Av. purchase price/cwt., $	23.33	23.33	23.33
Av. selling/cwt., $[a]	27.69	27.69	27.68
Av. purchase cost/head, $	108.20	108.01	108.43
Av. selling price/head, R	227.31	227.04	228.09
Av. feed costs/head, $[b]	60.31	58.05	57.92
Av. return/head over initial and feed costs, $	62.77	64.84	65.49

[a]Based on carcass yield and grade.

[b]Feed costs were as follows: corn silage, $8 per ton; urea, $86.53 per ton; limestone, $13 per ton; corn, $1.32 per bushel; hay, $35 per ton; and cottonseed meal, $85.05 per ton.

TABLE II

PERFORMANCE AND FINANCIAL RETURNS FROM FEEDER HEIFERS
(1967-1968)

Treatment	Level of Urea, Lb. Per Ton of Silage		
	10	15	20
Number of animals	18	18	18
Performance			
Av. initial wt., lb.	452	451	454
Av. wt., end roughage phase, lb.	691	681	699
Av. wt., end fullfeed phase, lb.	810	799	815
Av. gain, on roughage phase, lb.	239	230	245
Av. gain, on fullfeed phase, lb.	119	118	116
Overall average gain, lb.	358	348	361
Financial returns			
Av. purchase price/cwt., $	22.94	22.94	22.94
Av. selling/cwt., $[a]	25.18	24.73	24.91
Av. purchase cost/head, $	103.85	103.39	104.15
Av. selling price/head, $	199.19	196.38	200.56
Av. feed costs/head, $[b]	59.86	58.68	60.34
Av. return/head over initial and feed costs, $	40.41	35.20	38.53

[a]Based on carcass yield and grades.

[b]Feed costs were as follows: corn silage, $8 per ton; urea, $92.80 per ton; limestone, $13 per ton; corn, $1.31 per bushel; hay, $35 per ton; and cottonseed meal, $87.90 per ton.

TABLE III

PERFORMACNE AND FINANCIAL RETURNS FROM FEEDER HEIFERS
(1968-1969)

Treatment	Level of Urea, Lb. Per Ton of Silage		
	10	15	20
Number of animals	18	18	18
Performance			
Av. initial wt., lb.	475	475	475
Av. wt., end roughage phase, lb.	733	758	856
Av. wt., end fullfeed phase, lb.	856	863	856
Av. gain, on roughage phase, lb.	258	283	279
Av. gain, on fullfeed phase, lb.	123	105	102
Overall average gain, lb.	381	383	381
Financial returns			
Av. purchase price/cwt., $	23.71	23.71	23.71
Av. selling/cwt., $[a]	30.20	30.65	30.44
Av. purchase cost/head, $	112.54	112.62	112.70
Av. selling price/head, $	255.43	257.70	255.62
Av. feed costs/head, $[b]	60.76	57.41	55.50
Av. return/head over initial and feed costs, $	85.13	94.48	92.45

[a]Based on carcass yield and grades.

[b]Feed costs were as follows: corn silage, $8 per ton; urea, $80.25 per ton; limestone, $13 per ton; corn, $1.33 per bushel; hay, $35 per ton; and cottonseed meal, $82.20 per ton.

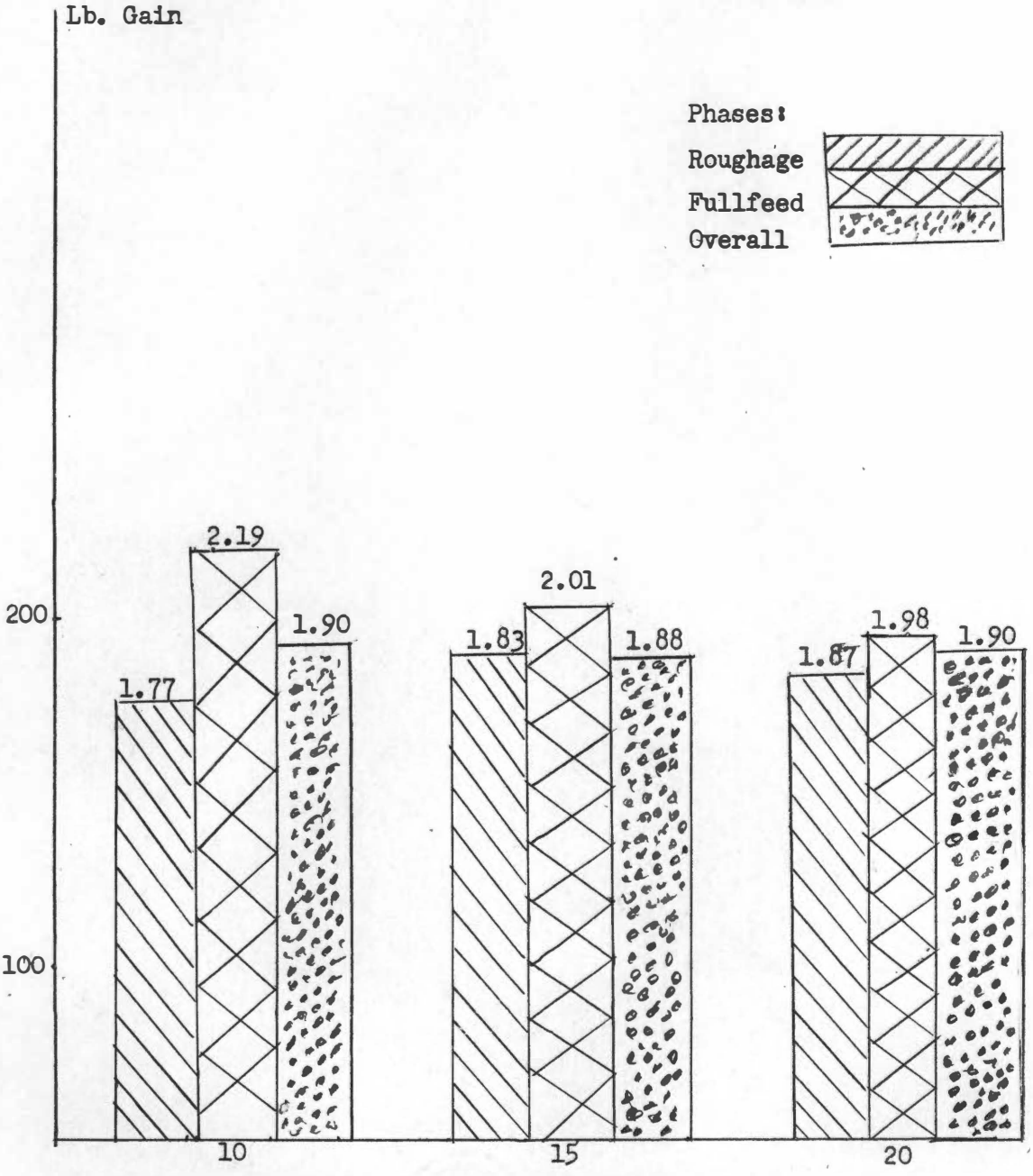

FIGURE 1

AVERAGE DAILY GAINS OF FEEDER HEIFERS FED CORN SILAGE TREATED WITH DIFFERENT LEVELS OF UREA TWO-YEAR SUMMARY (1967-68, 1968-69)

