UREA AND BIURET FOR RANGE CATTLE

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Submitted to the Faculty of the Graduate College
of the Oklahoma State University
in partial fulfillment of the requirements
for the Degree of
DOCTOR OF PHILOSOPHY
May, 1974

UREA AND BIURET FOR RANGE CATTLE

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ACKNOWLEDGEMENTS

The author wishes to express his sincere appreciation to Dr. Robert Totusek, Professor of Animal Science, for his guidance and counsel during the course of this study. Appreciation is also extended to Dr. R. R. Johnson, Professor of Animal Science and Biochemistry, for assistance in the design of the research and laboratory analysis. Acknowledgement is also extended to Dr. E. C. Nelson, Professor of Biochemistry, Dr. E. J. Turman, Professor of Animal Science and Dr. J. V. Whiteman, Professor of Animal Science, for their help in preparation of this manuscript.

Grateful acknowledgement is extended to Dr. R. K. Johnson, Assistant Professor of Animal Science, Dr. J. V. Whiteman, Professor of Animal Science and Dr. R. D. Morrison, Professor of Mathematics and Statistics, for assistance in the experimental design and statistical analysis of the research.

Further appreciation is extended to fellow graduate students and student workers who helped immensely in the course of this study. Special thanks goes to beef cattle herdsmen Bill Sharp and Ray Heldermon for their care of the experimental cattle.

A very special recognition is extended to the author's wife, Doris and children, Cynthia and Angela, for their help and encouragement during this program of graduate study.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

The ruminant animal is unique in that it can convert large quantities of cellulose into human food. This is possible due to the large population of microorganisms in the rumen and because of this capability ruminants will occupy an even more important role in world food production in the future, especially in areas where land is not suitable for crop production. The ruminant can also convert many by-products, now being wasted, into edible protein.

The microorganisms in the rumen can synthesize high quality microbial protein that is later digested by the animal and used for biological protein synthesis. The microbes must have a source of energy, alpha keto acids and nitrogen to synthesize protein. Fortunately, nitrogen from a non-protein-nitrogen (NPN) compound such as urea can be utilized effectively. This is important because urea can be synthesized from atmospheric nitrogen and petroleum products at a very low cost per unit of nitrogen.

Although urea is presently used extensively with high concentrate rations, a considerable amount of research has shown that because of the rapid hydrolysis of urea, it is not well utilized by animals consuming high roughage low quality rations and high levels may even cause toxicity. This has stimulated interest in other NPN compounds and also in alteration of urea so a slower rate of hydrolysis may be obtained. Of the many compounds investigated biuret appears to have the most promise because the rate of ammonia release is similar to the rate of production of the alpha keto acids derived from high roughage diets. An apparent problem with biuret is that a considerable length of time is required for the rumen microorganisms to develop the ability to hydrolyze it.

Many factors are known to affect NPN utilization, such as available energy, level of NPN in the ration, amount of protein in the diet, level of trace minerals in the diet and frequency of intake. The elucidation of these factors could facilitate an increased utilization of NPN.

The purpose of this study was to: 1) compare the utilization of feed grade biuret, "pure" biuret, urea and natural protein, 2) evaluate the effects of adding methionine hydroxy analogue and high levels of alfalfa to biuret and urea containing supplements, 3) evaluate the effects of heating and extruding urea-grain mixtures on urea utilization, 4) measure the rate and extent of adaptation to biuret under winter range conditions, and 5) evaluate the effects of frequency of feeding of urea-containing supplements on cattle grazing winter range grass.

CHAPTER II

REVIEW OF LITERATURE

Introduction

Protein is usually the first limiting nutrient for livestock production throughout the world (if forage is adequate) and because of the increasing human population a larger proportion of natural proteins will probably be used by humans in the future. Therefore the utilization of non-protein-nitrogen (NPN) as a protein substitute for ruminants will become increasingly important. As early as 1891 Zuntz suggested that ruminants could utilize NPN for protein synthesis and research in the early nineteen hundreds demonstrated that NPN could replace a portion of the dietary protein.

Since that time a vast amount of research concerning the feeding of urea and other NPN products to livestock has been conducted. Excellent reviews of the past research work on NPN have been published by Reid (1953); McLaren (1964); Briggs (1967); Loosli and McDonald (1968) and Helmer and Bartley (1971). No attempt will be made to review all the research concerning NPN in this review.

The use of urea is a common practice in feedlot rations and the level of utilization is usually high; however, when NPN is used in lower energy rations its utilization is frequently low. Because of the poor utilization of urea under range conditions methods to improve the utilization of urea and other NPN compounds have been investigated. Of the NPN compounds considered, other than urea, biuret has received the most attention and many researchers feel it has the greatest potential as a NPN supplement for low quality roughages. Biuret is a compound resulting from the condensation of urea; it is less soluble and is hydrolyzed at a slower rate.

This review will include a comparison of urea and biuret utilization by ruminants consuming low energy, high roughage rations and will investigate effects of adding methionine hydroxy analogue (MHA) and relatively high levels of dehydrated alfalfa to the NPN sources. The effects of the frequency of feeding urea supplements to ruminants consuming high roughage diets will also be reviewed. Particular attention will be directed toward the adaptation of the rumen microflora to biuret; biuret adaptation will refer to the ability of the rumen microorganisms to hydrolyze biuret.

Non-Protein-Nitrogen Utilization

Comparison of Urea and Biuret. Urea has been investigated more extensively as a protein replacement than any other compound. The principal disadvantage of urea is its rapid hydrolysis which prevents its efficient utilization by ruminal microorganisms in high roughage diets. When this occurs a large portion of the excess ammonia is absorbed through the rumen wall and is excreted in the urine. The slower rate of hydrolysis of biuret more nearly corresponds to the rate of fermentation of low quality forages. Theoretically the utilization of ammonia supplied by biuret should be superior to utilization of ammonia from urea when low quality forages are the major portion of the diet.

When animal growth and other performance traits are used as the measurement criteria to evaluate the utilization of urea and biuret in comparison to all natural protein the results have been highly variable. Berry et al. (1956) and Campbell et al. (1963) compared the growth of cattle supplemented with biuret and urea and concluded that biuret was inferior to urea as a protein replacement. In contrast, Raleigh and Turner (1968) reported that heifers on low quality roughage diets supplemented with biuret gained significantly more than groups supplemented with the same level of nitrogen from urea or cottonseed meal. Meiske et al. (1955), Ewan et al. (1958), Mies et al. (1967), Van Horn et al. (1969), Clanton (1970), Chicco et al. (1971) and Thomas and Armitage (1972) have shown that weight gains of cattle on urea or biuret supplements are not significantly different. This indicates that the utilization of the two NPN sources is similar. However, natural protein supplements have been superior to supplements containing NPN in terms of animal performance. One possible reason for discrepancies in the literature concerning biuret and urea utilization is that earlier investigators were not aware that the rumen microflora required an adaptation period before biuret could be degraded. Unawareness of this phenomenon has caused errors in the interpretation of short term digestion trials.

