THE USE OF UREA IN LIMITING SUPPLEMENTAL FEED INTAKE AND EFFICIENCY OF UREA UTILIZATION BY CATTLE ON HIGH ROUGHAGE RATIONS

by

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INTRODUCTION

It has been recognized for some time that urea may be used to replace a portion of the protein in the ration of ruminants. The concept of chemical urea as a ration constituent was born in Germany during World War I as a result of a shortage of protein feeds for cattle. In the United States, interest in urea as a feed for cattle and sheep has developed since 1936. According to Hall (1961) the use of urea in feed mixes on a commercial scale began in the United States about 1950.

The general concept of urea utilization by the ruminant is a conversion of urea to protein by primarily a microbial process. Microbes use nitrogen from compounds such as urea and combine it with other nutrients in the ration to build their own body protein. The protein in the microbes is then digested and absorbed in the same manner as feed protein.

Many tests using urea to replace a part of the protein in high energy rations have been conducted and have shown that it can be used with satisfactory results. Fewer tests have been made using urea to replace a part of the protein in low energy or roughage rations. Results of these tests have not been consistent, therefore, further work seemed warranted.

Protein is the highest cost feed per unit in a cattle ration, therefore, if satisfactory results can be obtained, the use of a cheaper ingredient such as urea is desirable.

The convenience and cost of labor in feeding is important to a successful operation. Self-feeding cattle on full feed is an established practice but restricting consumption when self-feeding presents problems. The addition of a relatively high per cent of salt in a ration has been used successfully

to restrict consumption. Urea has a rather bitter taste and would seem somewhat unpalatable to cattle, therefore, it might serve as an ingredient to restrict consumption and also to provide a part or all of the protein equivalent required by the animal.

The objectives of the three experiments reported here were:

Experiment I - To study palatability of urea by mixing it with salt and keeping it before the animal at all times. Two groups of heifer calves were fed salt and urea mixed in different proportions, in addition to prairie hay.

To compare a urea-sorghum grain mixture with a urea-soybean oil meal mixture and determine the value of urea as a limiting agent, the mixtures were before the heifers at all times.

Experiment II - To compare a self-fed sorghum grain-urea mixture with a self-fed salt-soybean oil meal mixture fed as a supplement to yearling steers wintered on prairie hay and to determine the value of urea as a limiting agent when feeding sorghum grain.

Experiment III - To determine whether urea can be used under pasture conditions to satisfactorily limit intake of supplemental feed for yearling steers being wintered on bluestem pasture.

LITERATURE REVIEW

Digestion

In two digestive trials with calves Embry and Gaslter, (1955) studied the influence of urea on ration digestibility by cattle. They used Hereford steers to obtain information on the value of high protein supplements

containing urea when fed in winter rations composed largely of roughage. In the first trial five rations were used starting with a straight hay ration containing approximately 7.2 per cent protein. The protein in the rations was increased until the fifth ration contained 13.35 per cent protein.

One group was fed soybean oil meal and the other group received a mixed supplement containing four per cent urea. Four per cent urea had no effect on the digestibility of dry matter or on the total digestible nutrients in the ration.

In this experiment the use of four per cent urea permitted the replacement of 35 per cent of the soybean meal with urea. The results indicated that the value of the protein supplement may be lower when this replacement was made with ingredients lower in total digestible nutrients than soybean oil meal.

In the second trial the protein content of the rations varied from 9 per cent up to 15 per cent. The results of this experiment did not indicate any difference in digestibility of high roughage wintering rations supplemented with protein supplements containing soybean oil meal or urea when the total digestible nutrients in the supplement were about the same.

All of the steers refused some of the supplement containing 5.5 per cent urea and 8.2 per cent urea. This indicated that protein supplements composed of only grain products and minerals with about five per cent or more of urea may be unpalatable to cattle when used as the only supplement to roughage.

In metabolism tests conducted by Gallup et al. (1959) results showed that low-protein roughage such as non-legume hay and cottonseed hulls were not efficiently supplemented with urea alone. Much of the nitrogen in the urea was not utilized unless some carbohydrate feed such as a cereal grain

was added to the ration. They also found that urea feeding had no effect on the normal metabolism of calcium, phosphorus, and vitamin A by sheep. It's favorable effect on the digestibility of low-protein rations was the same as that of other high protein supplements.

Feed Intake

Raleigh et al. (1961) studied feed intake and performance of steer calves wintered on meadow hay with and without additional protein. The rations were as follows: (1) hay only, (2) hay plus urea, (3) hay plus cottonseed meal, and (4) hay plus urea and cottonseed meal. Each of the last three rations were fed at three different protein levels - a six per cent crude protein level, a nine per cent crude protein level, and a 12 per cent crude protein level. The animals on each higher level of protein outgained the animals on the lower levels. As the trial progressed those receiving higher levels of protein continually increased their feed intake and gain up to the end of the trial.

The steers receiving their protein supplement from cottonseed meal alone, regardless of level of protein, were thriftier looking animals with more gloss in their hair coat, and appeared to carry a little more finish than those in corresponding levels of protein supplemented by urea and cottonseed meal or urea alone.

Morris (1958) found that the addition of a supplement of urea when silage was fed ad lib. greatly increased voluntary silage consumption. It was suggested that the supplement of urea increased silage consumption by providing nitrogen which was limiting bacterial growth and hence rate of fermentation in the rumen.

In another test he reported a similar increase in the voluntary intake of native grass hay (bush hay) resulting from the addition of supplements of vegetable protein, animal protein and urea with grain sorghum.