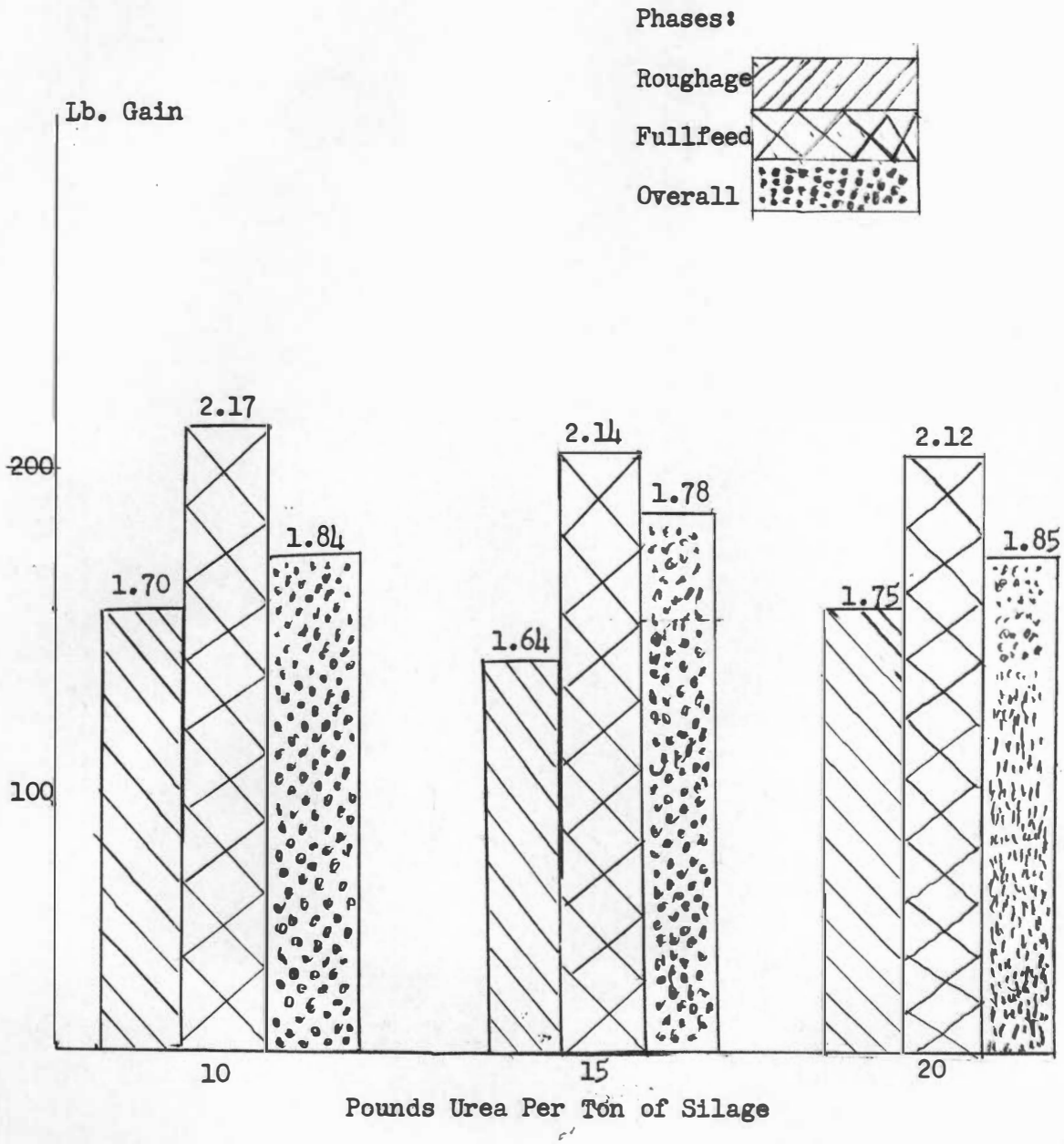

FIGURE 2

AVERAGE DAILY GAINS OF FEEDER HEIFERS FED CORN SILAGE TREATED WITH DIFFERENT LEVELS OF UREA 1967-1968

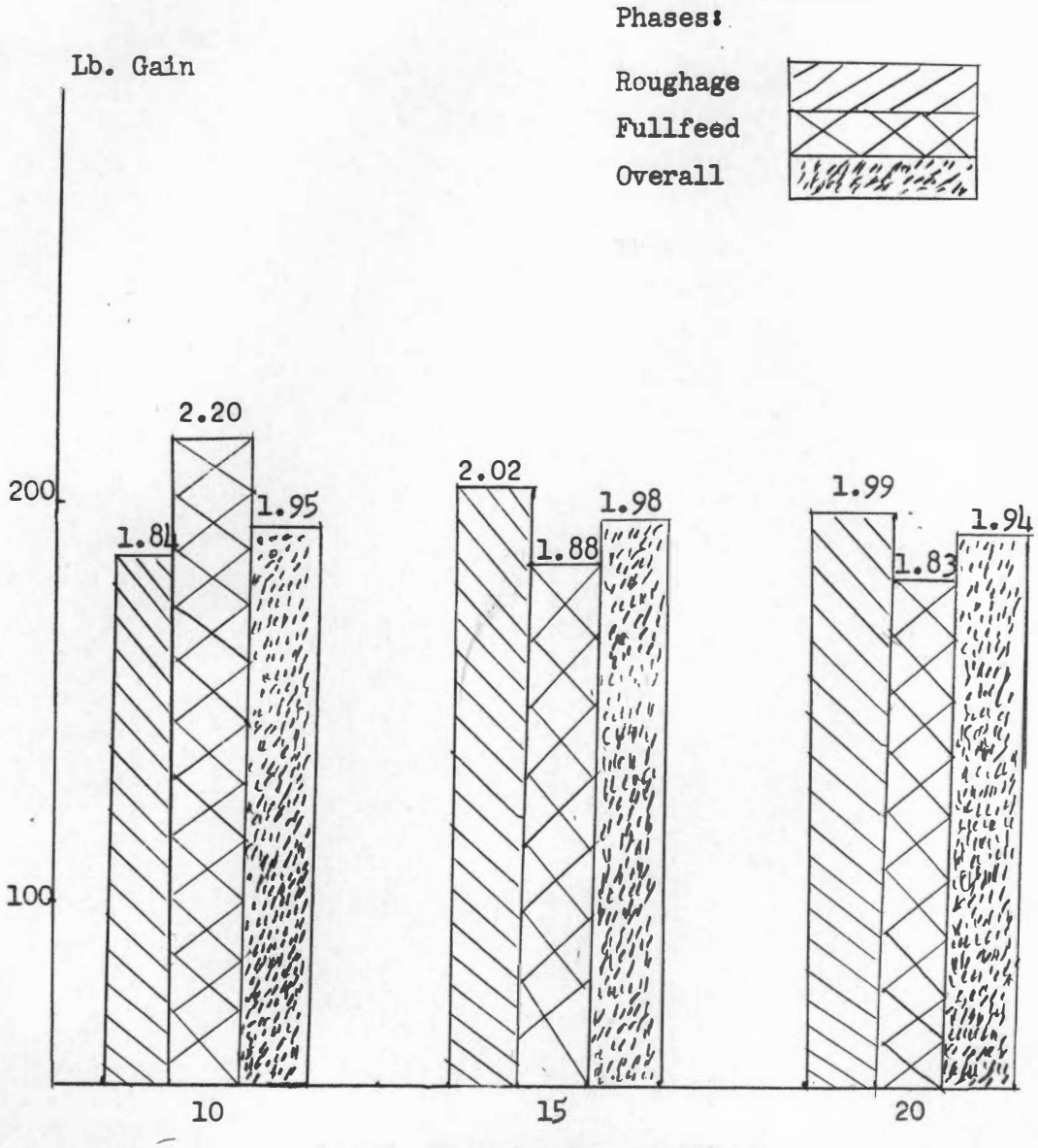

FIGURE 3

AVERAGE DAILY GAINS OF FEEDER HEIFERS FED CORN SILAGE TREATED WITH DIFFERENT LEVELS OF UREA 1968-69

Live Condition Grade

Neither the live condition grade (end roughage phase) or the final condition grade were affected by the level of urea fed when the results of both trials were combined, Table IV. The 1967-1968 data (Table V) showed a significantly higher condition grade for the roughage phase for the 10 pounds of urea level with no significant differences between the 15 and 20 pounds level. However, the final condition grade for Trial I was not affected by the various levels of urea. On the other hand, the 1968-1969 data (Table VI) showed that there were no significant differences in the live condition grade at the end of either the roughage or fullfeed phases.

Average Return Per Head Over Initial and Feed Costs

Average returns for both years are summarized in Table I on page 22 and show that the average return per head over initial and feed costs increased as the level of urea increased. However, between years there were differences. In 1967-1968, the 10 pound level had the highest average return while in 1968-1969, the 15 pound level had the highest average return, as shown in Table II, page 23 and Table III, page 24.

Acceptability of the Treated Silages

Average feed consumption per head per day is summarized in Table VII. These data show that pounds of dry matter consumed per head per day decreased as the levels of urea increased for the roughage and fullfeed phases and overall average. However, this trend was noticeable only in the 1968-1969 trial; in the 1967-1968 trial, there were only slight differences in daily dry matter consumption as is shown in Tables VIII and IX, respectively.

TABLE IV

GRADES AND CARCASS CHARACTERISTICS OF FEEDER HEIFERS FED CORN SILAGE TREATED WITH DIFFERENT LEVELS OF UREA
TWO-YEAR SUMMARY (1967-68, 1968-69)

Treatment	Level of Urea, Lb. Per Ton of Silage 10	15	20
Av. number of animals per year	18	18	18
Live grades[a]			
Av. initial type	8.1	8.0	8.0
Av. initial condition	8.7	8.4	8.4
Av. cond., end roughage phase	10.3	9.9	9.9
Av. final condition	11.9	11.9	12.0
Carcass characteristics			
USDA grade	11.6	11.4	11.2
Dressing percentage	58.8	58.7	58.9
Marbling score[b]	5.1	4.8	4.6
Ribeye area (sq. in.)	10.6	10.7	11.2
Fat thickness (inch)	0.47	0.45	0.43
Kidney fat percentage	3.0	2.7	2.7
Yield (cutability) grade	2.79	2.67	2.46

[a] Grades - 7 = average medium
8 = high medium
9 = low good
10 = average good
11 = high good
12 = low choice

[b] 1 - devoid
2 - practically devoid
3 - traces
4 - slight
5 - small
6 - modest
