UREA IN WINTER RATIONS FOR RANGE BEEF CATTLE

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INTRODUCTION

As early as 1891 German scientists demonstrated that the ruminant can utilize non-protein nitrogen by virtue of the bacteria and protozoa in the rumen. Since that time much research has been devoted to the use of urea as a means of extending protein supplies.

This research, together with periodic shortages of protein supplements, has resulted in a tremendous increase in the use of urea in livestock feeds during the last half-century. It is possible that urea can reduce animal production costs in areas where grass and roughage are abundant, but the supply of protein supplement is short. The Southwest is such an area, where protein deficiencies frequently occur in cattle and sheep rations during the winter months.

There have been many studies which indicate that urea may satisfactorily replace part of the protein in the rations of fattening cattle. But there is a lesser number of tests on the value of urea in wintering rations in which the quantity of concentrate feed offered as a supplement to grass hays or dry native grass pastures is very limited.

From previous work with fattening cattle, it has been concluded that a protein supplement should not contain over 1/3 urea nitrogen. However, it is desirable to test the effects of a larger percentage of urea nitrogen in a protein supplement for wintering beef cattle under range conditions for several successive winters.

REVIEW OF LITERATURE

Armsby (1911) was one of the first to review the literature concerning protein synthesis from non-protein sources. He concluded that when the protein level of the ration was low and other conditions favorable, non-protein nitrogen can partially replace natural protein feeds for maintenance, and possibly for growth and milk production. It was his belief that the protein synthesized by the rumen bacteria was of inferior quality, but that the addition of non-protein nitrogen might increase performance of ruminants fed protein deficient rations.

Krebs (1937) (as cited by Pope, 1952), published an extensive review of literature on non-protein nitrogen utilization and concluded that although there was evidence that bacterial protein synthesis took place in the rumen, the quantity of protein synthesized was small and of little benefit to the ruminant.

In a later review, Reid (1953) concluded that a low level of true protein and a high level of starch in the ration favors urea utilization. Highly soluble and readily hydrolyzable protein in the ration tends to depress the utilization of urea nitrogen, as bacteria prefer protein nitrogen. Sugars and cellulose are inferior to starch as sources of energy for ruminal microorganisms. Since urea is soluble in water and rapidly hydrolyzed, the need for available carbohydrates at the time of ingestion is indicated. Sugars disappear from the rumen too rapidly and cellulose is made available too slowly to satisfy the needs of the bacteria. He also stated that elemental sulfur or sulfur-containing amino acids apparently promote urea utilization in sheep but has no effect on cattle.

Growth Studies

Hart and co-workers (1939), were among the first in America to study urea utilization. They conducted long-term growth studies with young dairy stock fed a low-protein ration of timothy hay, corn, starch and molasses (containing about 6 percent total protein), and the same ration supplemented with urea, ammonium carbonate or casein. The addition of each of the nitrogenous supplements raised the total protein level of the ration to approximately 18 percent. They concluded that urea was utilized, that a readily fermentable carbohydrate increased utilization, and that urea was more effective when fed at a level of 43 percent of the nitrogen ingested than at a level of 66 or 70 percent.

One of the few long time growth experiments using urea was conducted by Schmidt and Kliesch (1943) (as cited by Dinning, 1948). They used three lots of five calves each and fed them over a period of 252 days. One group received a basal ration of clover hay and dried beet pulp, while a control group received the basal plus a concentrate thought adequate to cover their protein needs. For the third group urea nitrogen replaced 50 percent of the protein nitrogen of the control group. The growth curves of the control groups were far above those of the other two, while the group receiving urea grew at a rate only slightly above the basal group. These workers concluded that growing calves are not able to use the nitrogen of urea to any practical extent for growth.

Watson and associates (1949) combined growth studies and carcass analyses to measure the increase in body protein of steers and lambs fed low-protein rations supplemented with urea or casein. In one test, 30 steers were divided into five groups. Two steers of each group were slaughtered at the beginning of the experiment and their carcasses analyzed for protein, fat and ash. Of the remaining three steers in each group, one was fed the low-protein ration, one the low-protein ration plus urea, and one the low-protein ration plus casein. After a growth period of 40 to 50 weeks, the remaining steers in each group were slaughtered and their carcasses analyzed. Results obtained show that the carcasses of steers fed rations supplemented with either urea or casein contained a greater quantity of body protein, fat and ash as compared to steers fed the basal ration. However, casein was definitely superior to urea as a source of nitrogen when measured either by gains in weight during the feeding period or carcass composition.

Harris and Mitchell (1941a) conducted an experiment with sheep to study the value of urea nitrogen for maintenance. They found that sheep could be maintained in body weight and nitrogen equilibrium for more than 100 days on rations in which urea supplied nearly 90 percent of the nitrogen. They found that nitrogen equilibrium could be maintained on daily intakes of 202 mg. of urea nitrogen, as compared to 161 mg. of casein nitrogen per kilogram of body weight. At equilibrium the biological value of urea nitrogen was 62 and that of casein was 79. In further experiments with growing lambs, these same workers (Harris and Mitchell, 1941b) were able to obtain nearly normal growth by the addition of urea to a basal ration which had been proven inadequate to consistently maintain nitrogen equilibrium. They concluded that when the protein level of the ration exceeds 11 percent, bacterial synthesis of protein from urea nitrogen is retarded. With a constant percentage of urea nitrogen in the ration, they found that rations containing 8, 11, and 15 percent protein had biological values of 74, 60, and 44, respectively.

Urea Utilization as Affected by Source and Level of Protein

Wegner and co-workers (1941) used a fistulated heifer to study the utilization of urea as influenced by the level of protein in the ration. The heifer was fed a daily ration of corn silage, 15 pounds; timothy hay, 4 pounds; and 4 pounds of a grain mixture composed of equal parts of ground corn and ground oats. Linseed oil meal and urea were varied to increase the protein level of the concentrate from 11.3 to 31.1 percent. In one experiment both were varied, in a second the urea was constant, and in the third the urea was varied but no linseed meal was used. Samples of rumen contents were collected at various intervals following feeding and were analyzed for total nitrogen, ammonia nitrogen and non-protein nitrogen. These workers used the rate of ammonia formation and disappearance as an index of the rate of protein synthesis. They found that with the roughages used, the protein content of the grain mix could be raised to 20 percent and still have 4 percent protein equivalent from urea utilized. However, the greatest utilization of urea was obtained in the absence of linseed meal. When the protein level of the rumen ingesta increased above 12 percent or when the protein in the concentrate being fed exceeded 18 percent, the rate of conversion of ammonia nitrogen to protein began to decrease.

Rupel (1944) reported that the concentration of urea in a ration should not exceed 3 percent, and the protein equivalent of the concentrate should not exceed 18 percent.

Burroughs and co-workers (1951a), employing the artifical rumen technique, studied urea utilization by rumen microorganisms as influenced by the nature of protein. They found that urea utilization was greatest in the absence of other nitrogenous materials and that upon adding protein a higher quality protein permitted greater utilization than a poor quality protein. Hay protein was intermediate in value. From their work, they concluded that when urea is present, natural forms of protein are used by the rumen bacteria primarily as a source of energy, rather than as a source of nitrogen. Further, large quantities of ammonia from protein sources compete with the ammonia produced by the breakdown of urea and an inefficient use of urea nitrogen results. Accordingly, the efficiency of urea utilization should be improved when the level of protein in the diet is low. The authors interpret the data to indicate that the microorganisms of the rumen have a requirement primarily for simple nitrogen in the form of ammonia with energy and minerals meeting their remaining needs. They recognized that natural proteins could also supply mineral elements, in addition to nitrogen and energy, which could aid in bacterial fermentation. Pearson and Smith (1943b) also found that high levels of natural proteins in the ration resulted in an inefficient use of urea, with ammonia formation exceeding the ability of the rumen bacteria to synthesize protein.

Effect of Carbohydrates on Urea Utilization

Mills and associates (1942), using the rumen fistula technique, demonstrated that a readily available source of carbohydrate is necessary for most efficient utilization of urea. They measured the protein content of the rumen ingesta when a basal ration of 10 pounds of timothy hay was fed, and compared this to the protein content when 150 gm. of urea were added to the ration. They found that urea fed with hay only was slowly hydrolyzed, and that about one-half of the ammonia formed from urea remained in the rumen at the end of six hours. The protein level of the rumen ingesta was slightly less than when timothy hay was fed alone. The authors interpret the data as indicating low microbiological activity. When 4 pounds of starch and 150 gm. of urea were added to the basal ration, the urea was completely hydrolyzed within one hour after feeding, and the ammonia formed had disappeared at the end of six hours. The disappearance of ammonia was associated with a rise in the protein content of the rumen ingesta. The rise in the protein content of the rumen ingesta was nearly 57 percent higher when starch and urea were added to the basal ration than when urea alone was added.