Clark et al. (1963) and Ammerman et al. (1972) noted no difference in nitrogen balance in animals supplemented with urea or biuret while Chicco et al. (1971) found that biuret resulted in significantly more nitrogen retention than urea in bulls consuming a tropical forage.

Hatfield et al. (1959), Chicco et al. (1971), and Ammerman et al. (1972) have shown that dry matter and cellulose digestibility was increased when urea or biuret was used to supplement high roughage diets and usually forage intake was also increased.

Effect of Methionine Hydroxy Analogue. Methionine hydroxy analogue was first shown to increase milk production in dairy cows by Griel et al. (1968) when MHA was being tested as an additive to prevent ketosis. Chandler et al. (1970), Patton et al. (1970) and Polan et al. (1970) also showed that MHA supplementation increased milk production in dairy cows. The mode of action of MHA is not clear; however, several possibilities exist: 1) the analogue may bypass the rumen without degradation and be absorbed, aminated and utilized as methionine, 2) the sulfur from the analogue may be used for microbial synthesis of the sulfur containing amino acids, and 3) the analogue may be utilized by the rumen microorganisms.

Loosli and Harris (1945) showed that methionine supplementation to semipurified diets, containing large amounts of urea increased nitrogen retention; however, other research (Barton et al., 1971) has shown that sodium sulfate is as effective as methionine to promote in vitro cellulose digestion. Holter et al. (1972) showed that MHA supplementation of dairy rations increased fiber digestion. Gil et al. (1973) found that MHA significantly increased bacterial nitrogen and cellulose digestion in an in vitro system containing rumen fluid, urea and cellulose.

Performance data concerning MHA supplementation to low energy rations are limited; however, Varner et al. (1973) obtained a significant increase in adjusted weaning weight, daily gain of calves from birth to weaning and estimated milk production by feeding 15 g of MHA daily to cows grazing low quality roughage approximately 30 days before and 60 days after calving.

Griel et al. (1968), Lofgreen (1970) and Polan et al. (1970) reported that more than 25 g per head per day of MHA in high concentrate rations lowered feed intake, suggesting that MHA is unpalatable.

Effect of Alfalfa. Nelson et al. (1957) and Karr et al. (1965) showed that urea utilization could be improved with dehydrated alfalfa. Conrad and Hibbs (1968) reported that pellets containing dehydrated alfalfa (66%) and urea (31.6%) could effectively substitute for soybean meal in rations for lactating dairy cows. Similarly, Clanton (1970) found that high levels of dehydrated alfalfa (56 to 57%) improved gains of calves fed urea and biuret containing supplements. Wyatt (1973) showed that the level of alfalfa in the ration had no effect on the rate of adaptation to biuret.

Extruded Urea-Starch Mixture. Muhrer et al. (1968) heated a starch and urea mixture under pressure to 170^{o}C. They postulated that a starch carbamate may have been formed and in vitro studies indicated that ammonia was released at a rate which promoted more microbial protein synthesis than from unprocessed urea. Helmer et al. (1970) and Helmer, Bartley, and Deyoe (1970) pursued this work and developed Starea which is a urea-grain (milo, corn or barley) mixture that is processed under heat, pressure and proper moisture. This process gelatinizes the starch. When compared to an equal amount of an unprocessed urea-grain mixture, slower ammonia release, increased microbial protein synthesis and more milk produced by lactating dairy cows was reported. Tucker et al. (1972) and Tucker and Harbers (1972) reported that weight loss of mature cows and average daily gain of growing calves was intermediate for Starea-supplemented cattle when compared to an equivalent amount of natural protein and unprocessed milo-urea mixture.

Frequency of Feeding Urea. Campbell et al. (1963) fed growing heifers a urea containing ration six and two times daily and found that feeding more frequently improved rate of gain, ration digestibility and feed efficiency. Bloomfield et al. (1961) reported that whole blood albumin was increased and blood urea was decreased when urea was supplemented 16 times per day compared to daily feeding; however, nitrogen retention was not improved.

Other researchers (Dinning et al., 1949; Tollett et al., 1969; Thomas and Armitage, 1972; Rush and Totusek, 1973) found that feeding urea supplements at intervals less frequently than daily did not affect performance. Oltjen et al. (1973) found that daily gains of growing steers were improved, although not significantly, by feeding equivalent weekly amounts of urea supplements seven days per week in comparison to three times per week.

Many studies concerning frequency of feeding urea are confounded because energy and urea are consumed simultaneously and it is difficult to conclude if the responses are due to frequent intake of energy or nitrogen. Knight and Owens (1973) infused equivalent amounts of urea directly in the rumen of sheep over a 1, 3 and 12 hr. period. They showed that sheep consuming low energy diets and receiving urea infusions over a 1 and 3 hr. period had significantly higher nitrogen balance than control sheep receiving no supplemental urea; however, there were no significant differences in nitrogen retention of the control sheep and those receiving urea over a 12 hr. period.

Biuret Adaptation

Rumen contents from animals not previously fed biuret do not have the ability to effectively degrade it (Belasco, 1954; Oltjen et al., 1968). This led some early researchers to conclude that biuret could not be effectively utilized by rumen microorganisms as a protein replacement. It was later shown (Ewan et al., 1958; Hatfield et al., 1959) that biuret could be used as a protein replacement in a ration of low quality roughages; however, an adaptation period was required. The length of time required and the rate with which animals adapt to biuret is highly variable and appears to be influenced by many factors. McLaren et al. (1959) found that lambs fed biuret reached maximum nitrogen retention 30 to 40 days after they were started on the diet. Oltjen et al. (1969) compared the nitrogen retention of steers consuming an 85% roughage diet that was supplemented with urea, natural protein or biuret and found that the steers supplemented with biuret were adapted 21 days after the initial feeding. Other growth studies have shown that there is a lag phase during which there is no beneficial response to biuret feeding (Hatfield et al., 1959; MacKenzie and Altona, 1964a).