7 - moderate
8 - slightly abundant
9 - moderately abundant

TABLE V

GRADE AND CARCASS CHARACTERISTICS OF FEEDER HEIFERS FED SILAGE TREATED WITH DIFFERENT LEVELS OF UREA (1967-68)

Treatment	Level of Urea, Lb. Per Ton of Silage 10	15	20
Number of animals	18	18	18
Live grades[a]			
Av. initial type	7.3	7.2	7.2
Av. initial condition	9.0	8.6	8.3
Av. cond., end roughage phase	10.7	9.5[c]	9.5[c]
Av. final condition	12.0	11.5	11.7
Carcass characteristics			
USDA grade	12.2	11.5	11.0
Dressing percentage	58.9	58.4	59.2
Marbling score[b]	5.6	5.1	4.6
Ribeye area (sq. in.)	10.2	10.3	10.9
Fat thickness (inch)	0.53	0.46	0.45
Kidney fat percentage	2.7	2.2	2.2
Yield (cutability) grade	2.97	2.63	2.48

[a]Grades - 7 = average medium
8 = high medium
9 = low grade
10 = average good
11 = high good
12 = low choice

[b]1 - devoid
2 - practically devoid
3 - traces
4 - slight
5 - small
6 - modest
7 - moderate
8 - slightly abundant
9 - moderately abundant

[c]Means with the same superscript do not differ significantly ($P < .05$).

TABLE VI

GRADES AND CARCASS CHARACTERISTICS OF FEEDER HEIFERS FED CORN SILAGE TREATED WITH DIFFERENT LEVELS OF UREA (1968-69)

Treatment	Level of Urea, Lb. Per Ton of Silage 10	15	20
Number of animals	18	18	18
Live grades[a]			
Av. initial type	8.8	8.8	8.7
Av. initial condition	8.3	8.2	8.5
Av. cond., end roughage phase	9.8	10.2	10.3
Av. final condition	11.7	12.3	12.3
Carcass characteristics			
USDA grade	10.9	11.2	11.3
Dressing percentage	58.6	58.9	58.5
Marbling score[b]	4.5	4.5	4.6
Ribeye area (sq. in.)	10.9	11.0	11.4
Fat thickness (inch)	0.41	0.44	0.41
Kidney fat percentage	3.2	3.1	3.1
Yield (cutability) grade	2.6	2.7	2.44

[a]Grades - 7 = average medium
8 = high medium
9 = low good
10 = average good
11 = high good
12 = low choice

[b]1 - devoid
2 - practically devoid
3 - traces
4 - slight
5 - small
6 - modest
7 - moderate
8 - slightly abundant
9 - moderately abundant

TABLE VII

FEED CONSUMPTION PER HEAD PER DAY OF FEEDER HEIFERS FED CORN SILAGE TREATED WITH DIFFERENT LEVELS OF UREA TWO-YEAR SUMMARY (1967-68, 1968-69)

Treatment	Levels of Urea, Lb. Per Ton of Silage 10	15	20
Daily feed consumption per head			
Routhage phase			
Urea-lime-corn silage, lb.	25.15	21.25	21.15
Ground shelled corn, lb.	6.0	6.0	6.0
Total	31.15	27.25	27.15
Daily feed consumption per head			
Fullfeed phase			
Ground shelled corn, lb.	31.1	13.0	12.8
Cottonseed meal, lb.	1.65	1.60	1.60
Alfalfa hay, lb.	3.85	3.85	3.85
Total	18.60	18.45	18.25
Dry matter content of feeds			
Urea-lime-corn silage, %	38.97	38.44	37.82
Ground shelled corn, %	89.39	89.39	89.39
Cottonseed meal, %	91.21	91.21	91.21
Alfalfa hay, %	94.81	94.81	94.81
Dry matter consumed per head per day			
Roughage phase, lb.	14.9	13.5	13.3
Fullfeed phase, lb.	17.1	16.9	16.7
Overall average, lb.	15.5	14.5	14.3