Pearson and Smith (1943a), in *in vitro* studies obtained results which indicate that 40 to 80 gm. of urea can be converted to ammonia in the rumen per hour. In further *in vitro* experiments, the same authors (Pearson and Smith, 1943b) determined total protein and non-protein nitrogen of samples of rumen ingesta and urea, and from these values estimated the extent of protein synthesis. They found that the protein synthesis was equal to the ammonia produced by the breakdown of urea only when starch or simple sugars were present. Synthesis and hydrolysis of protein occur simultaneously, and while starch in the rumen ingesta favored protein synthesis, such substances as lactic acid and gelatin favored hydrolysis. Their results indicate that starch was a more effective carbohydrate than sugar, since bacterial synthesis of protein from urea was less when simple sugars were the only source of readily available energy.

Mills and associates (1944) used the rumen fistula technique in comparing starch and molasses as sources of energy for rumen microorganisms. They found that starch was superior to molasses for stimulating protein synthesis from urea, and that the addition of casein to the starch-urea mixture did not alter the extent of conversion of urea nitrogen to protein.

Arias et al. (1951), employing the artifical rumen technique, tested different sources and levels of energy with respect to urea utilization. They found that each source of energy whether a readily available carbohydrate or a complex carbohydrate, such as cellulose, aided urea utilization provided the later underwent digestion. However, when relatively large amounts of readily available carbohydrates were added to the media the extent of cellulose digestion and urea utilization was reduced. On the other hand, small amounts of readily available carbohydrate seemed to stimulate the digestion of cellulose and the utilization of urea. The authors concluded that urea utilization in vitro is greatest when medium amounts of both readily available carbohydrates and complex carbohydrates are present or when a small quantity of readily available carbohydrates and a large amount of complex carbohydrates are present in the medium.

Bell and co-workers (1951), in a series of digestion and nitrogen balance trials with steers, demonstrated the usefulness of urea as a nitrogen supplement in a ration adequately supplied with carbohydrates from widely different sources.

Belasco (1956), using the artifical rumen technique, found that starch was a better source of energy then xylan, pectin or a combination of either with starch. Optimum ratio of cellulose to starch ranged from 0.5 - 2.0:1. Within this range the extent of urea utilization (55 percent), cellulose digestion (90 percent) and production of fatty acids reached a peak.

Urea Utilization as Influenced by Minerals

Burroughs and associates (1951b) found that urea utilization and cellulose digestion were stimulated *in vitro* by water extracts of dehydrated clover meal, rumen ingesta and manure. Beneficial responses were also obtained with the ash of blackstrap molasses, clover, and timothy hay when each was added on an equivalent ash-weight basis. Their work indicates that iron and phosphorus are of primary importance in the digestion of cellulose and utilization of urea. However, iron was absent from the mineral mixture added to the fermentation flasks and thus an iron deficiency, due to the purified nature of the ingredients used, was not precluded.

Bentley and Moxon (1952), in an effort to determine the trace elements requirements of cattle, used a semi-synthetic ration, composed of urea, cerelose, iodized salt, calcium carbonate, calcium phosphate, vitamin A-D oil, corn and cob meal, and a poor quality, late-cut timothy hay, supplemented with alfalfa ash, a trace mineral mixture (copper, cobalt, manganese, zinc, and iron), or reduced iron. They found that alfalfa ash and the mineral mixtures improved the average daily gains 43 percent. The iron supplement alone had no effect on the growth performance of the steers. However, the trace mineral mixture and alfalfa ash increased feed efficiency 12 percent. None of the supplements appeared to improve the digestibility of the ration.

Thomas and co-workers (1951) conducted 3 trials to test the comparative response of lambs fed purified diets containing urea with and without sulfates. The lambs did not eat the purified diets readily and all lost weight during the first 60 days. Thereafter those fed the urea-plus-sulfur diet slowly increased in body weight, while those on the sulfur-deficient diet continued to lose weight. Deficient lambs exhibited gradual failure of appetite, loss of body weight, emaciation, and death. In the absence of dietary sulfur, urea nitrogen was apparently not utilized, since deficient lambs were consistently in negative nitrogen and sulfur balance.

Starks and associates (1953) used the paired feeding technique to study the utilization of urea nitrogen by lambs as affected by elemental sulfur. When elemental sulfur was added to a low-sulfur ration in which urea was the major source of nitrogen, they found that utilization of feed nitrogen was improved, nitrogen and sulfur retention increased, and wool growth increased. These results are in agreement with previous work conducted by the same authors (Stark et al, 1952).

Illinois workers (Anonymous, 1952), in determining the effect of mineral supplements upon the value of urea as a source of protein in the winter ration of beef calves, used three rations of equal energy and nitrogen content. Urea was used to provide about 40 percent of the total nitrogen in two of the rations. One of these rations was supplemented with a mineral mixture of equal parts bonemeal, limestone, and trace mineralized salt. Elemental sulfur was also added. The third ration was a control which contained the mineral mixture but no urea. The results showed a definite advantage for the urea ration containing the mineral mixture plus sulfur over the ration containing only urea. The calves receiving this ration gained 0.11 pound more daily and required about 10 percent less roughage and about 6 percent less concentrate for each pound of gain. The control ration contained soybean oil meal and was superior to either of the urea-containing rations.

Thomas and co-workers (1953) conducted an experiment with 56 weanling Hereford steers averaging 390 pounds to determine the effect of adding phosphorus or trace minerals-cobalt, copper, and manganese-to a winter ration containing either urea or soybean oil meal. They found that steers fed rations supplemented with soybean oil meal made significantly greater gains than steers fed rations supplemented with urea. However, there was no significant difference between gains made by steers receiving trace minerals and adequate phosphorus, regardless of source of nitrogen. Steers fed rations adequate in phosphorus made significantly greater gains when compared to steers fed rations low in phosphorus.

Effects of Antibiotics and "B" Vitamins on Urea Utilization

Prescott (1953) conducted an experiment to determine the effects of diet and antibiotics on utilization of urea. He used rumen bacteria in 8-hour incubation studies to follow in vitro utilization of urea. Urea and ammonia nitrogen were determined together and their reduction taken as an indication of bacterial protein synthesis. He found that a grass-roughage ration was more beneficial in promoting bacterial synthesis of protein than a heavy grain ration, and that adding graded levels of various antibiotics reduced the utilization of urea. The author points out the need for in vivo studies on the effect of antibiotics on the use of urea in rations.

Woods and Tillman (1956) conducted feeding trials to study the effects of soybean oil meal ash and "B" vitamins on urea utilization in purified diets. They found that soybean meal ash and "B" vitamins significantly increased gains of lambs.

start

Feeding Trials with Cattle

Murray and Romyn (1939), in Rhodesia, tested urea as a possible substitute for peanut cake for wintering young stock. Heifers varying in age from 10 to 18 months were wintered for 93 days on a ration designed to provide 1.2 oz. of nitrogen per head daily. Energy was equalized by varying the molasses content. All groups were judged to do equally well.

Baker (1944) conducted an experiment in which steer calves were wintered on a ration of silage, minerals, and different protein supplements. The results obtained indicate that the nitrogen from urea was not utilized as well as that of soybean oil meal or wheat distillers dried grains; however, greater gains resulted from the feeding of urea with corn than from the feeding of corn alone.

Briggs and associates (1947) conducted two experiments in which pellets containing 25 percent of the total nitrogen as urea were compared to cottonseed cake as supplements for wintering yearling heifers on dry, native grass pasture. When these supplements were fed at a level of 2.35 pounds per head daily, no essential difference was noted in the weight of the heifers, or in their apparent thrift or condition. The same urea pellets were fed to mature beef cows as a supplement to dry, range grass. The cows were wintered satisfactorily and no abortion nor other evidence of toxicity was observed during the wintering period. In further experiments the same authors (Briggs and associates, 1948) range-fed 8 head of breeding bulls an average of 2.9 pounds daily of the 25 percent urea pellet, as a supplement to 2.9 pounds of corn, 2.9 pounds of oats, and 12.1 pounds of prairie hay. The bulls remained in satisfactory condition during the 140-day wintering period and breeding efficiency was not impaired the following season.