A considerable amount of work has recently been conducted at the Oklahoma Agricultural Experiment Station and by South African researchers wherein biuretolytic activity was determined by measuring in vitro biuret disappearance in rumen fluid taken from animals consuming rations containing biuret. Gilchrist et al. (1968) and Johnson and Clemens (1973) found measurable biuretolytic activity in rumen fluid from sheep on high roughage rations within 1 to 2 weeks after biuret feeding began; however, 3 to 6 weeks were required to reach maximum activity.

There is considerable evidence which suggests that the length of the adaptation period can be reduced markedly. The level of protein and readily available carbohydrates in the diet appear to influence the length of adaptation. Schroder and Gilchrist (1969) found that when lambs were fed hay of low protein (3.4%), medium protein (5.0%), and high protein (10.3%) that maximum biuretolytic activity was reached approximately 15, 30 and 70 days after biuret feeding began with the respective diets. Clemens and Johnson (1973) showed that lambs on poor quality, high roughage diets developed significant biuretolytic activity 2 days after the initiation of biuret supplementation. The authors noted that the lambs had been adapted to biuret in an earlier trial (terminated 40 days previously) however, they were not adapted when the trial was initiated. Wyatt (1973) also found that lambs receiving an 80% cottonseed hull diet were well adapted to biuret 3 days after the experiment started. These lambs had not been previously fed biuret. MacKenzie and Altona (1964a) observed a live weight response one week after biuret was fed in a salt lick. There appears to be considerable animal to animal variation in the biuret adaptation trials.

Gilchrist et al. (1968), Schroder and Gilchrist (1969), and Clemens and Johnson (1973) have shown that the addition of soluble carbohydrates to the diet increases the rate of adaptation to biuret.

Schroder and Gilchrist (1969) and Clemens and Johnson (1973) showed that removal of biuret from the ration resulted in a loss of a major part of the biuretolytic activity in 4 days and a considerable loss 2 days post-feeding. Schroder and Gilchrist (1969) suggested that "re-adaptation" occurs at approximately the same rate as the initial adaptation period. Clemens and Johnson (1973) showed that biuret should be fed at least every 2 days to maintain biuretolytic activity in adapted sheep. When biuret was fed every 4 days to the adapted sheep biuretolytic activity was initially lost. It was partially recovered after the lambs were fed every 4 days for a 32 day period; however, activity was at a relatively low level.

CHAPTER III

SUPPLEMENTAL VALUE OF UREA AND FEED GRADE BIURET FOR COWS ON DRY WINTER GRASS[1,2]

Summary

Four trials were conducted to evaluate the supplemental value of feed grade biuret (in dry supplements) and urea (in dry supplements and liquid urea-molasses mixtures) for beef cows grazing low quality dry winter range grass. Urea or feed grade biuret provided approximately 50 and 94% of the nitrogen in 30% dry and liquid NPN containing supplements, respectively. Dry supplements were self-fed with salt added to limit intake.

Cows wintered on natural 30% protein supplements lost less weight than cows receiving isonitrogenous NPN-containing supplements in three of the four trials. Winter weight loss of cows fed dry biuret-containing supplements was greater than that of cows fed dry urea-containing supplements ($P < .05$). Cows supplemented with liquid cane molasses lost more weight ($P = .11$) and were in thinner condition at the end of winter

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[1]Journal Article of the Agricultural Experiment Station, Oklahoma State University, Stillwater.

[2]The author wishes to express his appreciation to Bill Sharp for his care of experimental animals; Nipak, Pryor, Oklahoma, for urea; Dow Chemical, Midland, Michigan, for feed grade biuret; and National Molasses Company, Willow Grove, Pennsylvania and Lyle Perry, Waukomis, Oklahoma, for liquid supplement in one trial.

than cows receiving urea-molasses liquid supplements although the molasses intake was considerably higher (3.08 vs. 1.55 kg per cow daily).

Spring and summer gain was greatest for cows that lost the most weight during the wintering period and fall weights of cows were not significantly different. Birth weight and weaning weight of calves were not significantly affected by treatment.

Introduction

Low quality forages are used extensively for wintering beef cattle and supplementation with protein is usually needed for satisfactory performance. Nelson and Waller (1962) summarized 16 experiments involving beef cattle wintered on low quality native range grass in Oklahoma and found that urea-containing supplements were of lower value than supplements containing cottonseed meal. Most research indicates that the urea utilization is poor when used to supplement cattle grazing low quality forage. Since the poor utilization is caused in part by rapid hydrolysis of urea, much attention has been directed toward the use of biuret which is hydrolyzed at a slower rate (Berry et al., 1956; Hatfied et al., 1959, Clanton, 1970, Raleigh and Turner, 1968; Oltjen, Burns and Ammerman, 1973).

Readily available carbohydrates improve the utilization of urea and in many areas of the world liquid molasses is an economical carbohydrate source and serves as a good carrier for urea. Urea-molasses blends offer the advantage of self-feeding which may reduce labor and also provide for a slow and intermittent intake.

Gains of cattle subsisting on low quality forages have been improved with urea molasses, but usually not with molasses alone, indicating that protein is the first limiting nutrient (Beames, 1959).

The purpose of these trials was to compare supplements containing all natural protein with supplements containing relatively high levels of urea and biuret for cows grazing low quality forage.

Experimental Procedure

The trials were conducted in Central Oklahoma on dry native range grass during winter. The predominant forage was of the tall-grass type with climax species consisting of little bluestem (Andropogon scorparius), big bluestem (Andropogon gerardi), Indian grass (Sorghastrum nutans) and switch grass (Panicum virgatum).

Angus and Hereford cows were randomly allotted, after stratification by breed, to treatment groups in each trial. The majority of calves were born during February, March and April. Cow treatment groups were rotated among pastures at approximately 28-day intervals in each trial to minimize differences due to pastures. At the end of each trial condition of cows was estimated by scoring each cow on a scale of 1 to 9, with 1 being the thinnest and 9 the fattest. The weaning weight of calves was adjusted to a 205-day steer equivalent basis.

Trial 1. Forty-two 5-year-old Angus and Hereford cows were used in a wintering trial of 140 days. A 25% natural protein was hand-fed to one treatment group at the rate of 1.35 kg per cow daily and the second treatment group was allowed to consume a 30% CP liquid urea-molasses supplement *ad libitum*.

The major ingredients in the dry supplement were milo and cottonseed meal with 5% alfalfa and 5% liquid molasses. Both supplements were formulated to contain 1.25% phosphorus and 22,000 IU of Vitamin A per kilogram. The protein equivalent from urea in the liquid supplement was 28.1%. In addition to the protein supplements good quality prairie hay was fed at the rate of 4.5 kg per cow daily beginning at the start of calving, approximately February 1, which was 84 days before the end of the trial. All cows calved before the end of the trial.