In South Africa the hay used during the dry months of the year is of poor quality. During this period the condition of the cattle deteriorates rapidly and they often starve to death. Altona et al. (1960) reported on three experiments using hay and urea. The first test was with two and a half year old steers fed 20 pounds veld hay only, compared to hay plus seven ounces of urea in one pint molasses. The urea-molasses mixture was sprayed on the hay. The difference in weight gain was statistically significant suggesting that veld hay plus urea-molasses could maintain summer weights. The second test was with yearling cattle and the urea-molasses was fed as a lick. Again the weight gains of cattle receiving urea were greater. The actual consumption of hay decreased when urea was added to the diet. In the third experiment, Altona et al. (1960) found that calves make poor utilization of urea and little was gained by spraying hay or silage with urea for calves.

In South Africa the protein in the summer grass is low; therefore, Altona et al. (1960) investigated the possibility of increasing the nitrogen in the rumen by adding urea to a salt lick. One group of yearling steers had access to a urea-molasses-salt block containing 30 per cent urea. At the beginning of the experiment the steers consumed very little of the block containing urea but as they became accustomed to the taste they ate more than the intended three ounces per head daily. The steers receiving the urea-molasses-salt block gained more pounds per head per day than the steers receiving the salt block.

Three tests were conducted by Minson and Pigden (1961) to see if continuous infusion of urea into the rumen of cattle or sheep fed oats straw would increase consumption and dry matter digestibility.

In trial I sheep were fed, every 90 minutes, a ration of pelleted wheat straw (0.6% N) containing two per cent urea, sodium sulphate and a mineral mixture. In trial II, sheep were fed chopped wheat straw and drenched every 90 minutes with an aqueous solution containing one gram of urea. In trial III, steers were fed chopped oats straw (0.5% N) either for four and one-half hours daily or the straw was available at all times. Urea, 150 grams per animal per day, was continuously infused in aqueous solution through rumen fistulas.

Urea had no consistent effect on digestibility coefficients for dry matter, energy, crude fiber and nitrogen free extract, but depressed consumption by 12, 15, and 12 per cent in trial I, II, and III respectively.

Treating Silage with Urea

If urea can be mixed with silage as it is being placed in the silo and supply the needed protein equivalent, it would be an easy convenient way to feed. Cullison (1943) added urea at the rate of 10 pounds per ton of silage at harvest time and compared this silage with regular sorghum silage for wintering beef calves.

Johnson grass hay was fed to both lots at the rate of five pounds per head daily and 35 pounds of silage per head was offered each group. On the urea treated silage, the cows maintained their weight of 930 pounds while on the untreated silage the average loss was 47 pounds per head. The treated silage was superior in palatability with the cows showing preference

for it over the hay. With the untreated silage, the reserve was true. After five and one-half months of storage the carotene content of the treated and untreated silages were 35.96 and 15.71 mcg. per gram thus showing better preservation of the carotene in the treated silage.

The results of a study by Goode et al. (1955) do not agree with Cullisons' results. In a two-year study, 10 pounds of urea per ton of green forage was added to corn silage at the time of ensiling. The resulting silage was similar to the untreated in color, odor, and palatability. The addition of urea increased the average crude protein content from 8.4 to 12.6 per cent on a dry matter basis. There was no significant difference in the performance of mature cows wintered on treated and untreated silage.

In a later test, four lots of eight calves, steers and heifers, were wintered as follows: Lot 1, corn silage plus 0.5 of a pound of soybean oil meal; Lot 2, urea treated corn silage plus 0.5 of a pound of soybean oil meal; Lot 3, corn silage, and Lot 4, urea treated silage. The performance of the calves fed untreated silage was significantly higher than those fed urea treated silage. In a third test yearling heifers fed corn silage made significantly higher daily gains than heifers wintered on urea treated silage. These data indicate that the addition of urea, 10 pounds per ton of silage, lowers the feed value of corn silage fed to young beef cattle.

Time of Feeding Urea

Baker (1963) introduced a management factor in the use of urea and soybean oil meal. In this test he compared urea and soybean oil meal in relation to the time of feeding of the roughage to steer calves. Three

different supplements were used, carrying approximately equal amounts of energy, but with different amounts or sources of nitrogen. The supplements were to be fed prior to the silage, on the silage, and approximately three hours after feeding silage.

In these tests, cattle receiving soybean oil meal ate slightly more silage per day, made higher average daily gains, and required less feed per hundred pounds of gain than did the cattle receiving their nitrogen from a urea source. There were no significant differences in rate of gain to conclude that either feeding with the silage or three hours after the silage had any effect on gains. Neither do the tests show any advantage in feeding supplement prior to feeding silage.

Addition of Minerals

The efficiency of urea utilization as influenced by mineral constituents in a wintering ration for beef steers was studied by Thomas et al. (1953). The effect of adding phosphorus or trace minerals, cobalt, copper and manganese to a wintering ration containing either urea or soybean meal was the subject of an experiment utilizing a factorial design.

Steers fed rations supplemented with soybean meal made significantly greater gains when compared with steers fed rations supplemented with urea. However, there was no significant difference between gains made by steers fed urea, trace minerals, and adequate phosphorus and gains made by steers fed soybean meal and adequate phosphorus.

Results of work reported by the University of Illinois at their 24th Cattle Feeders' meeting (1952) emphasized the advisability of supplying a mineral supplement when urea was fed. In setting up a test investigating

the effect of mineral supplementation upon the value of urea as a source of protein in the wintering ration of beef calves, three rations of equal energy and nitrogen content were compared.

The basal ration consisted of corn silage, ground corn meal, soybean meal and mineral mix. This was fed to Lot 1. Lots 2 and 3 were fed a mixed supplement containing approximately 40 per cent of the total nitrogen from urea. In addition Lot 2 received a trace mineral mixture. This mixture included bone meal, limestone, trace mineralized salt and sulfur. Lots 2 and 3 receiving the supplement containing urea made satisfactory gains but the gains were not as good as the cattle receiving soybean oil meal. A comparison of the results from Lot 2 and 3 emphasized the advisability of supplying a mineral supplement when urea was fed.