McClymont (1948), in Australia, compared the value of urea and certain natural proteins as supplements for low-protein rations fed to Shorthorn calves. With the ratio of concentrates to roughages in the rations varying from 46:50 to 0:97, average urea utilization was 60 percent. In arriving at this value, urea utilization was expressed as the ratio of the increased performance of the urea-fed calves over the basal group, to that of the protein-fed calves over the basal group. On this same basis the efficiency of feed utilization of calves on the urea rations, as compared to calves fed the natural protein rations, averaged 67.5 percent. McClymont estimated that the addition of urea to the basal ration reduced the feed required per pound of gain by about 24 percent.

Ross and co-workers (1950) obtained results indicating that pellets containing 25 percent urea nitrogen and 75 percent cottonseed meal nitrogen were as satisfactory as an equivalent amount of cottonseed cake for wintering three-year old steers on native grass pasture. However, the authors state that the level of protein supplement fed in this trial was quite high and it is possible that the natural protein in the urea pellets may have approached the minimum requirements of the cattle. Thus, in these tests the urea pellets may not have been fed at a critical level.

Beeson and Perry(1951) report that steers fed an average daily ration of ground corn cobs ad. lib., 2.25 pounds of soybean oil meal, 1 pound of molasses feed, minerals and vitamin A and D, made average daily gains of 1.28 pounds. When urea replaced one-third and two-thirds of the soybean oil meal at nitrogen equivalent levels, daily gains averaged 1.25 and 1.14 pounds, respectively. Their results indicate that with this type of ration urea can be utilized as a source of nitrogen with an efficiency which approaches that of soybean meal.

Embry and King (1953) conducted two feeding trials in which pellets containing approximately 25 percent of the total nitrogen as urea were compared to soybean oil meal as supplements to prairie hay for wintering calves. Their results indicate that the urea pellets were equal to soybean oil meal when used at this low level to produce daily gains of .75 to 1.0 pound.

Reynolds and co-workers (1956) conducted winter feeding trials to compare the value of urea and cottonseed meal, cottonseed meal, and a supplement composed of 2.25 pounds soybean meal, 1 pound molasses feed, minerals and vitamin A and D when fed with corn silage and grass hay or with hay alone. Protein supplements were pelleted and fed at the rate of one pound per head daily to all lots. The supplements containing urea were 7 percent urea. They found that there were no significant differences among lots on the same roughages; however, the corn silage-hay lots made significantly better gains than did the hay lots on each trial. The authors state that on the average urea was effective in replacing a part of the cottonseed meal in these supplements.

EXPERIMENTAL OBJECTIVES

The data reported in this thesis are the results of several tests of the value of urea in winter supplements of range beef cattle and the value of trace minerals or dehydrated alfalfa meal in such urea-containing supplements. These studies are divided into four parts:

Part I. The value of a feed supplement containing approximately 1/2 of the total nitrogen as urea fed to the same cattle for several consecutive winters as a supplement to dried native grass.

Part II. The value of a feed supplement containing approximately 1/3 or 1/2 of the total nitrogen as urea for wintering commercial beef cattle grazing native grass.

Part III. The value of a feed supplement containing approximately 1/3 of the total nitrogen as urea as a supplement to prairie hay for wintering beef cattle.

Part IV. The value of a urea-molasses mixture as a supplement to native grass for wintering beef cows.

PART I

THE VALUE OF A FEED SUPPLEMENT CONTAINING APPROXIMATELY 1/2 OF THE TOTAL NITROGEN AS UREA FED TO THE SAME CATTLE FOR SEVERAL CONSECUTIVE WINTERS AS A SUPPLEMENT TO DRIED NATIVE GRASS.

EXPERIMENTAL PROCEDURE

Sixty-grade Hereford heifer calves were divided into three lots of 20 head each on November 2, 1953. Each of these lots was placed in pastures which provided approximately 5 acres of native grass per heifer. In addition to the dried grass during the winter months, they were fed a protein supplement as follows:

Lot 1. 40-percent protein pelleted cottonseed meal.

Lot 2. 20-percent protein pellet.

Lot 3. 40-percent protein pellet containing urea.*

The 40-percent protein pellet was 97.99 percent cottonseed meal and 2.01 percent dicalcium phosphate.

The 20-percent protein pellet fed to the Lot 2 heifers was 37 percent cottonseed meal, 58.84 percent ground yellow corn, 2.36 percent dicalcium phosphate, and 1.80 percent monosodium phosphate.

The 40-percent protein pellet containing urea was the same as the 20-percent protein pellet except that 7.64 percent of the corn was replaced with urea in order to make the nitrogen content of the pellet equivalent to 40-percent protein (N x 6.25).

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*A commercial product Urea 262 supplied through the courtesy of E. I. DuPont de Nemours and Co., Wilmington, Delaware.

The calcium and phosphorus contents of all pellets were equalized by the addition of dicalcium phosphate and monosodium phosphate. The average chemical composition of the pellets fed in the four winter periods is reported in Table 1.

In the first two wintering periods the heifers received an average of 2 pounds per head daily of one of the different protein supplements. In the last two tests (1955-56, 1956-57) the various supplements were fed at an average of 3 pounds per head daily. Twice the daily allowance of supplement was fed every other day in all tests.

All cattle grazed the native grass pastures during the summer and were bred so as to drop their first calf in the fall when they were approximately two and one-half years old. Thus, the nutrient requirements during the third and fourth trials were for reproduction and lactation, in addition to maintenance and growth. Because of these increased requirements the experiment was believed to be a more critical test of the value of the various supplements. The rations were fed to the same cattle for several successive winters in order to study the long-time effect of the winter protein supplement on the reproductive performance of the cattle.

The cost of the various pellets was calculated from the cost of the individual feed ingredients plus a mixing and pelleting charge of $5.00 per ton. On this basis, the cost per ton for the various protein supplements for the four different tests was as given in Table II. It should be noted that with the exception of the 1954-55 wintering period the price of corn and cottonseed meal was such that the pellets containing urea cost more per ton than the 40-percent protein pellet containing cottonseed meal and minerals. Therefore, with the single exception the price relationships during the years of these tests did not favor the use of urea.

RESULTS AND DISCUSSION

Trial 1, Calves in 1953-54

A summary of the cost and production data is given in Table III. When urea was added to a supplement containing 20-percent protein in such amounts that the protein equivalent was raised to 40 percent (Lot 3) the weight loss of heifer calves was two pounds greater than when the 20-percent protein supplement (Lot 2) was fed. This indicates little, if any, of the urea was utilized in this test. The heifers fed a pellet containing an equal amount of protein as a natural feedstuff (Lot 1) gained 15 pounds during the winter. Thus, a difference in weight change of 29 pounds resulted from feeding two supplements of equal nitrogen content. At the end of the subsequent summer grazing period the difference in gain had been lessened to 18 pounds.

Trial 2, Yearlings in 1954-55

A summary of the cost and production data is given in Table IV. The average weight losses were -7, and -14, for Lots 1 and 2, respectively. The heifers in Lot 3 maintained their weight during the same wintering period. Although the difference in winter gain was relatively small, under the specific conditions of this test, the weight changes were in favor of the feeding of a protein supplement containing approximately 1/2 of the total nitrogen as urea. The feeding of the 40-percent protein pellet containing urea was also slightly advantageous from cost standpoint inasmuch as the wintering cost per head was $0.68 less than when the 40-percent protein pellet was fed. However, it should be noted that cottonseed meal was given a slight cost disadvantage due to mixing charges. There is no readily apparent explanation for the winter gains of the heifers. For example, the heifers of Lot 2 would be expected to gain more weight or lose less weight than those in Lot 1. A possible explanation of these gains and the gains of the heifers fed the urea-containing supplement relates to the observation that after mid-February many green plants could be found in the pastures and such quantities of protein may have been available from these plants that gains were not related to the protein supplement fed. There were no apparent differences in the amount of green material available in the different pastures.