TABLE VIII

FEED CONSUMPTION PER HEAD PER DAY OF FEEDER HEIFERS FED CORN SILAGE TREATED WITH DIFFERENT LEVELS OF UREA (1967-1968)

Treatment	Level of Urea, Lb. Per Ton of Silage		
	10	15	20
Daily feed consumption per head			
Roughage phase			
Urea-lime-corn silage, lb.	24.0	20.9	22.7
Ground shelled corn, lb.	6.0	6.0	6.0
Total	30.0	26.9	28.7
Daily feed consumption per head			
Fullfeed phase			
Ground shelled corn, lb.	12.8	13.1	13.3
Cottonseed meal, lb.	1.6	1.6	1.7
Alfalfa hay, lb.	4.0	4.0	4.0
Total	18.4	18.7	19.0
Dry matter content of feeds			
Urea-lime-corn silage, %	35.7	39.6	37.6
Ground shelled corn, %	89.0	89.0	89.0
Cottonseed meal, %	91.9	91.9	91.9
Alfalfa hay, %	94.8	94.8	94.8
Dry matter consumed per head per day			
Roughage phase, lb.	13.9	13.6	13.8
Fullfeed phase, lb.	16.7	16.9	17.1
Overall average, lb.	14.7	14.5	14.8

TABLE IX

FEED CONSUMPTION PER HEAD PER DAY OF FEEDER HEIFERS FED CORN SILAGE TREATED WITH DIFFERENT LEVELS OF UREA (1968-69)

Treatment	Level of Urea, Lb. Per Ton of Silage		
	10	15	20
Daily feed consumption per head			
Roughage phase			
Urea-lime-corn silage, lb.	26.3	21.6	19.6
Ground shelled corn, lb.	6.0	6.0	6.0
Total	32.3	27.6	25.6
Daily feed consumption per head			
Fullfeed phase			
Ground shelled corn, lb.	13.4	12.9	12.3
Cottonseed meal, lb.	1.7	1.6	1.5
Alfalfa hay, lb.	3.8	3.8	3.8
Total	18.9	18.3	17.6
Dry matter content of feeds			
Urea-lime-corn silage, %	42.23	27.28	38.04
Ground shelled corn, %	89.78	89.78	89.78
Cottonseed meal, %	90.51	90.51	90.51
Alfalfa hay, %	94.82	94.82	94.82
Dry matter consumed per head per day			
Roughage phase, lb.	15.9	13.4	12.7
Fullfeed phase, lb.	17.4	16.9	16.3
Overall average, lb.	16.3	14.4	13.8

It was considered that all three levels of urea were equally acceptable which was in general agreement with the findings of other workers. Huber et al. (1967) fed corn silage ad lib. which had been ensiled with 0.0, 0.5, or 0.75 percent urea. The level of urea in the silage did not significantly influence the silage intake or total feed intake. In a second trial, corn silage which had been ensiled with 0.0, 0.6, or 0.85 percent urea was fed ad lib. to lactating cows in 63-day trials. Again, no significant differences were observed in feed intake. Two trials in which lactating cows were fed silage treated with 0.5 and 0.75 percent urea or 1 percent diammonium phosphate (DAP) were conducted by Schmutz (1966). Decreases in silage intakes were noted from cows fed the 0.75 percent urea treated silages. Klosterman (1955) recommended 20 pounds urea per ton of corn silage for fattening cattle.

II. CARCASS CHARACTERISTICS

USDA Quality Grade

The summary of average USDA quality grades for heifers fed the various levels of urea in the years 1967-1968 and 1968-1969 is shown in Table IV, page 29. Differences were non-significant although there was a slight decrease in quality grade as the level of urea increased. This was also the trend in 1967-1968 but was the reverse in 1968-1969.

Dressing Percentage

Differences in dressing percent were non-significant for the average of the two trials and for each individual trial as shown in Table IV, page 29; Table V, page 30; and Table VI, page 31.

Marbling Score

Average marbling score for heifers fed the various levels of urea for both trials are shown in Table IV, page 29. Average marbling score decreased slightly as the level of urea increased in the corn silage, but the differences were not significant. Similarly, the data of Trial I, Table V, page 30 show the same results. However, examination of 1968-1969 data in Table VI, page 31 showed that the opposite trend evolved, but again the differences were not significant. Henderson and Burser (1968) found similar results. They indicated that adding 20 pounds of urea per ton corn silage was superior to 10 pounds addition, but that the marbling was the same for both urea levels.

Ribeye Area

Average ribeye area (sq. in.) for heifers fed the various levels of urea numerically increased with increased urea levels Table IV, page 29, but these differences were not significant. Data from individual years displayed similar trends as shown in Table V, page 30 and Table VI, page 31.

Fat Thickness

Average fat thickness for both trials, Table IV, page 29, decreased slightly as the levels of urea increased, but these differences were not significant. The same trend was also obtained in Trial I, Table V, page 30. In Trial II, Table VI, page 31, the highest fat thickness was for the 15 pounds urea level, but again the differences were not significant. Newland (1966) reported similar results that heifers fed 10 pounds of urea-corn silage had significantly less fat cover over the 12th rib compared with untreated corn silage, but Henderson and Burser (1968) indicated that adding

20 pounds of urea per ton of corn silage was superior to 10 pounds addition, and all silage groups had more fat thickness compared with the untreated silage.

Kidney Fat Percentage

Average kidney fat percentages are shown in Table IV, page 29, Table V, page 30, and Table VI, page 31. In all of these, there is a small numerical, but non-significant, difference in favor of the 10 pounds urea level. Similar work of Newland (1966) found that heifers fed 10 pounds of urea-corn silage had significantly less kidney fat compared with untreated corn silage.

III. CONCLUSION

A study was conducted to see if the amount of urea could be increased above 10 pounds per ton of silage without adversely affecting the acceptability of the silage, the feedlot performance, and carcass characteristics of slaughter heifers. The results showed that all three levels of urea were equally acceptable, and that feedlot performance and carcass characteristics were not significantly affected, either positively or negatively, by the addition of 10, 15 or 20 pounds of urea per ton of corn silage. Therefore, it was concluded that, when desirable, up to 20 pounds of urea could be added per ton of corn silage without adverse effects.

CHAPTER V

SUMMARY

The purpose of this experiment was to determine if the amount of urea could be increased above 10 pounds per ton of silage without adversely affecting the acceptability of the silage and the feedlot performance of the animals.

A two-year experiment was conducted at the University of Tennessee's Blount Farm, Knoxville. The first and second experiments were conducted during the fall and winter of 1967-1968 and 1968-1969, respectively. Three treatments with 10, 15 and 20 pounds per ton of urea treated corn silages were used in this two-year study.

In both trials, there were three replications (pens) per treatment with six feeder heifers per pen. At the beginning of both trials, 24 mg. of diethylstilbestrol were implanted per head.

The results from the study were as follows:

1. Average total gain per head for both trials was not affected by the levels of urea. A lowest and highest average total gain was with 15-pounds urea-corn silage for the first and second trial, respectively. The differences were not significant.