According to Nelson et al. (1961) tests conducted at the Oklahoma Experiment Station indicated that urea was apparently not efficiently utilized by cattle wintering on dry range grass when it was added to a mixture of corn and cottonseed meal to produce a pellet containing 40 per cent protein with one-third of the nitrogen furnished by urea.

The addition of trace minerals or dehydrated alfalfa meal to these supplements improved urea utilization. Additional work included a test of wintering weaning calves on dry native pasture where they were fed one of six different supplements. The supplements contained either 26 per cent or 40 per cent protein and each varied in its mineral content. Better gains were made by cattle fed supplements not containing urea than those receiving a supplement containing urea. More pounds of gain were made by the cattle in lots being fed urea and increasing quantities of minerals than in lots not receiving additional minerals.

Natural Protein vs. Urea

Weber (1944) compared four methods of supplementing light steer calves on an Atlas sorgo silage wintering program. One lot received no supplement, the second cottonseed meal, the third urea and the fourth urea plus ground corn. The daily gains of these lots indicated that stock calves derive considerable benefit from the nitrogen in urea.

Weber (1945) followed this work with a comparison of cottonseed meal and a mixture of urea, ground corn, and bone meal as a supplement for wintering yearling steers on prairie hay. The steers fed the urea protein received considerable value from the urea but their gains were not equal to the gains made by the cattle receiving cottonseed meal.

In Rhodesia, winter pastures are extremely deficient in protein and the cost of natural proteins is high. Murray and Romyn (1939) compared peanut cake and urea as a supplement for wintering yearlings on veld hay and silage. Three supplements were used, one pound peanut cake, 0.5 of a pound of peanut cake plus urea and all urea. The gains were quite similar and in this test all groups did equally well.

Reynolds et al. (1956) also found in two wintering feeding trials with beef heifers that there were no significant differences between feeding urea, urea plus cottonseed meal and Purdue Supplement A in both high silage and high hay rations. On the average urea was effective in replacing a part of the cottonseed meal.

Ewing et al. (1963) studied urea supplements for beef cows. This test was designed to evaluate urea as the major source of supplemental nitrogen in beef cow wintering rations, typical of the Corn Belt area.

Supplement I contained soybean oil meal; Supplement II contained urea, molasses, and dehydrated corn cobs, and Supplement III contained urea, molasses and ground corn. The energy content of the ration was regulated by the quantity of corn silage and ground corn cobs fed. The fortified soybean meal control supplement produced gains above those noted for the urea supplements; however, the gains observed in all lots would be considered adequate for good reproductive performance in beef cows. These results, along with those in two previous trials, indicate the possibility of using urea effectively in beef cow wintering rations of the type used in these studies. The corn silage fed in this ration apparently had enough corn in it to make it possible for the animal to utilize the urea in the ration.

In looking for an economical supplement for wintering calves in the Nebraska Sand Hills, Brouse (1955) conducted tests to find the relative value of mixed rations based on alfalfa meal, dehydrated alfalfa, oil meals, corn and urea in a wintering ration for calves in the Sand Hills of Nebraska.

In the first test, mixed supplements consisting of alfalfa meal, soybean oil meal, ground corn, urea and steam bone meal in various combinations were fed. The roughage used in this test was prairie hay. The rate of gain using a supplement of alfalfa meal, urea and steam bone meal was slightly less than various combinations of alfalfa meal, soybean oil meal, urea and steam bone meal. These feeding trials indicated that urea may be substituted for a part of the protein in a supplement for wintering calves.

Guyer (n.d.) made a summary of eight tests at four different experiment

stations where urea was used in the protein supplement under various conditions for wintering calves. Where limited amounts of grain were used in wintering rations, urea appeared to be a reasonable, effective substitute for protein. The following table shows the results of this summary:

Table 1. Plant protein vs. urea containing supplements for wintering calves in the feed lot.

Station	Year	Ration	Average Daily Gain	
			Control	Urea
Montana	1954	4 lb Barley-Prairie Hay	1.19	.97
Nebraska	1956	1.5 lb Grain-Corn Silage	2.00	2.04
Nebraska	1957	1.5 lb Grain-Corn Silage	1.72	1.63
Nebraska	1961	2.5 lb Milo-Corn Silage	1.94	1.74
Nebraska	1962	4 lb Milo-Corn Silage	1.60	1.50
Ohio	1960	4 lb Corn-Hay and Hay Silage	1.27	1.22
Tennessee	1955	Corn Silage	1.43	1.47
Tennessee	1956	Corn Silage	1.06	1.06

In a summary of seven year's work at the Oklahoma Experiment Station, Gallup et al. (1953) reported trials with wintering heifers and steers on dry native grass with supplements of cottonseed meal and pellets where 25 per cent of the nitrogen came from urea. For three consecutive years yearling Hereford heifers were divided into two groups and wintered on dry native grass and protein supplements for 100 to 148 days. The heifers in one group were fed a supplement of cottonseed meal and those in the corresponding group were fed a pelleted supplement with 25 per cent of its nitrogen as urea.

In another test, heifer calves were wintered on the range with cottonseed meal and urea pellets (25 per cent of nitrogen from urea). In a third

test, two year old steers were wintered on dry native grass and pellets for three consecutive trials. The results of these wintering trials show that steers or heifers fed the urea pellets wintered as well as those fed an equal amount of cottonseed meal, with the exception of the single trial with the heifer calves. The level of protein supplement in the trials with yearling heifers and two year old steers was quite high and it was possible that the natural protein in the urea pellets may have approached the minimum requirements of the cattle.