Trial 3, Two-year-olds in 1955-56

A summary of the cost and production data is reported in Table V. During this season the amount of protein supplement fed during the winter was increased from an average of 2 pounds to 3 pounds per head daily. Data are included for only those cows that weaned a calf during the summer of 1956. All cows lost weight during the wintering period. Such weight losses would be expected because of losses due to calving and lactation during the winter months. The average winter weight loss for Lots 1, 2, and 3 was -133, -215 and -162 pounds per head, respectively. When urea was added to a supplement containing 20-percent protein in such amounts that the protein equivalent was raised to 40 percent the weight loss per head was 53 pounds less than when the 20-percent protein supplement was fed. However, weight loss of the heifers fed the urea-containing pellet was 29 pounds greater than when the 40-percent protein was fed. Apparently some of the urea was utilized in this test inasmuch as the weight losses of the heifers fed the urea-containing pellet were intermediate between the losses of heifers fed equal amounts of the 20- and 40-percent protein supplements.

The conditions of the native grass pastures was considerably below normal during the unusually dry summer season of 1956. Because of the decreased amount of forage available in the pastures, the stocking rate was changed to approximately 8 acres per cow.

Calf data for both the 1955-56 and 1956-57 seasons will be presented following the cow gains in trial 4.

Trial 4, Three-year-olds in 1956-57

A summary of the cost and production data is given in Table VI. All cows lost considerably more weight during this winter feeding period than during the previous winter. The winter weight loss was -255, -307 and -325 pounds per head for Lots 1, 2 and 3, respectively. Since the weight loss of the cows fed the 40-percent protein containing approximately 50 percent of the total nitrogen as urea was greater than when the 20-percent protein was fed it appears that little, if any, of the urea was utilized. These losses are approximately 25, 31 and 32 percent of the fall weight of the cows in Lots 1, 2 and 3, respectively. These losses are considered excessive although practically no data which relate to the effect of such losses are available.

The summer gains of the cows were related to the winter gains in that those that lost the most during the winter months gained the most during the subsequent summer season.

Calf data of Trials 3 and 4

The calf data is summarized in Table VII. The average birth weight of calves in the 1955-56 study was 69, 73 and 73 pounds for Lots 1, 2 and 3, respectively. In the 1956-57 test the average birth weights (pounds) were: Lot 1, 73; Lot 2, 73 and Lot 3, 72. The cows calved in late fall and early winter after the feeding period had started. Thus, an additional protein requirement for final development of fetus was encountered. It appears that the kinds of protein supplement fed in this test had little effect on the average birth weight of the calves. However, the supplements were fed for such a short time of this later part of the gestation period that these supplements had only little time to exert an influence on birth weights of the calves.

The average daily gain of calves from birth to the end of the winter feeding period in the 1955-56 trial was 0.98, 0.80 and 0.80 pound for Lots 1, 2 and 3, respectively. The corresponding gains (pounds) in the 1956-57 study were: Lot 1, 0.71; Lot 2, 0.58 and Lot 3, 0.62. From this standpoint there was apparently little, if any, advantage obtained by adding urea to a supplement containing 20-percent protein in such amounts that the protein equivalent was raised to 40 percent. The daily winter gains of the calves in Lot 1 were greater in both tests than were the gains in either Lot 1 or 2.

The weaning weight of calves in the 1955-56 test was 415, 391 and 394 pounds for Lots 1, 2 and 3, respectively. All calves in these lots grazed native grass pastures from the end of the winter feeding trial until weaning. The differences in average daily summer gains (1956) were relatively small although they were related to previous winter gains. Those in Lot 1 gained more during the winter than those in Lot 3 but during the summer the gains in Lot 3 were slightly greater.

The final weight reported at this time for the 1956-57 study was taken on June 21 although the calves will be weaned later in the summer. The average calf weights (pounds) were: Lot 1, 340; Lot 2, 281 and Lot 3,

306. The average daily gain from end of winter feeding test to final weight was 2.18, 1.79 and 2.09 for Lots 1, 2 and 3, respectively.

Number of Cows in Experiment

When these trials started there were sixty head of grade Hereford heifer calves divided into 3 lots of 20 head each. At the conclusion of these trials there were 13, 11 and 12 cows in Lots 1, 2 and 3, respectively. A summary of number of cows in each trial of this experiment is given in Table VIII.

A pregnancy examination made June 21, 1957, showed that 5, 4 and 6 cows were open in Lots 1, 2 and 3, respectively. The number of open cows in all lots in the summer of 1957 was much above average. A possible explanation would be poor winter pasture conditions and cattle not rebreeding under conditions of low feeding while nursing a calf.

At all times during these tests the number of cows in each lot was equal (20 head). If a cow produced a dead calf or one which died during the wintering period she was not removed from the lot to which she had been assigned but the data on such cows were discarded. Open cows were also kept in their respective lots but data were not included in experimental results. Cows which died were replaced by cows of similar breeding, size and age in an effort to maintain the grazing conditions as nearly equal as possible. Data on replacement cows were discarded.

SUMMARY

Four trials were conducted to study the value of a supplement containing approximately 1/2 of the total nitrogen as urea fed for several consecutive winters to the same cattle as a supplement to dried native grass. When winter gains of cows, average daily gain of calves during the wintering tests, and weaning weights of calves were used as measurements to determine the efficiency of urea utilization, the results

indicated that urea was inefficiently utilized in supplements containing approximately 50 percent of the total nitrogen as urea when fed to commercial beef cattle grazing dried native grass.

TABLE I

Chemical Composition of Feeds Used in Part I

Feed	Year	Percent dry matter	Percentage Composition of Dry Matter						
			Ash	Protein	Fat	Fiber	NFE	Ca	P
40-CSM	1953-54	92.03	10.32	40.68	5.01	10.01	33.98	1.76	1.45
	1954-55	90.42	8.02	43.64	5.78	11.86	30.70	0.82	1.25
	1955-56	91.95	7.41	39.50	6.28	10.18	36.63	0.54	1.47
	1956-57	92.29	8.89	43.81	3.69	13.78	29.83	0.73	1.19
20-CSM + corn	1953-54	89.64	4.69	22.04	4.83	4.77	63.67	0.05	0.80
	1954-55	89.26	7.55	22.12	3.41	6.54	60.38	0.90	1.24
	1955-56	91.43	6.52	21.02	5.64	4.78	62.04	0.60	1.46
	1956-57	90.98	7.92	24.80	4.74	6.45	56.09	0.77	1.41
40-Urea	1953-54	88.81	7.99	41.84	5.66	4.93	39.58	1.61	1.34
	1954-55	89.06	7.56	43.76	3.93	5.36	39.39	0.92	1.22
	1955-56	91.55	6.45	41.34	6.04	5.16	41.01	0.71	1.48
	1956-57	89.52	6.69	46.70	4.02	6.37	36.22	0.73	1.33

TABLE II

Cost of Pellets Used in Part I
(Dollars per Ton)

Year	Lot 1 40-CSM	Lot 2 20-CSM + corn	Lot 3 40-Urea
1953-54	70.00	68.06	73.88
1954-55	83.32	75.84	81.14
1955-56	69.66	68.26	72.54
1956-57	69.66	68.26	72.54

TABLE III

Weight Gains and Feed Costs of Heifer Calves, 1953-54

	Lot 1 40-CSM	Lot 2 20-CSM + corn	Lot 3 40-Urea
Number of head per lot[1]	20	17	20
Average weight (lb)			
Initial 11-2-53	478	481	479
Spring 4-13-54	493	469	465
Winter gain	+15	-12	-14
Fall 10-30-54	685	674	668
Summer gain	192	205	203
Yearly gain	207	193	189
Cost of protein supplement ($)	11.34	11.02	11.99
Cost of pasture and minerals ($)[2]	17.37	17.40	17.36
Total feed cost ($)	28.71	28.42	29.35

1. Originally there were 20 cows per lot. In Lot 2, 2 cows calved in the spring of 1954 and 1 cow died in March 1954.

2. A mixture of 2 parts salt and 1 part steamed bonemeal was also available in all lots.

TABLE IV

Weight Gains and Feed Costs of Yearlings, 1954-55

	Lot 1 40-CSM	Lot 2 20-CSM + corn	Lot 3 40-Urea
Number of head per lot[1]	16	16	20
Average weight (lb)			
Fall 10-10-54	680	676	668
Spring 4-19-55	673	662	668
Winter gain	-7	-14	0
Fall 10-10-55	949	942	944
Summer gain	276	280	276
Yearly gain	269	266	276
Cost of protein supplement ($)	14.36	12.99	13.68
Cost of pasture and minerals ($)[2]	18.50	18.50	18.50
Total feed cost ($)	32.86	31.49	32.18

1. In the previous trial, there were 20, 17, and 20 cows in Lots 1, 2, and 3, respectively. In Lot 1, 4 cows calved in the spring of 1955. In Lot 2, 1 cow calved in the spring of 1955.