Trial 2. Thirty-one 4- and 5-year-old Angus and Hereford cows were used in a 139-day wintering trial. Three supplemental protein treatments were compared; natural protein, feed grade biuret and urea. The supplements were formulated to contain 30% CP with the NPN sources contributing 50% of the nitrogen. The major feed ingredients in the supplements were wheat and soybean meal. The supplements were formulated to contain 5% dehydrated alfalfa, 5% molasses, 1.5% phosphorus, 0.5% calcium, 0.5% sulfur and 22,000 IU of Vitamin A per kilogram. The supplements were self-fed with consumption regulated by the inclusion of salt. Hay was fed only when snow covered the grass. These cows were open at the beginning of the trial and were pasture exposed to bulls for 45 days during the trial.

Trial 3. The same supplements fed in trial 2 were utilized in trial 3. In addition, a fourth treatment group received a commercial 30% CP liquid supplement (28.1% CP equivalent from urea) *ad libitum*. Experimental cows in this 139-day trial were 38 6-year-old Hereford and Angus cows. Twenty-seven cows calved during the latter part of the trial. Because the number of cows which had not calved by the end of the trial was not equal among treatments and since calving involves considerable weight loss, the final weight of the cows that had not calved was adjusted to a calved basis. This was done by using a regression equation derived from data obtained in trials wherein cows were accurately weighed prior to and after calving; the calves were also weighed at birth (Ewing et al., 1966, unpublished data). The following equation was used to adjust the final winter weights of the cows which had not calved.

$$\text{Adjusted final weight} = \text{actual final weight} - [(\text{calf birth weight} \times 1.9697) - 19.0]$$

Aluminum sulfate (10 to 20 lb./ton) was used to limit intake of the liquid supplement which was provided in tanks equipped with self-feeding wheels. Hay was fed only on a few days when snow covered the grass.

Trial 4. Six supplements were fed, four dry and two liquid (Table I). Two dry all natural protein supplements containing 15 and 30% CP served as negative and positive controls, respectively. Two dry supplements containing 30% CP included urea or feed grade biuret to provide 50% of the nitrogen. Supplements were formulated to contain the same level of calcium and phosphorus as in trial 3 and to have a nitrogen: sulfur ratio of 14:1. Two liquid supplements were fed; one (same formulation as in trial 3) contained 30% CP (28.1% CP equivalent from urea) and the second was cane molasses which served as a negative control for the liquid 30% CP supplement. Aluminum sulfate was added to the two liquid supplements to prevent over consumption while salt was used to control intake of dry supplements.

Fifty-six Hereford and Angus cows 4 to 6 years old were used in the 84-day trial. The final weights of 21 cows which had not calved by the end of the trial were adjusted to a calved basis by using the same procedure described for trial 3.

The data were analyzed by analysis of variance (with unequal numbers per treatment) as outlined by Snedecor and Cochran (1967). Breed x treatment interaction was not significant ($P > .50$) for the traits studied in any of the trials; breeds were combined for subsequent analysis. The F test was used to test for treatment differences and the t test was used to test for differences between any two treatments.

Results and Discussion

Trial 1. Cow winter weight loss, cow summer gain and calf performance were not different ($P > .50$) for natural protein and liquid urea-molasses supplements (Table I). Cows receiving the liquid supplement consumed more supplemental nitrogen (91.4 g vs. 54.4 g per cow daily).

Trial 2. The pregnant cows in trial 2 consuming natural protein gained 3.3 kg during the wintering trial while the cows receiving NPN supplements lost weight (Table III). Weight change for natural and urea supplements was not different ($P > .05$), but cows consuming the biuret supplement lost more weight ($P < .05$). Condition of the cows at the end of the wintering period followed the same trend ($P = .10$); cows which lost the most weight were thinnest at the end of winter. Palatability of the urea and biuret supplements was similar, but level of salt required to control the intake of the natural protein supplement was considerably higher than that required for the NPN supplements.

Trial 3. Results of trial 3 were not consistent with results of trials 1, 2 and 4 (Table IV). Cows receiving the dry urea supplement lost less winter weight than cows receiving the other supplements, and significantly ($P < .05$) less than cows receiving natural protein and liquid urea-molasses supplements. Cows receiving the liquid urea-molasses supplement lost more weight ($P < .05$) than cows on the dry supplements. Summer gain was highest for cows which lost the most weight during winter. Condition score at the end of winter was highest for the cows receiving the dry natural protein supplement and lowest for cows consuming the liquid supplement. Calf birth weight ($P = .551$) and weaning weight ($P = .361$) were not affected by treatment.

Supplement intake was approximately equal for all treatments. The level of salt required to control intake of dry supplements was 28.2, 26.8 and 21.7% for natural, biuret and urea supplements, respectively, suggesting the order of palatability. A considerable pasture effect in supplement intake was noted when cows were rotated among pastures. At the beginning of the trial the intake of liquid supplement was very high (4.08 kg per cow daily); aluminum sulfate was added to limit its intake. By the end of the trial the intake of liquid supplement had decreased to a low level (0.5 kg) without aluminum sulfate added.

Trial 4. Cows consuming the natural 30% CP lost the least winter weight (Table V). Winter weight loss of cows receiving the 15% natural protein supplement was 38 kg greater ($P = .15$) than that of the cows receiving the 30% natural protein, indicating a need for supplemental protein above the amount supplied by the 15% protein supplement. Cows receiving the 30% natural protein lost less weight ($P < .10$) as a percent of initial weight than cows on all treatments except the dry urea supplement. Weight loss of cows consuming molasses was greater ($P < .10$) than that of cows on the protein supplements. As in previous trials, cows which lost the most weight during the winter compensated by gaining the most weight during the summer.

Winter treatment did not affect calf birth weight ($P = .67$) or weaning weight ($P = .81$).

The level of salt required to control the intake of dry supplements was highest for the 30% natural protein supplement and lowest for the biuret containing supplement. The intake of molasses was excessively high even after a high level of aluminum sulfate (4.5 to 9.0 kg/ton) was added.