Further work at the Oklahoma Experiment Station was summarized by Nelson and Waller (1962). Urea-containing supplements were not efficiently utilized by beef cattle wintered on dry range grass. A total of 879 cattle were used in 16 tests to investigate the value of urea when it furnished one-third or one-half of the nitrogen in the supplement. The addition of trace minerals improved urea utilization. Cows did not efficiently utilize a supplement containing 50 per cent of the nitrogen from urea.

Molasses-Urea Mixtures

Many different types of compounds have been fed in combination with urea in an effort to obtain the most desirable combination of nutrients that would enable the animal to best utilize urea. The possibility of feeding a mixture of liquid molasses and urea in combination with other minor ingredients, free choice to cattle, was investigated by several research workers.

Richardson et al. (1958d) studied the value of ammoniated blackstrap molasses in beef cattle rations using varying amounts of sorghum grain and soybean oil meal with ammoniated blackstrap molasses. The animals received

all of the sorghum silage they would clean up in all of the lots. The remainder of the ration was as follows (per head daily): Lot 1 - one pound soybean oil meal and two pounds sorghum grain; Lot 2 - free choice ammoniated blackstrap molasses (16% protein equivalent) and 0.5 of a pound of soybean oil meal; Lot 3 - free choice ammoniated blackstrap molasses (16% protein equivalent) 0.5 of a pound of soybean oil meal and 1.5 pounds of sorghum grain.

Although the rate of gain was satisfactory in all lots, higher rates of gain were made by the cattle in lots receiving some natural protein supplementation.

In order to provide animals with an adequate supply of phosphorus to utilize the urea-molasses supplement, Richardson et al. (1958c) investigated the value of phosphoric acid mixed in a blackstrap molasses urea mixture. Heifer calves received all the sorghum silage they would clean up each day. In addition, Lot 1 received free choice molasses, urea, phosphoric acid; Lot 2 same as Lot 1 plus 0.5 of a pound of soybean oil meal and 1.5 pounds of sorghum grain per head daily; Lot 3, one pound soybean oil meal and two pounds of sorghum grain per head daily. Satisfactory gains were obtained on the silage and urea-molasses mixture; however, the rate of gain was increased by adding soybean oil meal and grain to the ration.

In other studies by Richardson et al. (1958b) adding ethyl alcohol to a molasses, urea, phosphoric acid supplement was investigated. Heifers on sorghum silage were fed a supplement of either (1) soybean oil meal plus two pounds grain, (2) free choice urea-molasses mixture or (3) free choice urea-molasses plus ethyl alcohol mixture. The rate of gain in the molasses-urea and molasses-urea-alcohol lots was satisfactory and about the same,

but gains were better in the soybean oil meal lot.

In a second test where Richardson et al. (1958a), self-fed ammoniated blackstrap molasses with or without ethyl alcohol and ammoniated hydrol to beef heifers the results were about the same as previous tests. Self-fed ammoniated molasses can be used as a source of nitrogen by ruminants where fed a non-legume roughage; however, results were vastly improved when a small amount of natural protein concentrate was added to the ration. These results showed that ethyl alcohol was of very little, if any, value in the ration.

Bohman et al. (1954) conducted an experiment that indicated urea was not a good supplement for poor quality roughage rations. In every lot but one, the animal that received the soybean oil meal rations, with corn or molasses, gained significantly more than the urea supplemented animals. The nitrogen balance data showed that adequate synthesis of protein from urea did not occur in the urea rations.

Horton et al. (1962) conducted a series of five trials on supplementing certain roughages with a liquid urea-molasses preparation. Each trial compared a urea-molasses supplement with a cottonseed meal supplement. The first trial used cottonseed hulls; the second trial corn silage and sorghum silage; the third trial red clover hay and lespedeza hay; the fourth trial native pasture, and the fifth trial winter native pasture and prairie hay.

The results indicated that when cottonseed hulls were supplemented with either cottonseed meal or a urea-molasses mixture the feeding value was approximately equal. When corn silage or sorgo silage was supplemented with urea-molasses or with cottonseed meal, an increased rate of gain was obtained by using the cottonseed meal. When lespedeza or red clover hay was supplemented with either molasses alone or urea-molasses, the average daily

gain was essentially the same. There was no significant difference in feeding a urea-molasses mixture or a 15 per cent protein grain supplement on growing pasture. In most tests, feeding urea molasses free choice resulted in the cattle eating more than was necessary to supply adequate protein. These tests indicated that the urea-molasses mixture could be used as a satisfactory supplement under certain circumstances, but in most cases by feeding it free choice the cost was high.

According to Woods et al. (1963) urea did not adequately replace one-half of the protein of cottonseed meal in steer wintering rations composed chiefly of Bermuda hay. However in three feeding trials conducted to determine whether urea-molasses could be used to partially replace cottonseed meal in wintering rations for steers when ground snapped corn was included in the ration to facilitate the conversion of urea nitrogen to protein, there was no significant difference between the rate of gain of steers on the two rations. In this test, one pound of ground snapped corn satisfactorily replaced one pound of cottonseed meal when a 10 per cent non-protein nitrogen urea-molasses mixture was included in the ration.

Thompson (1961) found that 600 pound cattle wintered on corn silage made one-fourth pound per head per day more gain when supplemented with two pounds of soybean oil meal than calves supplemented with free choice liquid urea-molasses supplement. The cattle on the soybean oil meal supplement required about 1800 pounds less silage per hundred pounds of gain.

At times other products containing nitrogen are available for feed uses. Dougherty and Denham (1964) investigated the value of LPC and AEP as a replacement for soybean oil meal. LPC is liquid protein concentrate from sugar beet manufacture containing 5.9 per cent nitrogen. AEP is acid

end product from sugar beet manufacture containing 3.5 per cent nitrogen.