2. A mixture of 2 parts salt and 1 part steamed bonemeal was available in all lots.

TABLE V

Weight Gains and Feed Costs of Two-Year-Olds, 1955-56

	Lot 1 40-CSM	Lot 2 20-CSM + corn	Lot 3 40-Urea
Number of head per lot[1]	15	11	15
Average weight (lb)			
Fall 10-10-55	953	955	935
Spring 4-24-56	820	740	773
Winter gain	-133	-215	-162
Weaning 8-4-56	984	987	978
Gain from spring	164	247	205
Fall 9-26-56	1015	985	982
Summer gain	195	245	209
Yearly gain	62	30	47
Cost of protein supplement ($)	20.57	20.17	21.44
Cost of pasture and minerals ($)[2]	22.88	22.88	22.88
Total feed cost ($)	43.45	43.05	44.32

1. In Trial 2, there were 16, 16, and 20 cows in Lots 1, 2 and 3, respectively. In Lot 1, 1 cow was open. In Lot 2, 3 cows were open, 1 calf born dead, and 1 cow died. In Lot 3, 2 cows were open and 3 calves were born dead or died during the wintering period.

2. A mixture of 2 parts salt and 1 part steamed bonemeal was available in all lots.

TABLE VI

Weight Gains and Feed Costs of Three-Year-Olds, 1956-57

	Lot 1 40-CSM	Lot 2 20-CSM + corn	Lot 3 40-Urea
Number of head per lot[1]	13	11	12
Average weight (lb)			
Fall 9-26-56	1023	985	1023
Spring 4-26-57	768	678	698
Winter gain	-255	-307	-325
Summer 6-21-57	870	815	886
Gain 4-26 to 6-21-57	102	137	188
Cost of protein supplement ($)	22.05	21.60	22.96
Cost of pasture and minerals ($)[2]	25.38	25.37	25.37
Total feed costs ($)	47.43	46.97	48.33

1. In Trial 3, there were 15, 11, and 15 cows in Lots 1, 2, and 3, respectively. In Lot 1, 1 cow was open and 1 calf died shortly after birth. In Lot 3, 3 cows were open.

2. A mixture of 2 parts salt and 1 part steamed bonemeal was available in all lots.

TABLE VII

Calf Data, 1955-56 and 1956-57

	Lot 1 40-CSM	Lot 2 20-CSM + corn	Lot 3 40-Urea
		1955-56	
Number of steers	5	7	7
Number of heifers	10	4	8
Average birth date	Nov. 9	Nov. 16	Nov. 10
Average weight (lb)[1]			
Birth weight	69	73	73
Spring 4-24-56	219	191	192
Daily winter gain[2]	0.98	0.80	0.80
Weaning 8-4-56	415	391	394
Summer daily gain[3]	1.47	1.5	1.52
Daily gain (total)	1.17	1.07	1.07
		1956-57	
Number of steers	9	2	6
Number of heifers	4	9	6
Average birth date	Oct. 11	Oct. 22	Oct. 14
Average weight (lb)[1]			
Birth weight	73	73	72
Spring 4-26-57	218	181	189
Daily winter gain[2]	0.71	0.58	0.62
Summer 6-21-57	340	281	306

TABLE VII (Continued)

	Lot 1 40-CSM	Lot 2 20-CSM + corn	Lot 3 40-Urea
Daily summer gain[3]	2.18	1.79	2.09
Daily gain (total)	1.04	0.86	0.95

1. All average weights were calculated by adding the average weights of heifers plus the average weights of the steers and dividing the sum by 2.

2. All average daily winter gains were computed by calculating the average gain of each heifer and dividing by the number of heifers in trial plus the same calculation for steers and dividing the sum by 2.

3. Summer daily gains were calculated by finding the differences between average weights at end of winter test and average weights at end of summer (determined as in 1.) and dividing by the number of intervening days.

TABLE VIII

Number of Cows in Experiment (Part I)

	Lot 1 40-CSM	Lot 2 20-CSM + corn	Lot 3 40-Urea
Total heifers at beginning	20	20	20
Calved spring of 1954	0	2	0
Died in March 1954[1]	0	1	0
Heifers in 1953-54 trial	20	17	20
Calved spring of 1955	4	1	0
Heifers in 1954-55 trial	16	16	20
Open	1	3	2
Cows died[2]	0	1	0
Calves born dead or died later	0	1	3
Cows in 1955-56 trial	15	11	15
Open	1	0	3
Calves born dead or died later	1	0	0
Cows in 1956-57 trial	13	11	12
Open on 6-21-57	5	4	6
Cows remaining for 1957-58 trial[3]	8	7	6

1. Cause of death unknown

2. Death was apparently due to accidental causes.

3. In addition, all open cows which have lost calves have been retained in the experiment although the data were not included. The number of calves actually raised in the summer of 1957 was 16, 14, and 14 for Lots 1, 2, and 3, respectively.

PART II

THE VALUE OF A FEED SUPPLEMENT CONTAINING APPROXIMATELY 1/3 OR 1/2 OF THE TOTAL NITROGEN AS UREA FOR WINTERING COMMERCIAL BEEF CATTLE GRAZING NATIVE GRASS.

In a preliminary test (Trial 1, Part I) beef heifer calves fed 2 pounds of a feed having 50 percent of the nitrogen furnished by urea as a supplement to dry native grass during the winter months lost more weight than similar heifers fed the basal ration. Weights taken during the first week of March show that the average gain per heifer was 27, -34 and -27 pounds for those fed a 40 percent protein, 20 percent protein and 40 percent protein supplement containing urea, respectively. Thus the gain of the heifers fed the urea-containing supplement were not as satisfactory as those fed the 20 percent protein supplement.

The winter gains based on April 13 weights were 15, -12 and -14 for Lots 1, 2 and 3, respectively. The differences present at the earlier date were decreased as the season progressed apparently because of the presence of many green plants in the pastures after mid-February. Such plants could serve as source of nitrogen for the cattle.

In vitro studies conducted by Burroughs and associates (1951b) and *in vivo* studies by Bentley and Moxon (1952), Illinois workers (Anonymous, 1952) and Thomas and co-workers (1953) indicate that trace minerals and ash from clover meal, alfalfa, manure and black strap molasses increase urea utilization.

With these results in mind, experiments were designed to study the value of urea in supplements for beef calves and yearlings wintered on dry native grass. The tests were conducted during the late fall and winter months of 1954-55, 1955-56 and 1956-57 and are designated as Trials 1, 2, 3, and 4.

EXPERIMENTAL PROCEDURE

In Trial 1, a 40-percent protein supplement containing approximately 1/2 of the total nitrogen as urea was compared to a 20-percent protein pellet. The urea-containing supplement was fed with and without trace minerals. In Trials 2 and 3, urea-containing protein supplements with and without trace minerals were compared to a 40-percent protein pellet. Urea supplied approximately 1/3 of the total nitrogen in the urea-containing supplements. In Trial 4, studies identical to those in Trials 2 and 3 were made. In addition, the urea-containing supplement plus dehydrated alfalfa meal was compared to the 40-percent protein pellet.

In all tests, the phosphorus and calcium contents of all pellets were equalized by the addition of dicalcium phosphate and monosodium phosphate where necessary. The chemical composition of the various pellets is reported in Table IX.

The cost of the different pellets was calculated from the cost of the individual feed ingredients plus a mixing and pelleting charge of $5.00 per ton. The cost per ton of the pellets used in these tests is given in Table X.

All cattle were alloted on the basis of sex and weight. Weights were taken at approximately one month intervals and twice the daily allowance of supplement was fed every other day.

RESULTS AND DISCUSSION

Trial 1, Heifer Calves, 1954-55

The first test started on December 20, 1954, and continued for 99 days. Forty-five grade Hereford heifer calves were divided into three lots of 15 head each. In addition to dry native grass the heifers were fed an average of two pounds per head daily of a basal 20-percent protein supplement, a 40-percent protein supplement with 50-percent of the nitrogen furnished by urea or this urea-containing supplement plus trace minerals.