Discussion. Although the effect of type of supplement on weight loss of cows was not completely consistent, cows receiving natural protein supplement tended to lose less weight during the wintering period than cows fed the NPN supplements, in agreement with Clanton (1970), Raleigh and Wallace (1963), Tollett et al. (1969), and Turner and Raleigh (1969). These trials suggested that nitrogen utilization was greater from urea than from biuret (in dry supplements); cows receiving urea supplements lost less weight than cows receiving isonitrogenous supplements containing feed grade biuret. This is in agreement with results of Berry, Riggs and Kunkel (1956) and Campbell et al. (1963) but in contrast with results of Raleigh and Turner (1968) and Turner and Raleigh (1969).

It is not readily apparent why the cows receiving the dry urea supplement in trial 3 lost significantly less weight than cows receiving natural protein. However, it was noted that most of the difference in weight loss occurred during the last 42 days of the trial. During the earlier and most severe part of the winter, cows fed natural protein supplement actually lost less weight ($P < .05$). Pasture differences in growth of early spring grass could have caused the difference in weight loss observed the last 42 days.

Winter weight loss of cows consuming the liquid urea-molasses supplement was greater than that of cows consuming any of the dry protein supplements; however, the difference in trial 1 was very small. Intake of liquid supplement in trial 1 was greater than that of the dry natural protein supplement; consequently, the supplemental nitrogen intake was considerably higher on the liquid supplement (91 vs. 54 g per cow daily). Apparently the utilization of the larger quantity of nitrogen in the liquid supplement was not sufficiently high to elicit a beneficial weight response. The greater weight loss of cows consuming liquid urea-molasses supplement compared to cows consuming dry urea supplements was probably due to the higher (44%) level of NPN in the liquid supplement and its poor utilization (Clanton, 1970; Raleigh and Wallace, 1963). It is also possible that starch, present in the dry supplements, supported greater urea-nitrogen utilization than sugars in the molasses fraction of the liquid supplements (Bloomfield, Muhrer and Pfander, 1958). Some utilization of urea nitrogen supplied by the liquid supplement apparently occurred; the cows consuming liquid urea-molasses lost less weight ($P = .11$) than the cows consuming approximately twice the quantity of liquid cane molasses. This is in agreement with Beames (1959), Beames (1963), and Coombe (1959) and demonstrates that supplemental energy is of little benefit to a low protein diet.

Winter weight loss did not appear to adversely affect summer gain of the cow. Cows that lost the most weight during winter compensated by gaining the most summer weight and were in comparable condition by the time calves were weaned at the end of summer grazing.

Condition scores of cows at the end of winter followed the same trend as winter weight change; cows which lost the most weight had the lowest condition scores. The results of trial 3 were not in agreement with this trend; cows fed the natural protein supplement lost the most weight but had the highest condition score. Although cows were assigned to treatment at random, cows fed the natural protein supplement were in better condition at the beginning of the wintering treatment. It is also possible that body weight change did not accurately affect body composition changes.

Weaning weight of calves was not affected by the wintering treatment and weight loss of the cows, in agreement with Turner, Raleigh and Phillips (1970). This was not surprising since the majority of cows calved either during the latter part of winter or after the trials were completed.

TABLE I

INGREDIENT MAKEUP OF DRY SUPPLEMENTS (PERCENT), TRIAL 4

Ingredient	Supplement, % CP			
	1 Natural 15	2 Natural 30	3 Urea[a] 30	4 Biuret[a] 30
Milo	72.8	34.0	63.1	61.4
Soybean meal, sol. (44%)	17.4	56.8	19.4	19.9
Alfalfa, dehydrated	5.0	5.0	5.0	5.0
Urea (45% nitrogen)	--	--	5.31	--
Feed grade biuret[b]	--	--	--	6.46
Dicalcium phosphate	1.28	0.90	1.27	1.27
Monosodium phosphate	3.52	3.30	3.58	3.59
Sodium sulfate[c]	--	--	2.35	2.35
Vitamin A[d]	+	+	+	+

[a]To furnish one-half of total crude protein.
[b]Approximate chemical composition (dry matter basis): biuret 60%; urea 15%; cynanuric acid and triuret 21%; total nitrogen 37%.
[c]Formulated to supply nitrogen sulfur ratio of 14:1.
[d]Added to supply 22,000 IU per kg.

TABLE II

PERFORMANCE OF COWS AND CALVES, TRIAL 1

Item	Supplement, % CP: Natural 25	Liquid 30	Probability[a]
No. cows	22	20	
Supplement consumed, kg	1.36	1.91	
Weight per cow			
Initial, kg	426	434	
Winter loss, kg	65 ± 4.1[d]	64 ± 4.3	0.837
Winter loss, %	15.26 ± .70	14.74 ± .73	0.508
Summer gain, kg[b]	77 ± 3.6	73 ± 3.8	0.515
Adjusted weaning wt., kg[c]	229 ± 4.9	226 ± 5.2	0.736

[a]Probability that differences in means are due to chance.
[b]Gain from end of wintering trial to weaning date of calf.
[c]Adjusted to a 205 day, steer equivalent.
[d]Standard error of mean.

TABLE III

PERFORMANCE OF PREGNANT COWS, TRIAL 2

Item	Supplement, % CP: Natural 30	Urea[a] 30	Biuret[a] 30	Probability[b]
No. cows	10	11	10	
Daily supplement intake				
Protein supplement, kg	1.33	1.30	1.22	
Salt, kg	0.47	0.36	0.37	
Weight per cow				
Initial, kg	400	412	412	
Winter change, kg	3.3 ± 4.7[ce]	-8.5 ± 4.5[e]	-26.0 ± 4.7[f]	.0007
Winter change, %	1.14 ± 1.1[e]	-2.09 ± 1.1[f]	-6.21 ± 1.1[g]	.0004
Condition, end of winter[d]	4.6 ± .26	4.1 ± .25	3.8 ± .26	.105

[a]To furnish one-half of total crude protein.
[b]Probability that differences in means are due to chance.
[c]Standard error of mean.
[d]On a scale of 1 to 9, one the thinnest and 9 the fattest.
[e,f,g]Means with different superscripts are significantly different ($P < .05$).