2. Average daily gain for the roughage phase increased slightly as the level of urea increased. However, the opposite was true for the fullfeed phase for both trials; but differences between treatments were small and not significant for either the roughage or fullfeed phases or the overall treatment averages.

3. Neither the live condition grade (end roughage phase) or the final condition grade was affected by the level of urea fed when the results of both trials were combined. However, the live condition grade for the roughage phase showed a significantly higher condition grade for the 10 pounds urea level. In Trial I there were no significant differences between treatments were small and not significant (Trial II).

4. Carcass characteristics, differences between treatments were non-significant for the average of the two trials and for each individual trial, Table IV, page 29, Table V, page 30, and Table VI, page 31.

5. The results from this study showed that all three levels of urea were equally acceptable, and that feedlot performance and carcass characteristics were not significantly affected, either positively or negatively, by the addition of 10, 15 or 20 pounds of urea per ton of corn silage at the time of ensiling.

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APPENDIX

APPENDIX A

FURTHER FIGURES AND STATISTICAL TABLE

Figures 4 through 9 indicate the economy of gain and are included in this thesis for the further information of anyone who may be interested in this area. The summary of the statistical data appears in Table 10.

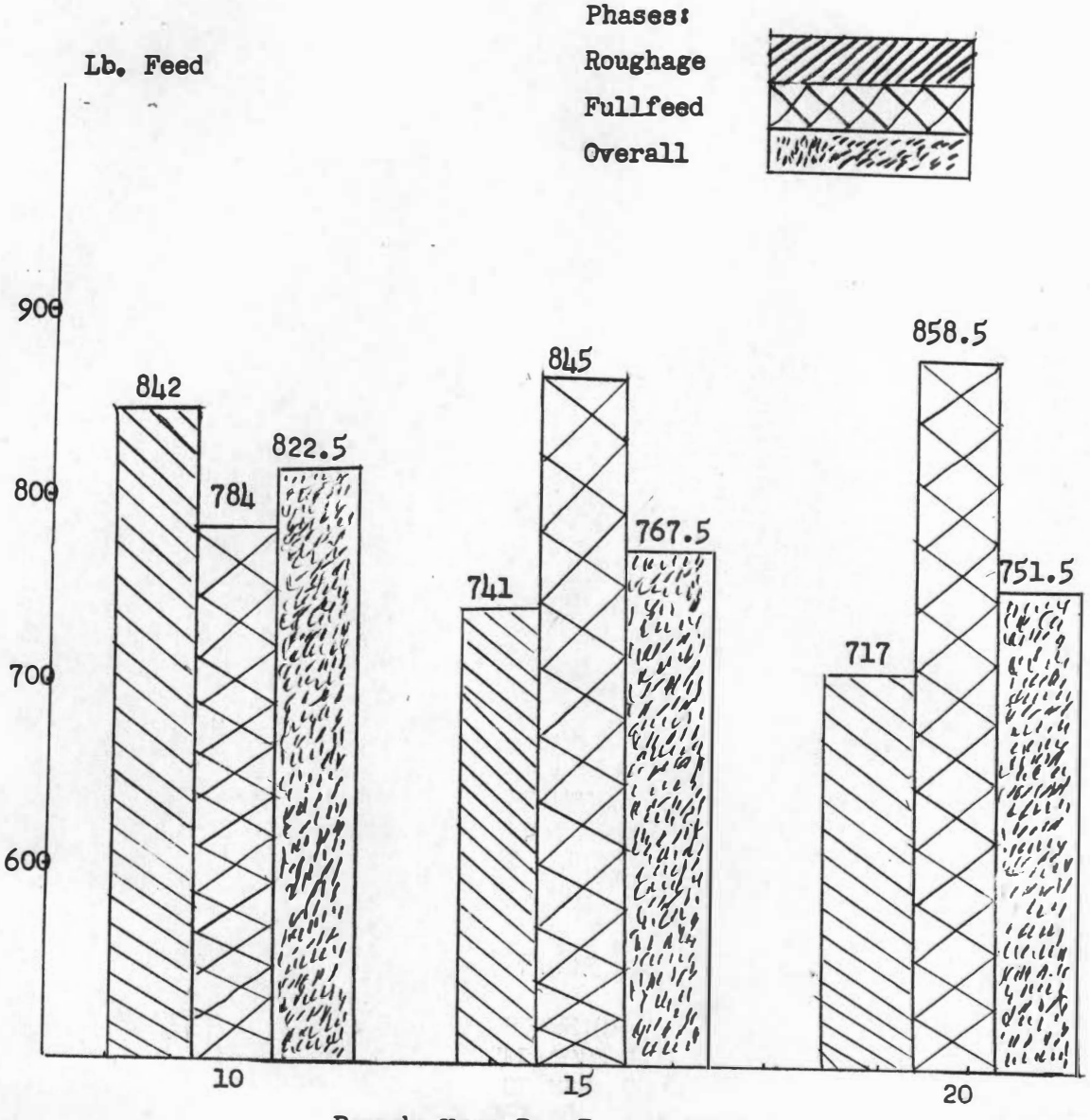

FIGURE 4

FEED CONSUMED PER HUNDERD WEIGHT GAIN (DRY MATTER BASIS) BY FEEDER HEIFERS FED CORN SILAGE TREATED WITH DIFFERENT LEVELS OF UREA TWO-YEAR SUMMARY (1967-68, 1968-69)