During the wintering period weaner steer calves were fed two types of roughage - cane fodder or millet hay. The winter gains were as follows:

(1) cane fodder and soybean oil meal 110.63 pounds

(2) cane fodder and LPC 67.19 pounds

(3) cane fodder and soybean oil meal and AEP 119.07 pounds

(4) millet and soybean oil meal 76.88 pounds

(5) millet and LPC 32.19

(6) millet and soybean oil meal and AEP 62.19.

Another product, Biuret, has been tested by Berry and Franke (1961). This study was designed to compare the effectiveness of biruet, urea and cottonseed meal as sources of nitrogen supplementary to sorghum silage for growing beef heifers. Group 1 was fed two pounds of cottonseed meal and three pounds of ground sorghum grain per head daily. Group 2 was fed 4.75 pounds of ground sorghum grain plus 0.25 of a pound of urea. Group 3 was fed 4.75 pounds of sorghum grain plus 0.25 of a pound of biuret. Group 1, the control group, and Group 2, the urea group, made about the same amount of gain while Group 3, the biuret group, gained about 26 pounds less in the 160 day feeding period. In this test where 4.75 pounds of sorghum grain was fed, in addition to the urea, the heifers made efficient use of the urea as a supplemental protein.

Urea in High Energy Rations

Where properly supplemented, urea nitrogen can be utilized by cattle and can supply most or all of the supplemental protein required by the animal.

Gallup et al. (1953) summarized eight years of work with feeding supplements where 25 per cent, 50 per cent and 85 per cent of the total nitrogen was supplied by urea. These supplements were used in a full feeding program. There was little difference between 25 per cent and 50 per cent urea lots. Palatability of the feed may have been the limiting factor rather than the lack of utilization of the urea in the 85 per cent urea supplement.

Newland et al. (1962) studied full feeding steers using 33 per cent and 100 per cent of the supplemental protein equivalent from urea. Supplying 100 per cent of the supplemental protein from urea did not significantly depress growth rate.

Burroughs et al. (1963) compared four supplements in a full feeding program. The protein supplements included no urea, one-third non-protein nitrogen, urea, two-thirds non-protein nitrogen, urea and 100 per cent non-protein nitrogen, urea. All supplements performed well and the 100 per cent urea supplement performed as well or better than any lot.

EXPERIMENT I

Experiments using urea as a source of supplemental protein in low energy rations have been conducted by several experiment stations. The results of these tests have varied considerably. This experiment was conducted to collect additional information on the utilization of urea by heifer calves on a low energy ration and to study the possibility of using urea not only as a source of protein but also as an agent to restrict feed intake where it may be desirable to have feed before cattle at all times but a limited intake is desired.

Method and Procedure

Eight heifer calves, weighing from 330 to 390 pounds each, were divided into two lots of four calves each. Two sets of identical twins, one Hereford and one Angus, and four additional good quality Hereford heifer calves were used. One of each set of twins was allotted to each treatment and the other four calves were allotted by weight. Prior to going on test the heifers were on a ration of alfalfa hay and two pounds of sorghum grain per head daily.

The calves were housed in pens with sheds open to the South. Calves in each pen had access to electrically heated waterers. They were fed supplement in a trough placed in the corner of the back of each shed so that it was protected from rain and snow. The hay was fed in a rack under the shed. The cattle were weighed at the start of the test, October 9, 1961, weighed about every 28 days and weighed off test May 9, 1962.

The supplements were mixed at each feeding. Prairie hay was kept before the animals at all times.

The first two days on test both pens had placed before them a mixture made up of one pound salt and one pound urea. None of this material was consumed. It was removed and a mixture of 0.25 of a pound of salt to one pound urea was placed in each pen. The purpose of reducing the salt and increasing urea was to determine if, when the animals become "salt hungry" they would consume the salt-urea mixture. On the 11th day, Pen B's mixture was changed to 0.125 of a pound of salt to one pound of urea. This mixture was kept before them until the 56th day on test. Pen A continued to receive the mixture composed of 0.25 of a pound of salt to one pound of urea.

On the 57th day, Pen A was changed to supplement of 0.05 of a pound of salt, 0.125 of a pound of urea and one pound soybean oil meal per head per day. Pen B was changed to 0.05 of a pound of salt, 0.125 of a pound of urea and one pound fine ground sorghum grain per head per day. The urea in each ration was increased gradually up to 0.25 of a pound per head per day. At this point the urea restricted the consumption of both supplements to 1.25 pounds per head per day. After reaching this point several days feed supply was kept in the trough at all times.

Results and Discussion

Consumption of Urea-Salt Mixture. The results of this phase of the experiment are reported in Table 2. The urea salt mixture was before the calves at all times. The total consumption per calf in Pen A of urea was one pound and of salt 3.3 pounds. The calves in Pen B consumed only 0.37 of a pound of urea and 1.1 pound of salt. The greater percentage of urea included in the mixture fed to Pen B seemed to retard salt consumption. By mixing only 0.125 of a pound of salt with each pound of urea for Pen B an attempt was made to obtain urea consumption through developing a hunger for salt. This was not accomplished. Greater consumption of urea was obtained in Pen A where salt was increased to 0.25 of a pound per pound of urea, although neither pen consumed the mixture in sufficient quantity to supply adequate nitrogen.

The Use of Urea in Restricting Intake of Supplemental Feed - Comparison of a Urea-Soybean Oil Meal Mixture and a Urea-Sorghum Grain Mixture. The results of this test are reported in Table 3. The consumption of both

soybean oil meal and sorghum grain was restricted to one pound per head per day by feeding a ratio of 0.25 of a pound of urea to one pound of grain or soybean oil meal.