The basal protein pellet which was fed to Lot 1 consisted of 37 percent cottonseed meal, 58.8 percent ground yellow corn, 2.4 percent dicalcium phosphate, and 1.8 percent monosodium phosphate. The 40-percent protein supplement which was fed to Lot 2 was the same as the basal except 7.64 percent of urea replaced a like amount of corn. Lot 3 was fed the same supplement as Lot 2 except trace minerals were added at the rate of 0.14 percent of the supplement. The trace mineral mixture, in percent, was: $FeSO_4$, 26.8; $CoSO_4$, 0.6; KI, 0.9; $CuSO_4.5H_2O$, 3.8; and $MnSO_4$, 67.9.

The average weight gains of the heifer calves and average wintering costs during Trial 1 are shown in Table XI. The heifers in Lot 1 (20-percent protein) gained an average of 31 pounds per head during the 99-day wintering period. The replacement of corn with urea to make the crude protein content of the pellet equivalent to 40-percent was not satisfactory as measured by weight gains of heifers because these heifers gained only 6 pounds during the winter. The heifers were reluctant to eat these pellets, especially at the beginning of the test. For several days the pellets were not all eaten by the time of the next scheduled feeding (twice the daily allowance fed every other day). It was during this period that one of the heifers was found dead, although the cause of death was not determined. Throughout the test the urea pellets fed Lot 2 were consumed more slowly than the pellets fed in other lots.

The addition of trace minerals to a supplement having 50-percent of the nitrogen furnished by urea resulted in greatly increased gains. These heifers gained 53 pounds compared to the 6 pounds gained by those fed the urea-containing pellet without trace minerals.

Trial 2, Yearlings in 1955-56

The wintering period started December 6, 1955, and continued for 95 days. Thirty-six grade Hereford yearling beef cattle (21 steers and 15 heifers) were divided into lots of 12 head each. They were fed an average of 2 pounds per head daily of the following protein supplements:

Lot 1. 40-percent protein supplement.

Lot 2. 40-percent protein supplement containing urea.

Lot 3. Same as Lot 2 plus trace minerals.

The 40-percent protein supplement was 97.25 percent cottonseed meal plus 1.75 percent dicalcium phosphate and 1 percent monosodium phosphate. The 40-percent protein pellet containing urea was 59 percent cottonseed meal, 32 percent ground yellow corn, 5 percent urea, 2 percent dicalcium phosphate and 2 percent monosodium phosphate. Urea supplied approximately one-third of the nitrogen in this pellet. The third supplement was the same as that fed to Lot 2 except trace minerals were added in the kinds and amounts listed in Trial 1.

The weight and cost data during Trial 2 is summarized in Table XII. The cattle fed the cottonseed meal pellet (Lot 1) nearly maintained their weight during the 95-day test period while the cattle in Lots 2 and 3 lost 62 and 45 pounds, respectively. Apparently little, if any, of the urea in the pellets was utilized. If the urea had been completely utilized, the gains in Lot 2 should have equalled the gain in Lot 1. However, the addition of trace minerals to the urea-containing pellet resulted in approximately 27 percent less weight loss than when the urea-containing pellet without trace minerals was fed.

Trial 3, Yearling Heifers, 1956-57

The third wintering test started November 10, 1956, and continued for 118 days. Fifty-one grade Hereford yearling heifers were divided into 3 lots of 17 head each. They received an average of 2 pounds per head daily of the following protein supplements:

Lot 1. 40-percent protein supplement.

Lot 2. 40-percent protein supplement containing urea.

Lot 3. Same as Lot 2 plus trace minerals.

The 40-percent protein supplement fed Lot 1 was 97.9 percent cottonseed meal, 1.1 percent dicalcium phosphate and 1.0 percent monosodium phosphate. The 40-percent protein supplement containing urea was 59 percent cottonseed meal, 33 percent ground yellow corn, 5 percent urea and 3 percent dicalcium phosphate. The third supplement was the same as that fed to Lot 2 except a commercial trace mineral mixture[1] was added at the rate of 0.1 pound per 100 pounds of the supplement. According to the manufacturers' recommendations the additional minerals provided were in mgs. per pound of pelleted supplement: manganese, 55.0; iodine, 1.76; cobalt, 1.18; iron, 36.6; copper, 3.3; and zinc, 3.04. At the rate fed the trace minerals cost only 1-2 cents per head during the winter.

[1]Furnished through the courtesy of Calcium Carbonate Company, Chicago, Illinois.

The average weight gains and average wintering costs during Trial 3 are reported in Table XIII. The heifers fed the cottonseed meal pellet (Lot 1) lost 35 pounds in the 118-day wintering period. When one-third of the nitrogen in the supplement was supplied by urea the heifers (Lot 2) lost 96 pounds per head. This would indicate little apparent utilization of urea. However, when a trace mineral mixture was included in the supplemental feed, the loss was 30 pounds or approximately the same as that of the control heifers (Lot 1). Apparently the trace minerals provided were lacking in the range grass and the urea-containing pellet fed to Lot 2.

Trial 4, Steer Calves, 1956-57

In Trial 4, the wintering period started November 13, 1956, and continued for 115 days. Forty grade Hereford steer calves were divided into 4 lots of 10 head each. They were fed an average of two pounds per head daily of the following supplement:

Lot 1. 40-percent protein supplement.

Lot 2. 40-percent protein supplement containing urea.

Lot 3. Same as Lot 2 plus trace minerals.

Lot 4. Same as Lot 2 plus dehydrated alfalfa meal.

The supplements fed to Lots 1, 2 and 3 were as described in Trial 3. The supplement fed to Lot 4 was 56 percent cottonseed meal, 26 percent corn, 5 percent urea, 10 percent dehydrated alfalfa meal, 2.5 percent dicalcium phosphate and 0.5 percent monosodium phosphate.

A summary of the average weight gain and average feed costs during Trial 4 is given in Table XIV. The Lot 1 steers which were fed the basal ration of pelleted cottonseed meal made the greatest gain (61 pounds) during the 115-day wintering test. In agreement with results obtained from Trials 1, 2 and 3, the cattle fed the urea containing supplement alone made the smallest gain (3 pounds) during the wintering period. This would indicate little, if any, utilization of urea. The addition of trace minerals or dehydrated alfalfa meal apparently increased the utilization of urea as measured by weight gain of the steers. The gains were 35 and 36 pounds for additional trace minerals and dehydrated alfalfa meal, respectively. The utilization was not complete, however, because these gains were approximately 25 pounds less than the gains of the steers fed pelleted cottonseed meal in Lot 1.

SUMMARY

A total of 169 head of beef cattle (calves and yearlings) were used in four trials to study the value of urea in a protein supplement for cattle wintered on dry range grass. As measured by winter weight gain the utilization of urea is apparently increased by the addition of trace minerals (Mn, Co, Fe, Cu, Zn, I) to a protein supplement containing 1/3 or 1/2 of the total nitrogen as urea when fed to young beef cattle wintered on dried native grass. Also, dehydrated alfalfa meal apparently increased urea utilization in a protein supplement containing 1/3 of the total nitrogen as urea when fed under the same conditions.

TABLE IX

Chemical Composition of Feeds Used in Part II and Part III

	Percent dry matter	Percentage Composition of Dry Matter						
		Ash	Protein	Fat	Fiber	NFE	Ca	P
1954-55								
20-CSM	88.18	7.19	26.57	4.84	6.29	55.11	0.87	1.70
40-Urea	88.52	7.78	48.31	4.96	5.34	33.61	0.95	1.86
40-Urea + trace minerals	88.98	7.63	48.19	4.73	5.48	33.97	0.89	1.82
1955-56								
40-CSM	93.64	7.92	40.31	5.12	10.70	35.95	0.66	1.15
40-Urea	94.05	7.66	42.59	5.55	7.14	37.06	0.82	1.25
40-Urea + trace minerals	94.26	9.92	43.59	5.60	6.99	33.90	0.76	1.30
Prairie hay	95.46	6.63	5.58	2.89	30.57	54.33	0.44	0.09
1956-57								
40-CSM	92.89	8.62	43.46	3.43	10.41	34.08	0.94	0.66
40-Urea	91.59	8.05	45.04	3.60	8.29	35.02	0.96	0.70
40-Urea + trace minerals	91.72	7.93	44.63	4.19	9.04	34.21	0.97	0.69
40-Urea + dehydrated alfalfa meal	91.59	8.33	45.34	4.03	11.48	30.82	0.97	0.68
Prairie hay	94.85	6.61	4.59	1.68	35.27	51.85	0.40	0.80

TABLE X

Cost per Ton (Dollars) of Feeds Used in Part II and Part III

	1954-55	1955-56	1956-57
20-CSM + corn	75.86		
40-CSM		70.15	73.86
40-Urea	81.12	71.82	73.26
40-Urea + trace minerals	83.51[1]	73.20[1]	73.30
40-Urea + dehydrated alfalfa meal			74.36
Prairie hay		20.00	25.00

1. The cost of the minerals included in the pellets was relatively high compared to the cost of commercially available mixtures.