TABLE IV

PERFORMANCE OF COWS AND CALVES, TRIAL 3

Item	Supplement, 30% CP Dry Natural	Dry Urea	Dry Biuret	Liquid Urea	Probability[a]
No. cows	9	10	9	10	
Daily supplement intake					
Protein supplement, kg	1.48	1.47	1.45	1.45	
Salt, kg	0.58	0.41	0.53		
Weight per cow					
Initial, kg	471	468	473	460	
Winter loss, kg	68 ± 7.0^{bg}	39 ± 6.6^{h}	58 ± 7.0^{gh}	89 ± 6.6^{i}	.0002
Winter loss, %	14.42 ± 1.45^{g}	8.28 ± 1.37^{h}	11.77 ± 1.45^{gh}	19.48 ± 1.37^{i}	.0001
Summer gain, kg[c]	36 ± 6.9^{g}	16 ± 6.6^{h}	31 ± 6.9^{gh}	59 ± 6.6^{i}	.0023
Condition, end of winter[d]	$4.33 \pm .24$	$4.20 \pm .23$	$4.00 \pm .24$	$3.50 \pm .23$	.120
Calf performance					
Adj. birth wt., kg[e]	30.5 ± 1.7	32.2 ± 1.6	34.0 ± 1.7	32.6 ± 1.6	.551
Adj. weaning wt., kg[f]	206 ± 6.2	209 ± 5.9	200 ± 6.2	195 ± 5.9	

[a]Probability that differences in means are due to chance.
[b]Standard error of mean.
[c]Gain from end of wintering trial to weaning date of calf.
[d]Based on a scale of 1 to 9 with 1 being the thinnest and 9 the fattest.
[e]Heifer calves adjusted to bull equivalent by multiplying actual birth weight by 1.048.
[f]Adjusted to 205 day, steer equivalent.
[g,h,i]Means with different superscripts are significantly different ($P < .05$).

TABLE V

PERFORMANCE OF COWS AND CALVES, TRIAL 4

Item	Supplement, % CP						Probability[a]
	Dry				Liquid		
	Natural 15	Natural 30	Urea 30	Biuret 30	Urea 30	Molasses 3	
No. cows	10	10	9	9	9	9	
Daily supplement intake							
Protein supplement, kg	1.22	1.18	1.33	1.23	1.55	3.08	
Salt, kg	0.39	0.45	0.39	0.31	--	--	
Weight per cow							
Initial, kg	470	488	465	477	464	482	
Winter loss, kg	89 ± 8.47[bgh]	72 ± 8.47[g]	79 ± 8.93[hi]	92 ± 8.93[gh]	96 ± 8.93[hij]	117 ± 8.93[j]	.016
Winter loss, %	18.90 ± 1.57[g]	14.82 ± 1.57[h]	17.21 ± 1.65[gh]	19.04 ± .165[g]	20.84 ± 1.65[gi]	24.27 ± 1.65[i]	.0047
Summer gain, kg[c]	72 ± 10.8	55 ± 10.8	71 ± 11.4	87 ± 11.4	87 ± 11.4	95 ± 11.4	.152
Condition, end of winter[d]	3.60 ± .29[g]	4.00 ± .29[g]	3.89 ± .31[g]	3.33 ± .21[gh]	3.11 ± .31[hi]	2.56 ± .31[i]	.015
Calf performance							
Adj. birth wt., kg[e]	34.5 ± 1.4	36.3 ± 1.4	36.8 ± 1.5	33.4 ± 1.5	35.8 ± 1.5	35.2 ± 1.5	.67
Adj. weaning wt., kg[f]	236 ± 6.7	245 ± 6.7	246 ± 7.1	250 ± 7.1	248 ± 7.1	246 ± 7.1	.81

[a]Probability that differences in means are due to chance.
[b]Standard error of mean.
[c]Gain from end of wintering trial to weaning date of calf.
[d]Based on a scale of 1 to 9 with 1 being the thinnest and 9 the fattest.
[e]Heifer calves adjusted to bull equivalent by multiplying actual birth weight by 1.048.
[f]Adjusted to 205-day, steer equivalent.
[g,h,i,j]Means with different superscripts are significantly different ($P < .10$).

CHAPTER IV

COMPARISONS OF RANGE SUPPLEMENTS CONTAINING NPN SOURCES[1,2]

Summary

Two winter trials involving a total of 304 range cows were conducted to evaluate the supplemental value of non-protein-nitrogen (NPN) from biuret, feed grade biuret, urea and extruded grain-urea for lactating beef cows grazing low quality winter forage. Each NPN source provided one-half of the nitrogen in a 30% protein supplement which was compared to a negative (15% natural protein) and a positive (30% natural protein) control supplement; winter weight loss of cows was significantly ($P < .01$) greater on the negative than on the positive control. The value of methionine-hydroxy-analogue (MHA) and a high (40%) level of dehydrated alfalfa in biuret and urea supplements was determined.

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[1]Journal Article of the Agricultural Experiment Station, Oklahoma State University, Stillwater.

[2]The author expresses appreciation to Dr. R. K. Johnson and Dr. J. V. Whiteman for assistance in statistical analysis and Bill Sharp and Ray Heldermon for care of experimental animals. Grateful acknowledgement is also expressed to Dow Chemical, Midland, Michigan, for feed grade biuret and partial financial support; E. I. dePont de Nemours and Company, Wilmington, Delaware, for a source of methionine-hydroxy-analogue and partial financial support; Far-Mar-Co., Inc., Hutchinson, Kansas, for a source of extruded urea-grain and partial financial support; Nipak, Pryor, Oklahoma, for urea and pure biuret and Triple "F" Feeds, Des Moines, Iowa, for a source of extruded urea-grain.

Observations were also made on the rate and extent of biuret adaptation under range conditions.

Supplements containing NPN were compared to negative and positive controls on the basis of weight and condition changes of cows during winter. Urea appeared to be poorly utilized, since performance of cows fed urea and negative control supplements was similar. Apparent utilization of urea was not improved by extruding with grain. Apparent utilization of biuret and feed grade biuret was similar but greater than that of urea. Considerable biuretolytic activity occurred within 6 days and reached a near-maximum level within 21 days; high activity was maintained throughout the trial even though biuret feeding was frequently interrupted.

MHA did not improve apparent NPN utilization, but apparent urea utilization was improved by 40% dehydrated alfalfa. Palatability of supplements containing urea, poorer than that of supplements containing biuret or feed grade biuret, was decreased with MHA or by extruding urea with grain but slightly improved with 40% alfalfa. Gain of calves during winter or to weaning was not consistently affected by kind of supplement. Cows with the highest winter weight loss had the highest summer gain, so that cow weights among treatments tended to equalize by end of summer.

In a third trial 30% crude protein (CP) supplements containing one-half of the nitrogen from NPN of urea or extruded urea-grain were compared with a 30% natural protein control supplement for yearling heifers in drylot fed prairie hay or late-winter-harvested range grass. Weight gains were not different for the three supplements on prairie hay, but on harvested winter range grass gains indicated that apparent utilization of both urea supplements was poor.