Table 2. The consumption of a urea-salt mixture by calves. (December 19, 1961 to February 13, 1962, 56 days)

Treatment	0.25 lbs salt to 1.0 lb urea		0.125 lbs salt to 1.0 lb urea	
Lot Number	A	A Twins	B	B Twins
No. of heifers per lot	4	2	4	2
Initial wt. per heifer lbs	357.5	356.3	360.0	360.0
Total gain lbs	17.5	21.2	20.0	22.5
Final wt. per heifer lbs	375.0	377.5	380.0	382.5
Av. daily gain per heifer lbs	.32	.38	.36	.40
Av. daily ration				
Prairie hay lbs	10.6		10.2	
Urea lbs	.018		.006	
Salt lbs	.059		.018	
Feed per cwt. gain lbs				
Prairie hay lbs	3405.0		2226.0	
Urea lbs	5.7		1.8	
Salt lbs	18.8		5.2	
Feed cost per cwt. gain	$27.82		$17.99	

Both pens consumed practically the same amount of prairie hay, however, Pen A, receiving urea-soybean oil meal, gained 0.8 of a pound daily while Pen B, receiving urea-sorghum grain, gained 0.35 of a pound daily. The addition of 0.25 of a pound of urea and one pound of sorghum grain to Pen B did not result in a greater daily rate of gain over their previous gain reported in Table 2, while the addition of 0.25 of a pound of urea and one pound of soybean oil meal more than doubled the daily rate of gain in Pen A.

In a summary of several experiments in Oklahoma, Gallup (1953) also found that heifer calves did not perform as well when fed a supplement

containing urea when compared to calves receiving cottonseed meal although yearlings and two year old steers performed satisfactorily when fed a supplement containing urea.

Table 3. The use of urea to restrict intake of supplemental feed. A comparison of a soybean oil meal and urea mixture and sorghum grain and urea mixture. (February 14, 1962 to May 9, 1962, 85 days)

Treatment	Soybean oil meal and urea		Sorghum grain and urea	
Lot Number	A	A Twins	B	B Twins
No. of heifers	4	2	4	2
Initial wt. per heifer lbs	375.0	380.0	377.5	382.5
Total gain per heifer lbs	67.5	65.0	30.0	32.5
Final wt. per heifer lbs	442.5	445.0	407.5	415.0
Av. daily gain lbs	.80	.77	.35	.39
Av. daily ration				
Prairie hay	11.9		11.9	
Urea lbs	.23		.224	
Soybean oil meal lbs	1.0			
Sorghum grain lbs			.97	
Salt	.047		.046	
Feed per cwt. gain				
Prairie hay lbs	1497.5		3335.0	
Urea lbs	28.7		60.3	
Soybean oil meal lbs	124.4			
Sorghum grain lbs			273.3	
Salt lbs	5.8		12.6	
Feed cost per cwt gain	$18.76		$35.64	

EXPERIMENT II

Wintering steers on roughage and a protein supplement is a practice followed by some Kansas stockmen. If the steers are to be grazed the following summer, a high rate of gain during the wintering period is not important. It is desirable to winter the steers as cheaply as possible and the steers gain a small amount of weight and remain in good healthy condition.

Reducing the cost of the protein supplement and cutting labor cost by self-feeding the supplement is desirable. Salt has been used successfully to restrict consumption of soybean oil meal, therefore, this material can be used as a limiting agent, varying the per cent of salt with the desired consumption of soybean oil meal.

Under certain conditions urea can supply the supplemental protein equivalent needed in the ration for steers. This experiment was conducted to compare a self-fed urea-sorghum grain supplement with a self-fed salt-soybean oil meal supplement for yearling steers wintered on prairie hay and to study the use of urea to restrict consumption of sorghum grain. The results were measured by the growth performance of the steers.

Method and Procedure

The steers used in this experiment were purchased as calves, in the fall, from near Ft. Davis, Texas. They were wintered and then summer grazed on bluestem pastures prior to this test.

Twenty good quality yearling Hereford steers were divided into two lots, 10 in each lot, on the basis of weight.

The cattle were in open lots with no shelter and the hay and supplement was fed in open bunks. The cattle were individually weighed at the start and end of the experiment and about every 28 days during the test. They were taken off feed and water in the evening, stood in dry lot over night and weighed at 8:00 a.m. in the morning. Each lot was fed all the prairie hay they would consume.

Lot 1 was started on a supplement made up of 0.15 of a pound of salt and one pound of soybean oil meal per head per day. The salt content of

the supplement was gradually raised to 0.8 of a pound of salt to one pound of soybean oil meal. At this point consumption stablized at one pound of soybean oil meal per head per day. On the 85th day of the experiment, 0.05 of a pound of dicalcium phosphate was added to the mixture. This mixture was continued to the end of the experiment.

Lot 2 was started on a supplement made up of 0.15 of a pound of salt, 0.05 of a pound of urea plus one pound of fine ground sorghum grain per head per day. The salt and urea were gradually raised and on the 12th day on test the mixture was 0.35 of a pound of salt, 0.1 of a pound of urea plus one pound of fine ground sorghum grain per head per day. At this point the salt was gradually lowered and the urea raised until the 56th day on test the supplement was made up of 0.1 of a pound of salt, 0.3 of a pound of urea plus one pound of fine ground sorghum grain per head per day. At this point consumption stablized at one pound of grain per head per day. At this point 0.05 of a pound of dicalcium phosphate was substituted for 0.05 of a pound of salt in the mixture. After 10 days of this mixture consumption started to drop slightly so the urea content was lowered to 0.25 of a pound per head per day. Consumption remained steady at one pound of sorghum grain per head per day for the remainder of the experiment. The mixture was 0.05 of a pound of salt, 0.05 of a pound of dicalcium phosphate, 0.25 of a pound of urea plus one pound of fine ground sorghum grain.