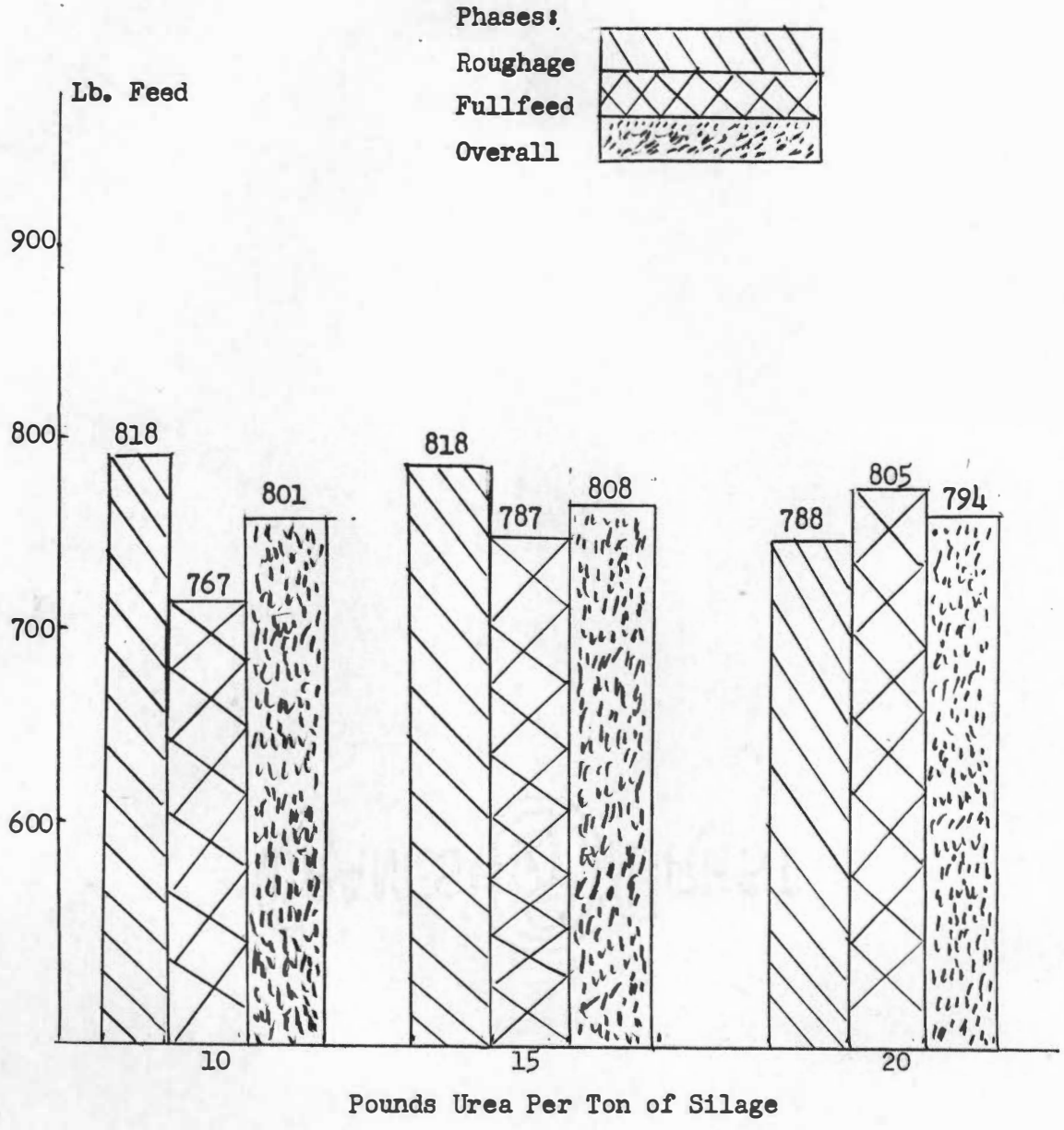

FIGURE 5

FEED CONSUMPTION PER HUNDRED WEIGHT GAIN (DRY MATTER BASIS) BY FEEDER HEIGERS FED CORN SILAGE TREATED WITH DIFFERENT LEVELS OF UREA (1967-1968)

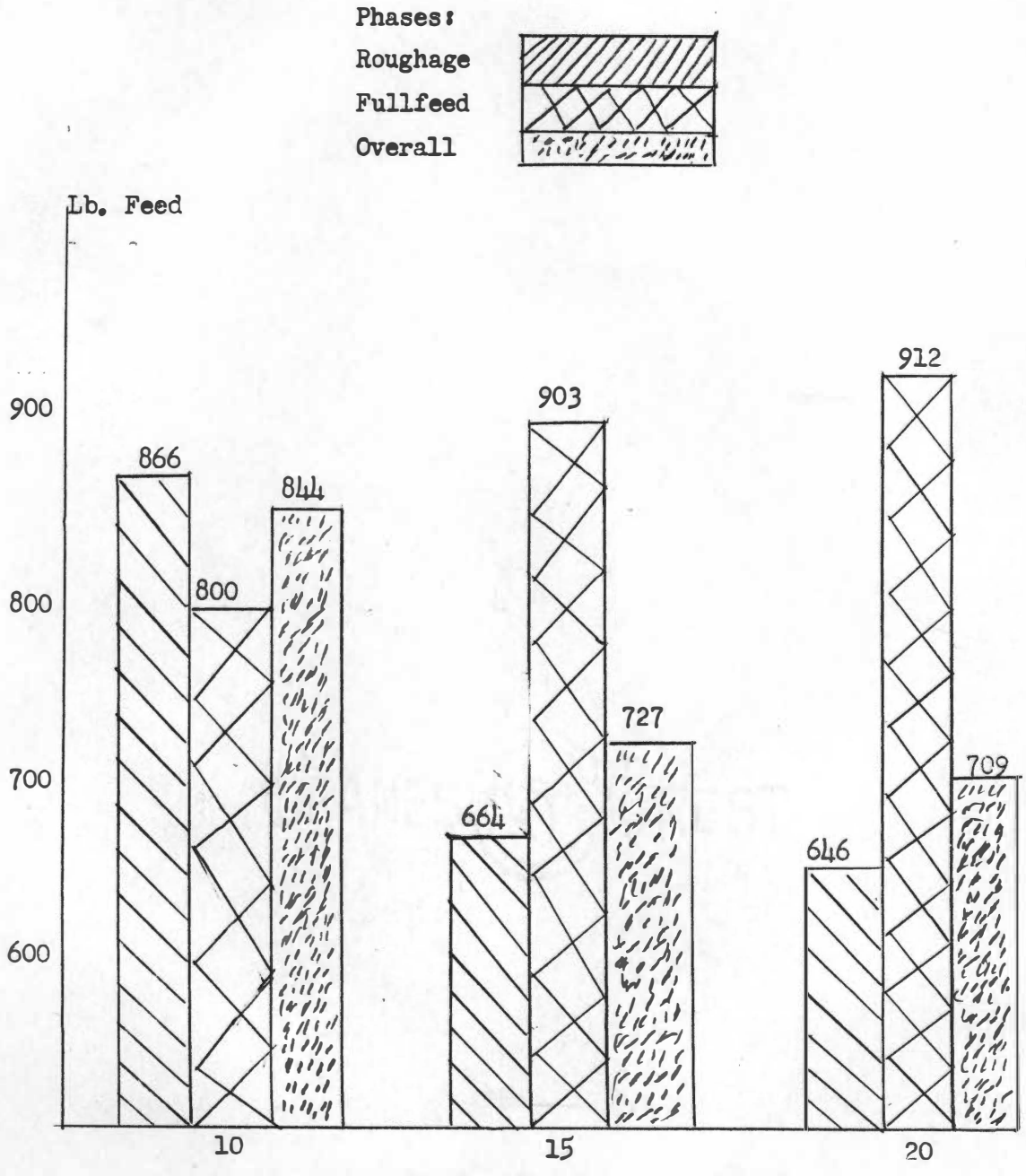

FIGURE 6

FEED CONSUMED PER HUNDRED WEIGHT GAIN (DRY MATTER BASIS) BY FEEDER HEIFERS FED CORN SILAGE TREATED WITH DIFFERENT LEVELS OF UREA (1968-1969)