Introduction

Considerable research has shown that non-protein-nitrogen (NPN) can be successfully utilized as a supplement to harvested roughages. However, when NPN is used to supplement low quality roughage, results are often poor. Urea is the most common NPN source used in range supplements; however, because of its rapid hydrolysis, the ammonia produced is usually in excess of the available energy supplied by the low quality forage and much of the ammonia is lost (Bloomfield, Garner and Muhrer, 1960).

A slower ammonia release may improve NPN utilization when fed with low quality roughages (Knight and Owens, 1973). Ammonia release is slower from biuret (Johnson and Clemens, 1973), and biuret supplemented cattle may gain faster than cattle receiving a urea supplement (Raleigh and Turner, 1968). However, in other research the performance of biuret supplemented cattle was inferior to that of urea fed cattle (Berry, Riggs and Kunkel, 1956; Campbell et al., 1963). A major disadvantage of biuret, which may explain some of the discrepancies in the literature, is that rumen microflora must adapt to it before developing biuretolytic activity. Time required for biuret adaptation depends on the level in the ration (Clemens and Johnson, 1973; Gilchrist, Potgieter and Voss, 1968; Johnson and Clemens, 1973; Schroder and Gilchrist, 1969). Most adaptation studies have been conducted under laboratory procedures and with sheep and harvested roughage. Similar data is needed for cattle grazing low quality forage.

Non-protein-nitrogen utilization was improved with low levels of dehydrated alfalfa (Karr et al., 1965), and high levels of dehydrated alfalfa and urea satisfactorily replaced soybean meal in lactating dairy cow rations (Conrad and Hibbs, 1968). Methionine-hydroxy-analogue (MHA) apparently improved milk production of dairy cows (Griel et al., 1968) and beef cows (Varner, Bellows and Oltjen, 1973) when added to rations containing all natural protein. Because beef cows wintered on low quality forage are subjected to stress and lose weight in a pattern similar to higher producing dairy cows, the value of high levels of dehydrated alfalfa and MHA in range supplements containing high levels of NPN should be determined.

The purpose of this experiment was to determine: (1) the apparent utilization of biuret (pure and feed grade) and urea (unprocessed and extruded with grain) in range cattle supplements, (2) the effects of MHA and high levels of dehydrated alfalfa in range cattle supplements containing high levels of urea and biuret, and (3) the rate and extent of biuret adaptation by cattle under range conditions.

Experimental Procedure

Trial 1. Trial 1 was conducted during the winter on the Lake Carl Blackwell Range in Central Oklahoma on dry native range grass. Predominant forages are of the tallgrass prairie type with climax species consisting of little bluestem (Andropogon scorparius), big bluestem (Andropogon gerardi), Indian grass (Sorghastrum nutans), and switch grass (Panicum virgatum). Dry range grass was in abundant supply during the experiment; prairie hay was fed only when ice or snow covered the grass.

A total of 140 experimental cows included 82 mature Hereford and Angus cows and 58 first-calf Hereford heifers approximately 32 months old at first calving. Mature cows calved either shortly before or after the trial started while first-calf Hereford heifers calved during early fall before the experiment started. Cows were randomly assigned within breed and age to nine supplement treatments. The trial lasted 88 days.

Ingredient makeup of supplements is shown in Table VI; supplements 1, 2, 3, 4, 5, 6A, 7A, 8 and 9 were fed in trial 1. Supplements 1 (approximately 15% CP) and 2 (approximately 30% CP) contained all natural protein and served as negative and positive controls, respectively. The remaining seven supplements were formulated to contain 30% CP (90% DM basis) with one-half of the CP from NPN sources. The supplements were also formulated to contain 1.25% phosphorus, 0.5% calcium and a nitrogen: sulphur ratio of 14:1. The MHA[3] was added to provide 10 and 20 g per head daily before and after calving, respectively. Supplements were processed into 0.98 mm ($\frac{1}{4}$ in.) pellets. Dry matter and crude protein of supplements were determined by A.O.A.C. procedures.

Cows, allowed to graze in a common pasture, were gathered to a central feeding area each day (6 days each week), placed in 0.91 x 2.44 m stalls and individually fed their supplement. Twenty minutes were allowed for consumption of supplements; feed refusals were recorded daily. Amounts of supplement offered per cow each feeding were 0.79 and 1.59 kg for mature cows and 1.06 and 2.12 kg for first-calf heifers, before and after calving, respectively. Severe weather prevented feeding of supplements on 6 days. Cows and calves were weighed after being gathered at daybreak and withheld from feed and water for approximately

[3]"Hydan," E. I. duPont de Nemours and Company, Wilmington, Delaware 19898.

6 hours. Calves were also weighed shortly after birth. Condition loss of cows was estimated by scoring the cows for condition at the initiation and conclusion of the trial. Scores of 1 to 9 were used with 1 being the thinnest and 9 the fattest.

Since the number of mature cows which calved previous to the trial was disproportionate among treatments, initial weight of the mature cows that had calved before the trial was adjusted to a pregnant weight basis. The regression equation used to correct the initial cow weight, derived from data (Ewing et al., 1966 and unpublished data) where calving weight loss and calf birth weight were accurately obtained, is as follows:

$$\text{Adjusted initial weight} = \text{Actual initial weight} + (\text{calf birth wt.} \times 1.9697) - 19.0$$

Calves out of mature cows were sired by Charolais bulls while calves out of first-calf heifers were sired by Hereford bulls. Weaning weights were adjusted to a 205-day, steer basis by multiplying the adjusted 205-day weight of heifers by 1.05. Dehydrated alfalfa pellets were provided for calves in a creep during the later part of the trial.

Data were analyzed by least squares regression analysis with the F test utilized to test for significant treatment differences. The students' t test was utilized to test for differences between any two treatments.

Trial 2. Trial 2 was conducted at the same location as trial 1 during the following winter. Cows were managed in the same manner, including the supplementation of cows in individual stalls. A total of 164 experimental cows consisted of 81 Herefords, 44 Angus and 39 Angus x Holstein crossbreds. They calved either shortly before or after the trial started. Initial weights of cows that calved before the experiment started were adjusted to a pregnant basis as in trial 1.

Supplements were formulated as in trial 1; however, supplements containing MHA (6A and 7A) were replaced. In supplement 6B the NPN fraction was a mixture of urea (50%) and biuret (50%) while in supplement 7B urea, present in an extruded milo-urea mixture,[4] contributed one-half of the crude protein. Amounts of daily supplement offered per cow were 1.06 and 2.12 kg for Hereford and Angus cows and 1.59 and 2.65 kg for crossbred cows, before and after calving, respectively.