TABLE XI

Weight Gain and Feed Costs of Heifer Calves, 1954-55 Trial

	Lot 1 20-CSM Basal	Lot 2 40-Urea	Lot 3 40-Urea + trace Minerals
Number of heifers per lot[1]	15	14	15
Average weight (lb)			
Initial 12-20-54	409	408	410
Final 3-29-55	440	414	463
Winter gain	31	6	53
Daily gain	0.31	0.06	0.54
Cost of protein supplement($)	7.51	8.03	8.27
Cost of pasture ($)	3.00	3.00	3.00
Cost of minerals ($)[2]	.10	.10	.10
Total feed cost ($)	10.61	11.13	11.37

1. Originally there were 15 heifers per lot. In Lot 2, one heifer died, cause of death was not determined.

2. A mixture of 2 parts salt and 1 part steamed bonemeal was available in all lots.

TABLE XII

Weight Gain and Feed Costs of Yearlings, 1955-56

	Lot 1 40-CSM	Lot 2 40-Urea	Lot 3 40-Urea + trace Minerals
Number of head per lot	12	12	12
Average weight (lb)			
Initial 12-6-55	693	687	688
Final 3-10-56	691	625	643
Gain	-2	-62	-45
Daily gain	-0.02	-0.65	-0.47
Cost of protein supplement($)	6.66	6.82	6.95
Cost of pasture ($)	4.00	4.00	4.00
Cost of minerals ($)[1]	.31	.31	.31
Total feed cost ($)	10.97	11.13	11.26

1. A mixture of 2 parts salt and 1 part steamed bonemeal was available in all lots.

TABLE XIII

Weight Gain and Feed Costs of Yearlings, 1956-57

	Lot 1 40-CSM	Lot 2 40-Urea	Lot 3 40-Urea + trace Minerals
Number of heifers per lot[1]	16	16	17
Average weight (lb)			
Initial 11-10-56	727	726	736
Final 3-8-57	692	630	706
Gain	-35	-96	-30
Daily gain	-.30	-.81	-.25
Cost of protein supplement($)	8.72	8.64	8.65
Cost of pasture ($)	4.00	4.00	4.00
Cost of minerals ($)[2]	.12	.12	.12
Total feed costs ($)	12.84	12.76	12.77

1. Originally there were 17 heifers in each lot. In Lot 1, one heifer was pregnant. In Lot 2, one heifer was pregnant.

2. A mixture of 2 parts salt and 1 part steamed bonemeal was available in all lots.

TABLE XIV

Weight Gain and Feed Costs of Steer Calves, 1956-57

	Lot 1 40-CSM	Lot 2 40-Urea	Lot 3 40-Urea + trace Minerals	Lot 4 40-Urea + dehydrated alfalfa meal
Number of steers per lot	10	10	10	10
Average weight (lb)				
Initial 11-13-56	456	456	458	455
Final 3-8-57	517	460	493	491
Gain	61	3	35	36
Daily gain	.52	0.03	.30	.31
Cost of protein supplement($)	8.49	8.42	8.43	8.55
Cost of pasture ($)	3.50	3.50	3.50	3.50
Cost of minerals ($)[1]	.10	.10	.10	.10
Total feed costs ($)	12.09	12.02	12.03	12.15

1. A mixture of 2 parts salt and 1 part steamed bonemeal was available in all lots.

PART III

THE VALUE OF A FEED SUPPLEMENT CONTAINING APPROXIMATELY 1/3 OF THE TOTAL NITROGEN AS UREA AS A SUPPLEMENT TO PRAIRIE HAY FOR WINTERING BEEF CATTLE.

Burroughs and associates (1951b) conducted in vitro studies to determine the effect of minerals upon urea utilization and cellulose digestion by rumen microorganisms. They found that a water extract of dehydrated clover meal stimulated urea utilization. A similar response was obtained by additions of clover and timothy hay ash.

Bentley and Moxon (1952) report that trace minerals and alfalfa ash increased average daily gains when added to a ration containing poor quality timothy hay as the chief source of roughage.

In a preliminary test (Trial 1, Part II), three lots of 10 heifer calves each were allowed to graze the native grasses during the winter months. In addition, they were fed an average of 2 pounds per head daily of a 20-percent protein supplement, a 40-percent protein supplement with 50 percent of the total nitrogen furnished by urea, or the 40 percent protein supplement containing urea plus trace minerals. The winter gains of these heifers were 31, 6, and 53 pounds, respectively. Apparently the urea in the supplement was not utilized when urea furnished 50 percent of the nitrogen. However, when trace minerals were added to the urea-containing pellet the gains were greater than those of the control heifers.

According to Morrison (1948), prairie hay contains more protein and phosphorus than dry range grass. Its composition of these and other nutrients makes prairie hay of greater feeding value than dry range grass.

With these results in mind, tests were designed to study the value of protein supplements containing approximately 1/3 of the total nitrogen content as urea as a supplement to prairie hay for wintering beef calves.

These experiments were conducted in the late fall and winter months of 1955-56, and 1956-57, and are designated as Trials 1 and 2, respectively.

EXPERIMENTAL PROCEDURE

In Trial 1, three lots of 10 grade Hereford steer calves each were placed in 5-acre traps on December 6, 1955. In addition to prairie hay fed *ad libitum*, they received 1 pound per head daily of the following supplements:

Lot 1. 40-percent protein supplement.

Lot 2. 40-percent protein supplement containing urea.

Lot 3. Same as Lot 2 plus trace minerals.

These supplements were mixed as described in Trial 2 of Part II.

In Trial 2, the wintering period started November 15, 1956, and continued for 133 days. Sixty grade Hereford heifer calves were divided into 6 lots of 10 head each. They were trap-fed and in addition to prairie hay fed *ad libitum* they received an average of one pound per head daily of the following supplements:

Lots 1 and 2. 40-percent protein supplement.

Lots 3 and 4. 40-percent protein supplement containing urea.

Lots 5 and 6. Same as Lots 3 and 4 plus trace minerals.

These supplements were as described in Trial 3, Part II.

The calcium and phosphorus contents of all pellets fed in both tests were equalized by the addition of dicalcium phosphate and monosodium phosphate where necessary. The chemical composition of the pellets fed in these tests is shown in Table IX.

The cost of the pellets was calculated from the cost of the individual feed ingredients plus a mixing and pelleting charge of $5.00 per ton. The cost of the various pellets is given in Table X. Twice the daily ration of supplement was fed every other day. All calves were weighed at approximately one-month intervals.

RESULTS AND DISCUSSION

A summary of the weight gain and feed cost during Trial 1 is given in Table XV.

The gains of all groups of steers were nearly the same indicating that the steers apparently utilized at least part of the urea. The average gain of those fed the pellet in which urea furnished one-third of the nitrogen was twelve pounds less (70 vs. 82 pounds) than those fed the supplement having all nitrogen furnished by cottonseed meal. The gains of the heifers fed the pellet containing urea and trace minerals were intermediate. All differences were small.

In this test high-quality prairie hay was the roughage fed. These results are not in agreement with Trial 2, Part II, in which yearlings did not utilize the urea in pellets fed as supplements to dried native grass. The difference in nutritive value of the two roughages may have affected the utilization of urea.

In Trial 2, the physical facilities (insufficient water in some ponds) did not permit the feeding of 6 separate lots of cattle; the two lots fed each supplement were combined and fed as 3 groups of 20 head each. All lots of heifers were fed approximately the same quantity of hay. Weight data for the different lots were kept separate in order to allow study of the variation among two groups of animals fed alike. The results are summarized in Table XVI.

The addition of trace minerals to a pellet containing urea which was fed as a supplement to prairie hay apparently increased the utilization of urea only slightly, if at all. The gain (86 pounds) of these cattle fed additional trace minerals was only an average of five pounds greater than the gain of heifers fed the urea-containing supplement without trace minerals. The gains of the heifers fed pelleted cottonseed meal (Lots 1 and 2) were 92 and 104 pounds, which were slightly greater than the gains in the other lots. Urea was apparently at least partially utilized by the heifers in Lots 3, 4, 5, and 6.