Results and Discussion

Growth and feed consumption data are shown in Table 4.

Table 4. A comparison of urea-sorghum grain and salt-soybean oil meal self-fed as a supplement to yearling steers wintered on prairie hay. (December 19, 1961 to April 30, 1962, 133 days)

Lot No.	1	2
No. of steers	10	10
Initial wt/steer lbs	688.0	686.0
Total gain/ersteer lbs	25.5	47.5
Final wt/steer lbs	713.5	733.5
Daily gain/steer lbs	.19	.36
Average daily feed consumption per steer		
Prairie hay lbs	16.8	17.9
Sorghum grain lbs		.99
Soybean oil meal lbs	.97	
Urea lbs		.21
Salt	.73	.11
Dicalcium phosphate lbs	.022	.03
Av. Total Feed Cost/Head	$24.64	$23.64
Av. daily feed consumption last 65 days of test		
Prairie hay lbs	17.0	15.0
Sorghum grain lbs		1.0
Soybean oil meal lbs	1.0	
Urea		.25
Salt	.8	.05
Dicalcium phosphate lbs	.05	.05
Feed/cwt gain		
Prairie hay lbs	8749.0	5019.0
Sorghum grain lbs		276.0
Soybean oil meal lbs	507.0	
Urea lbs		56.0
Salt	379.0	30.0
Feed cost/cwt gain	$93.04	$49.33

The steers in Lot 2 receiving the urea-grain supplement gained slightly more than the steers in Lot 1 receiving the salt-soybean oil meal. The respective total gains were 47.5 pounds and 25.5 pounds per steer. Prairie hay consumption in Lot 2 was approximately one pound per day more per head than Lot 1, 17.9 pound compared to 16.8 pound. Wintering

cost per steer was $1.00 less for Lot 2 than Lot 1. The cost of the urea-grain supplement was over $2.00 cheaper per steer for the entire feeding period than the salt-soybean oil meal supplement but the urea-grain lot consumed more hay. On a feed cost per pound of gain basis gains in Lot 1 cost almost twice as much as gains in Lot 2, $93.04 compared to $49.33.

In this test a urea-sorghum grain mixture seemed to be better utilized than a salt-soybean oil meal mixture where salt intake was fairly high.

Weber (1945) found that steers fed a supplement of urea, ground corn and bonemeal gained less on a silage wintering ration than steers supplemented with cottonseed meal. The meal was not mixed with salt. Yearling steers on a maintenance program, where winter gains are not important, can be limited on their intake of supplemental feed by using urea.

In this test it required 0.8 of a pound of salt per head per day to restrict soybean oil meal consumption to one pound per head per day and it required 0.25 of a pound of urea per head per day to restrict the consumption of fine ground sorghum grain to one pound per head per day.

It was interesting to note that in Experiment I it took 0.25 of a pound of urea to restrict consumption of heifer calves to one pound of fine ground sorghum grain per head per day, the same amount was required in the yearling steer ration.

EXPERIMENT III

Self-feeding a supplement to cattle being wintered on grass would reduce the labor required in caring for the cattle during the winter. Adding salt to a protein supplement has been used successfully in restricting consumption to a desired level. The use of urea to restrict

consumption has the added possibility of supplying a part of the protein equivalent required by the animal.

This test utilized four bluestem pastures to determine whether urea could be used under pasture conditions to satisfactorily limit intake of supplemental feed. The supplemental feed during the winter period was offered free choice and depended on either salt or urea or a combination of the two to limit consumption to under two pounds of supplemental feed per steer daily.

Method and Procedure

Yearling Hereford steers with an average grade of high good were used. The steers came from near Thermapolis, Wyoming, were received at the Kansas station in March, 1961, and were used in summer grazing studies preceding this test. The weights reported were taken after an overnight stand in dry lot without feed or water.

Ten steers were allotted to each of the four pastures and the test was conducted for 138 days. At the beginning of the test a relatively high per cent of salt and low per cent of urea was included in the supplement. As the test continued the per cent salt was decreased and per cent urea increased. In some instances additional salt was added to the supplement in some pastures in order to keep the consumption in all pastures about equal.

Table 5 shows the various supplemental mixtures and the number of days they were fed.

Table 5. Supplemental mixtures fed free choice to yearling steers on pasture. (December 13, 1961 to May 1, 1962, 138 days.)

No.	1	2	3	4	5
No. of days fed	47	13	28	35	15
Salt (%)	20	12	5	5	5
Urea (%)	5	10	12	12	12
Dicalcium Phosphate (%)	5	5	5	5	
Soybean oil meal (%)	30	10	30		
Grain sorghum (%)	40	53	38	78	82.6
Dehydrated alfalfa (%)		10	10		
Phenothiazine (%)					.4
Per cent Protein Equivalent	29.5	41.78	49.38	37.68	44.28

Results and Discussion

The results of this test are reported in Table 6. In three of the four pastures the consumption of the supplement fed in this experiment was restricted to about 1.75 pounds per head daily, when 12 per cent urea and 5 per cent salt was included in the mixture. In the fourth pasture additional salt was added to the supplement to restrict consumption to the desired level.

Although urea did satisfactorily limit intake, the steers lost weight. According to Gnadt (1964) steers receiving this amount of feed should gain about 65 pounds each.

Altona et al. (1960) found that in Africa steers on pasture consuming a urea-salt-molasses block gained more weight than steers receiving only a salt block. The pasture grass was low in protein.