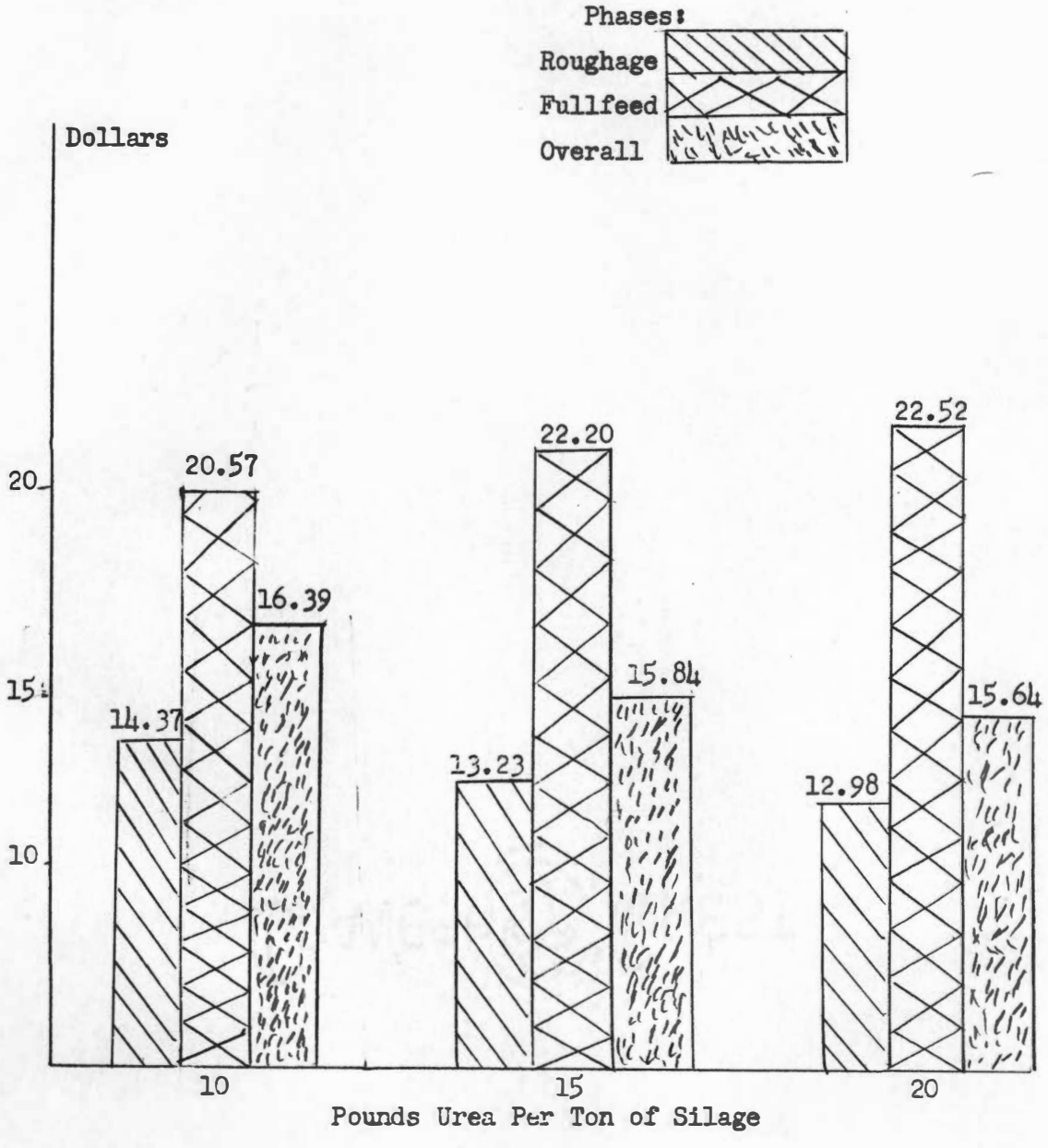

FIGURE 7

FEED COSTS PER HUNDRED WEIGHT GAIN OF FEEDER HEIFERS FED CORN SILAGE TREATED WITH DIFFERENT LEVELS OF UREA
TWO-YEAR SUMMARY (1967-68, 1968-69)

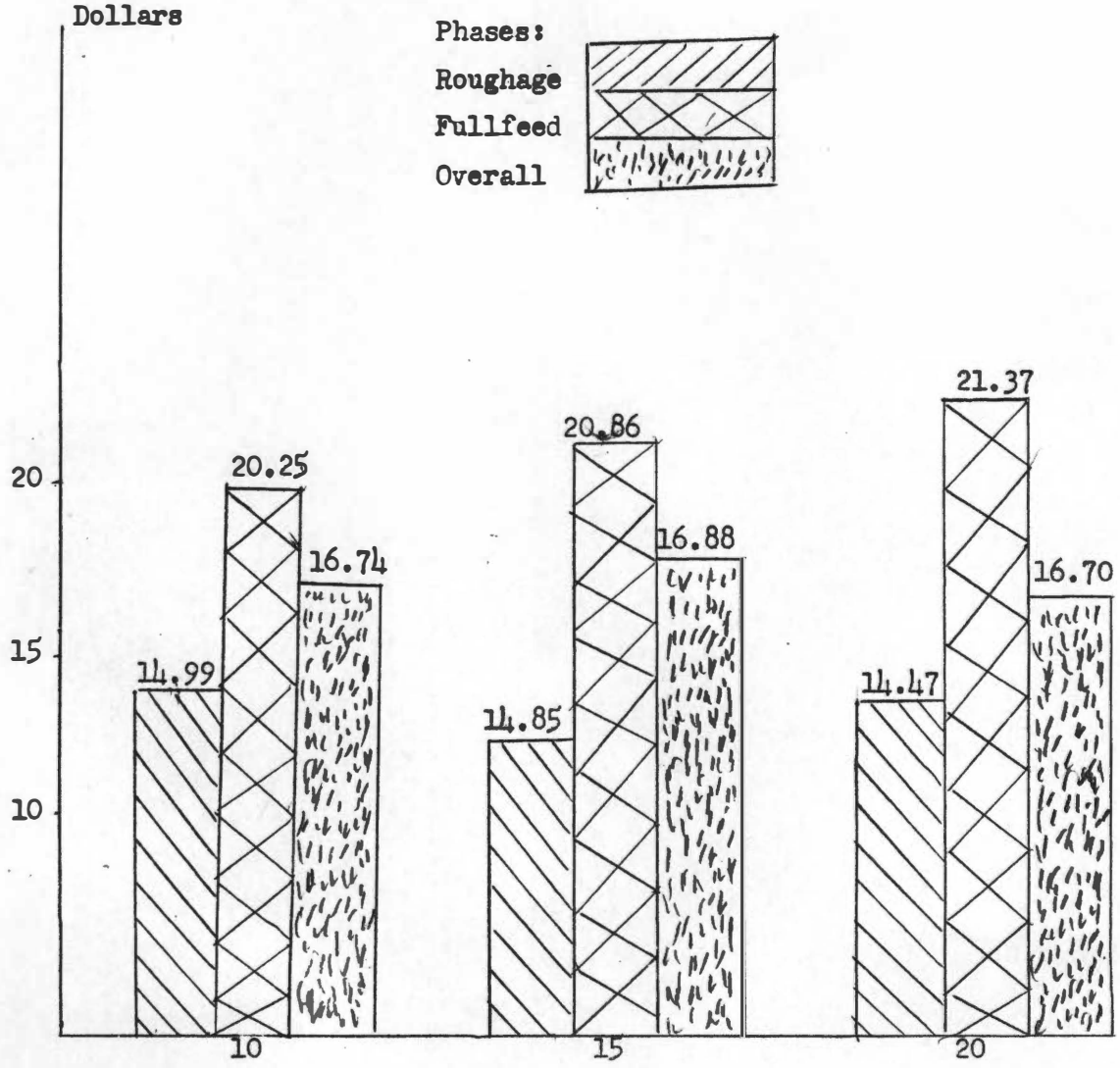

FIGURE 8

FEED COSTS PER HUNDRED WEIGHT GAIN OF FEEDER HEIFERS FED CORN SILAGE TREATED WITH DIFFERENT LEVELS OF UREA (1967-1968)