The average winter gains of the two groups of heifers fed the same supplement were nearly the same.

SUMMARY

A total of eighty-nine Hereford steer and heifer calves were used in two trials to study the value of urea in a protein pellet fed as a supplement to prairie hay for wintering young beef cattle. As measured by winter weight gain urea was apparently at least partially utilized in supplements containing about 1/3 of its nitrogen as urea. The addition of trace minerals to the urea-containing supplement resulted in slightly increased winter gain.

TABLE XV

Weight Gain, Feed Allowances and Feed Costs of Steer Calves, 1955-56

	Lot 1 40-CSM	Lot 2 40-Urea	Lot 3 40-Urea + trace Minerals
Number of steers per lot	10	10	10
Average weight (lb)			
Initial 12-6-55	458	458	458
Final 4-2-56	540	528	536
Gain	82	70	78
Daily gain	.69	.59	.66
Average daily feed per steer (lb)			
Prairie hay[1]	12.4	12.4	12.4
Protein supplement	1.0	1.0	1.0
Minerals	.06	.06	.06
Cost of prairie hay ($)	14.63	14.63	14.63
Cost of protein supplement ($)	4.14	4.24	4.32
Cost of minerals ($)	.12	.12	.12
Total feed costs ($)	18.89	18.99	19.07

1. An equal number of bales of prairie hay was fed to each group. Several bales were weighed periodically for calculation of the average weight per bale.

TABLE XVI

Weight Gain, Feed Allowances, and Feed Costs of Heifer Calves, 1956-57

	40-CSM		40-Urea		40-Urea + trace mineral	
	Lot 1	Lot 2	Lot 3	Lot 4	Lot 5	Lot 6
Number of heifers[1]	10	10	10	10	10	9
Average weight (lb)						
Initial 11-15-56	448	448	448	448	448	439
Final 3-28-57	540	552	529	529	537	522
Gain	92	104	81	81	89	83
Daily gain	0.69	0.78	0.61	0.61	0.67	0.62
Average daily feed per head (lb)						
Prairie hay[2]	14.9	14.9	14.9	14.9	14.9	14.9
Protein supplement	1.0	1.0	1.0	1.0	1.0	1.0
Minerals	0.04	0.04	0.04	0.04	0.04	0.04
Cost of prairie hay ($)	24.77	24.77	24.77	24.77	24.77	24.77
Cost of protein supplement ($)	4.91	4.91	4.87	4.87	4.88	4.88
Cost of minerals ($)	0.09	0.09	0.09	0.09	0.09	0.09
Total feed costs ($)	29.77	29.77	29.73	29.73	29.74	29.74

1. Originally there were 10 heifers in each lot. One heifer died in Lot 6, cause of death was not determined.

2. An equal number of bales of prairie hay was fed to each group. Several bales were weighed periodically for calculation of the average weight per bale.

PART IV

THE VALUE OF A UREA-MOLASSES MIXTURE AS A SUPPLEMENT TO NATIVE GRASS FOR WINTERING BEEF COWS.

EXPERIMENTAL PROCEDURE

Thirty-four mature Hereford cows were divided into two lots of 17 head each on November 4, 1955. In addition to native grass, the control group of cows (Lot 1) received 1.5 pounds of cottonseed meal pellets per head daily, while the experimental group (Lot 2) was fed an average of 2.2 pounds of a urea-molasses mixture supplying an equivalent amount of crude protein and T.D.N.

The urea-molasses mixture contained 1.95 pounds molasses, 0.24 pound urea, 0.008 pound steamed bonemeal and 0.002 pound trace mineral mixture. The trace mineral mixture provided, in mgs per day: manganese, 110.8; iodine, 3.44; cobalt, 2.36; iron, 87.2; copper, 6.6; and zinc, 6.08. At the rate fed the trace minerals cost only 2-3 cents per head during the winter.

The supplements were fed daily in open troughs. The amount of urea-molasses mix was gradually increased over the first 35 days of the test, while cottonseed meal was reduced, until the cows were receiving only urea-molasses as a supplement. Costs of the supplement per ton was $65.00 and $48.20 for Lots 1 and 2, respectively. Costs of handling the urea-molasses product were not considered.

RESULTS AND DISCUSSION

A summary of weight gain, feed costs, and calf data is given in Table XVII. The gains to calving (104-day period) of both groups of cows were essentially the same indicating that the cows apparently utilized at least part of the urea. The average gain of those fed the urea-molasses mixture was only two pounds less (86 vs. 88 pounds) than those fed the cottonseed meal pellets.

Average weight gain for the entire wintering period was -80 and -94 pounds for Lots 1 and 2, respectively. Average birth weight of calves in each lot was 82 pounds while the average corrected weaning weight was 518 and 515 pounds for calves produced by cows fed cottonseed meal pellets and a urea-molasses mixture, respectively.

SUMMARY

Thirty mature Hereford cows were used in this trial to study the value of a urea-molasses mixture as a supplement to native grass for wintering beef cows. Results obtained indicate that mature cows may winter as well on a supplemental mixture of urea-molasses fortified with minerals as on cottonseed meal when the protein and energy contents of the supplemental feeds are equalized. Average weight gains to calving and average weaning weights of calves were essentially the same in both groups. There was a small difference in average winter weight gain (152 days) in favor of the cows fed cottonseed meal pellets.

TABLE XVII

Weight Gains, Feed Costs, and Calf Data of Cows, 1955-56

	Lot 1 40-CSM	Lot 2 Urea-Molasses Mixture
Number of cows per lot[1]	15	15
Average weights (lb)		
Initial 11-4-55	1205	1214
Before calving 2-16-56	1293	1300
Gain	88	86
Spring 4-4-56[2]	1125	1120
Gain	-80	-94
Weaning 10-11-56	1252	1234
Cost of protein supplement ($)	7.41	8.05
Cost of pasture and minerals ($)	22.68	22.77
Total feed costs	30.09	30.82
Average birth date of calves	March 27	April 2
Average calf weight (lb)		
Birth weight[3]	82	82
Weaning weight 10-11-56[4]	518	515

1. Originally there were 17 cows in each lot. In Lot 1, 2 cows calved before 2-16-56. In Lot 2, one cow calved before 2-16-56 and one cow was open.

2. On April 4, 1956, nine of the 15 cows in each lot had calved.

3. Five pounds was added to the birth weight of each heifer to correct for sex.

4. Weaning weights were corrected for age and sex by using factors determined by Botkin (1952). Three steers in each lot were implanted with 15 mg of stilbestrol on July 2, 1956.

SUMMARY

A total of 11 feeding trials were conducted to study the value of urea in wintering rations for beef cattle.

A feeding experiment was conducted over a 4-year period using the same animals to test the value of a feed supplement containing approximately 1/2 of the total nitrogen as urea for wintering commercial beef cattle grazing native grass. When average winter gain of cows, average daily gain of calves during the wintering period, and weaning weight of calves were used as measurements of urea utilization, the results indicated that urea fed at this level was inefficiently utilized.

Four feeding trials were conducted over a 3-year period to evaluate a protein pellet in which urea supplied about 1/3 or 1/2 of the nitrogen when fed as a supplement to dried native grass for wintering beef calves and yearlings. These urea-containing pellets were fed with and without trace minerals. Results obtained showed that the addition of trace minerals to the urea-containing pellet increased urea utilization as measured by weight gains of the cattle. Dehydrated alfalfa meal was added to the protein pellet containing 1/3 of its nitrogen as urea in one trial. The data indicated that dehydrated alfalfa meal and trace minerals were approximately equal in improving urea utilization when added to the protein pellet in which urea furnished 1/3 of the nitrogen.

A total of 89 Hereford calves were used in two winter feeding trials conducted over a 2-year period to study the value of a feed protein containing approximately 1/3 of the total nitrogen as urea when fed with and without trace minerals as a supplement to prairie hay. Results indicated that little, if any, improvement in urea utilization was obtained by the additions of trace minerals to the urea-containing supplement.

Thirty mature Hereford cows were used in one feeding trial to test the value of a urea-molasses mixture as a supplement to native grass for wintering beef cows. Average weight gains of cows from the beginning of the winter feeding period to the beginning of the calving period and average weaning weight of calves were essentially the same in both groups indicating that cows may be wintered as satisfactorily with a urea-molasses mixture as with cottonseed meal provided equal amounts of energy and protein are supplied.

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