Table 6. The use of urea to limit intake of supplemental feed by yearling steers on pasture. (December 5, 1961, to May 1, 1962, 147 days.)*

Pasture No.	7A	7B	13	15
No. steers	10	10	10	10
Initial wt lbs	581	594	591	592
Weight loss per steer lbs	-36	-46	-14**	-13**
Daily loss per steer lbs	-0.25	0.31	0.10	-0.09
Daily ration per steer, self-fed:				
Salt lbs	.271	.230	.208	.297
Urea lbs	.158	.150	.154	.150
Dicalcium phosphate lbs	.047	.045	.045	.047
Defluorinated phosphate lbs	.028	.028	.026	.026
Phenothiazine lbs	.007	.006	.006	.006
Dehydrated alfalfa lbs	.056	.056	.052	.052
Soybean oil meal lbs	.317	.317	.303	.310
Ground sorghum grain lbs	.881	.831	.872	.846
Total	1.765	1.663	1.670	1.734
Bluestem pasture	----------Free choice----------			

*This was the total wintering period, but supplement was not added to the ration until December 13, so the daily ration is figured on 138 days.

**Gains significantly different from those in Pastures 7A and 7B, .05 level of significance.

SUMMARY

Eight heifer calves including two sets of twin heifers were used in Experiment I to investigate the possibility of using urea to restrict feed intake where it may be desirable to have feed before cattle at all times but a limited consumption is desired and also to compare a urea-soybean oil meal mixture and a urea-sorghum grain mixture supplement for calves fed prairie hay.

In the first phase of the experiment comparing a mixture of 0.25 of a pound of salt and one pound of urea and a mixture of 0.125 of a pound of

salt and one pound of urea, neither pen consumed the mixtures in sufficient quantity to supply adequate nitrogen.

In the second phase of the experiment the consumption of both soybean oil meal and sorghum grain was restricted to one pound per head daily by feeding a ratio of 0.25 of a pound of urea to one pound of soybean oil meal or grain.

Although both pens consumed about the same amount of prairie hay the pen receiving a mixture of urea and soybean oil meal made the most rapid daily gain.

In Experiment II the use of urea to restrict intake of sorghum grain was studied and a comparison made of a urea-sorghum grain supplement and a salt-soybean oil meal supplement.

In this test using 10 yearling steers per lot a mixture of 0.25 of a pound of urea to one pound of fine ground sorghum grain restricted the feed intake to one pound of grain per head daily.

This test indicated that a urea-sorghum grain mixture seemed to be better utilized than a salt-soybean oil meal mixture where salt intake was fairly high.

Forty yearling steers wintered in four different pastures were used in Experiment III to determine whether urea could be used under pasture conditions to satisfactorily limit intake of supplemental feed.

In three of the four pastures supplemental feed intake was restricted to 1.75 pounds per head daily when 12 per cent urea and 5 per cent salt was included in the mixture. In the fourth pasture it was necessary to add more salt to restrict intake to 1.75 pounds per head per day.

All steers lost weight during the experiment. According to Gnadt (1964) steers receiving this amount of soybean oil meal should gain about 65 pounds each.

It was fairly well established in all three experiments that urea when mixed with concentrates could be used to limit intake of the concentrate mixture to a fairly low level. About 0.25 of a pound of urea per animal daily, consumed as a part of the concentrate mixture, seemed to limit concentrate intake to one or two pounds per animal daily. This was in addition to as much roughage as the animals would consume.

In none of the experiments were any toxic effects noted.

The efficiency of the use of this mixture compared to more conventional supplements was not clearly established. There was some indication that with poor quality roughage such as old mature weathered grass that a urea-grain mixture was inefficient in maintaining weight gains.

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THE USE OF UREA IN LIMITING SUPPLEMENTAL FEED INTAKE AND EFFICIENCY OF UREA UTILIZATION BY CATTLE ON HIGH ROUGHAGE RATIONS

by

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Urea has been used for some time as an effective source of supplemental nitrogen in high energy diets for ruminants. The research reported here was concerned with the use of urea in high roughage rations for young growing cattle. The primary objective was to determine if urea could be used to restrict the intake of supplemental concentrate feed, which was before the animal at all times, as well as serve as an efficient source of nitrogen.

In the first experiment, two groups of heifer calves were fed salt and urea mixed in different proportions to study the palatability of a mixture of salt and urea. One group had available to them at all times a mixture of 0.25 of a pound of salt to one pound of urea, the other a mixture of 0.125 of a pound of salt to one pound of urea. Prairie hay was also fed. Neither group consumed the mixture in sufficient quantity to supply adequate nitrogen. The urea was very unpalatable to the animals.

In the second phase of the first test, one group of heifers had before them at all times a mixture of urea and soybean oil meal, another group a mixture of urea and ground sorghum grain. The consumption of both soybean oil meal and sorghum grain was restricted to about one pound per head daily by feeding a ratio of 0.25 of a pound of urea to one pound of grain or soybean oil meal. Prairie hay was fed to both groups. The group receiving the urea-soybean oil mixture gained 0.8 of a pound per head daily, those receiving the urea-sorghum grain mixture gained only 0.35 of a pound each daily.

In a second experiment with two groups of yearling steers, a comparison was made where a urea-sorghum grain mixture was before the steers of one group at all times and a salt-soybean oil meal mixture was before the other group. Prairie hay was fed both groups. It required 0.25 of a pound of

urea per head daily to restrict the consumption of fine ground sorghum grain to one pound per head daily and 0.80 of a pound of salt to restrict the soybean oil meal intake of the other group to one pound per steer daily. Those receiving the urea-sorghum grain mixture gained 47.5 pounds each and those receiving the salt-soybean oil meal mixture 25.2 pounds each for a winter feeding period of 133 days.

In the third experiment, a urea mixture was fed to steers on winter bluestem pasture to determine if urea would restrict the intake of a concentrate mixture kept before them at all times. Consumption of the concentrate mixture varied somewhat and in some periods salt was used to restrict consumption to the desired level. About 12 per cent urea proved effective in limiting intake of the concentrate mixture to about 1.75 pounds per steer daily.