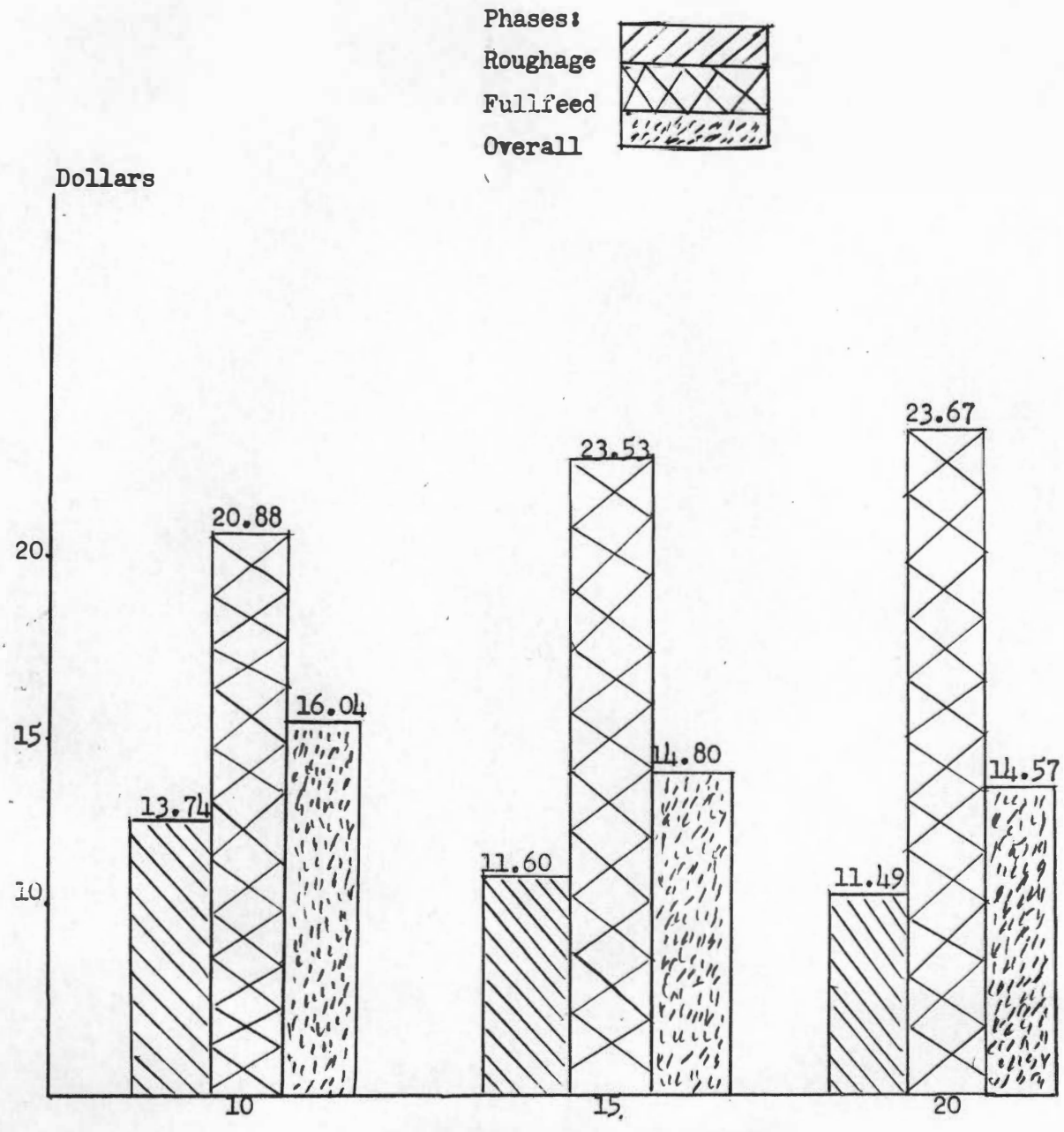

FIGURE 9

FEED COSTS PER HUNDRED WEIGHT GAIN OF FEEDER HEIFERS FED CORN SILAGE TREATED WITH DIFFERENT LEVELS OF UREA (1968-1969)

TABLE X

STATISTICAL ANALYSES OF FEEDER HEIFERS FED CORN SILAGE TREATED WITH DIFFERENT LEVELS OF UREA SUMMARY (1967-68, 1968-69)

		Mean Square										
Source	d.F	Total Gain	ADG a	ADG b	ADG c	d	e	f	g	h	i	j	k
Treatments	2	97.3	0.055	0.37	0.005	1.55	0.20	2.01	0.375	1.695	4.065	0.010	0.90
Years	1	21224.1*	0.610	1.90*	0.49*	0.60	3.40	5.33*	0.180	9.190*	10.960	0.090*	14.81*
(T) (Y)	2	1164.5	0.120	0.39	0.03	8.10	3.55	5.25*	3.750	2.385	0.155	0.025	0.62
Pen/T, Y	12	2552.8	0.133	0.203	0.066	3.23*	2.475*	1.07	1.857	1.186	2.313	0.018	0.345
Ani./P,T,Y	90	22181.11	0.094	0.180	0.056	1.01	0.646	1.03	2.575	0.716	1.207	0.015	0.438

*Significantly different ($P < 0.05$).

Note: The lower case letters at the head of each column represent the headings which should read as follows:
(a) Roughage Phase; (b) Fullfeed Phase; (c) Overall Average; (d) Condition Grade Roughage (e) Final Condition Grade; (f) USDA Quality Grade; (g) Dressing Percentage; (h) Marbling score; (i) Ribeye Area (sq. in.); (j) Fat Thickness (in.); (k) Kidney Fat Percentage.

VITA

Kadhim Abdul Ruhman Khalil was born in Mosul, Iraq, on July 1, 1945. He graduated from Al-Sharkia High School in June, 1961. The following fall he entered the Agricultural College of the University of Baghdad located in the capital city of Iraq. On June 22, 1966, he received his Bachelor of Science Degree with a major in Animal Husbandry. In November, 1966, he joined the staff of the Animal Science Department of the University of Mosul. During this two-year period as an instructor and research associate, he published two studies, "A Preliminary Study of Wool Characteristics of Awasi Rams in Iraq," and "A Study on the Effect of Feeding Dried Beet Pulp on Growth Rate of Friesian Calves," in Mesopotamia, the Journal of Agriculture and Forestry Research for the University of Mosul.

On August 23, 1968, he arrived in Knoxville, Tennessee, to begin work toward the Master of Science Degree in Animal Husbandry with Beef Production being his field of special interest. While in Graduate School, he also worked at the University of Tennessee's Blount Farm, Knoxville, and as an assistant in the departmental meat lab. In December, 1969, he received his Master of Science Degree. He plans to advance his education with work toward a Doctor of Philosophy Degree in Animal Science.