The weather during trial 2 was more severe and prevented the feeding of supplements 22 days of the 112-day feeding trial. When supplements were not fed, prairie hay was fed daily. In addition, the 30% natural protein supplement was group-fed at the rate of 1.36 kg per head per day when the experimental supplements had not been fed for three consecutive days. Cows were weighed after overnight confinement in corrals without feed or water for 12 to 14 hours.

Statistical analysis of the data was conducted as in trial 1, except analysis of co-variance was used to adjust the initial weight of the Hereford cows to an equal basis (Snedecor and Cochran, 1967).

Since trial x treatment, breed of cow x treatment and age of cow x treatment interactions were not significant (P > .10), treatments 1, 2, 3, 4, 5, 8, and 9 were pooled for trials 1 and 2, and the pooled data were analyzed in the same manner as in each individual trial.

<u>Trial 3</u>. A growth trial was conducted in drylot during a 93-day period during the summer to compare the apparent utilization of

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[4]"Golden Pro," Triple "F" Feeds, Des Moines, Iowa 50322.

of supplemental nitrogen from natural protein, unprocessed urea and urea in an extruded grain-urea mixture[5] (supplements 2, 5 and 10, Table VI). A total of 27 yearling heifers (9 Hereford and 18 Hereford x Angus-Holstein) were blocked according to breed and weight and randomly assigned to three treatment groups of 9 heifers each. Nine heifers (three from each treatment) were maintained in each of three lots. Tallgrass prairie forage was fed ad libitum. Hay for the first phase (44 days) had been cut in mid-July and was of moderate quality. Hay for the second phase (44 days) had been cut in early April and resembled late-winter dry range grass. Crude protein of the two hays was 5.0 and 3.9% respectively. Supplements were fed in individual stalls twice daily at the rate of 454 g per feeding (908 g/day).

Heifers were weighed at 14-day intervals after a 14-hr. shrink without feed or water. Change in condition was estimated in the same manner as in trials 1 and 2. Hay intake of each treatment group was measured for 5 days at the end of each phase of the experiment. During this time supplemental feeding continued as before; however, each treatment group was maintained in a separate lot which allowed daily mesurement of hay intake for each group.

Analysis of variance was used to test for significance and the LSD multiple range test was used to test for significant differences between treatment means (Snedecor and Cochran, 1967).

Biuret Adaptation Trials. Nine mature steers, equipped with rumen cannulas, were used to measure the rate and extent of adaptation of rumen microorganisms to biuret under range conditions. The steers were allowed to graze in the same pasture as the cows during the first 74 days of trial 2 and were fed and managed in the same manner as the cows. They were randomly allotted to supplemental treatments 2, 4 and 8 (Table VI) and were individually fed 1.59 kg of the supplement per day.

Rumen samples from each steer were obtained on days 0, 4, 6, 17, 20, 28, 34, 49 and 74 of the experiment. Biuretolytic activity of the rumen contents was determined by procedures described by Johnson and Clemens (1973).

These data were analyzed with analysis of variance with the F test utilized to test significant differences. Differences between means were determined by the LSD method (Snedecor and Cochran, 1967).

Results and Discussion

Treatments 6 and 7 were different in trials 1 and 2 and will be discussed within each trial; the results and discussion of treatments 1, 2, 3, 4, 5, 8 and 9 will be based on the pooled data of trials 1 and 2.

Trial 1. The results of trial 1 are shown in Table VII. Cows receiving the negative control (15% natural protein) supplement lost ($P \approx .025$) more weight than cows consuming the positive control (30% natural protein) indicating that protein was deficient in the negative control and providing validity for the experimental design for comparing supplements.

The effect of MHA, when added to the urea (U) or biuret (B) containing supplements, on the weight loss of the cow was small. Weight loss of the cows receiving B, B + MHA, U and U + MHA was not significantly different ($P < .05$); however, the cows consuming the supplement containing urea and MHA had the largest weight loss.

Addition of MHA lowered palatability and consequently intake of supplements. Although the levels fed (10 and 20 g before and after calving, respectively) did not cause palatability problems in lactating dairy cows (Polan, Chandler and Miller, 1970), MHA has been shown to be low in palatability (Chandler et al., 1970; Lofgreen, 1970). Effects of MHA on palatability were probably more pronounced in this research because of the high levels of NPN (especially in the case of urea) and the higher percentage of MHA in the concentrate portion.

The increase in weight loss of cows receiving supplements containing urea and/or MHA may have been due to lower nitrogen and energy intake and not entirely to lowered nitrogen utilization. Lack of competition among cows due to individual feeding may have contributed to low intake of certain supplements. Lactating cows grazing similar forage were group fed the urea containing supplement at levels higher than fed in this trial with no intake problems (Rush and Totusek, 1973).

Analysis of covariance (Snedecor and Cochran, 1967) was used to correct the cow weight loss means of differences in supplement intake. Adjusted weight losses (kg or percent) of cows receiving B, B + MHA and U were not significantly different ($P > .10$), but they were significantly ($P < .05$) greater than weight loss of cows receiving U + MHA. An explanation for this possible benefit of MHA for urea but not biuret is not apparent.

Treatment did not affect condition change of cows ($P \approx 0.69$) or summer cow gain ($P \approx 0.55$).

Since treatment did not affect daily gain of calves from birth to end of treatment ($P \approx 0.75$) and adjusted weaning weight ($P \approx 0.79$), milk production of cows was apparently not affected by MHA. This lack of lactation response to MHA is in contrast to reported increases in calf gain and estimated milk yield in beef cows wintered on dry native range

(Varner et al., 1973) and improved milk production in dairy cows (Polan et al., 1970). These workers added MHA to rations containing only natural protein, but MHA significantly increased bacterial nitrogen and cellulose digestion and lowered ammonia levels in an in vitro system containing urea (Gil, Shirley and Moore, 1973).

Trial 2. Supplements 6B and 7B in trial 2 contained a combination of urea and biuret (U + B) and an extruded urea-grain mixture (EU), respectively. The results of trial 2 are shown in Table VIII. As in trial 1 cows on the negative control lost more ($P \approx .025$) winter weight than those on the positive control.

Weight loss (kg and %) of cows consuming B, U, U + B and EU supplements were not significantly different ($P > .05$).

Processing urea by extruding it with a grain did not appear to be of any benefit. The EU supplement was less palatable than the one containing unprocessed urea. The large weight loss of cows on EU was conceivably a reflection of the low supplement intake. However, correcting weight loss means for supplement intake indicated little difference between U and EU; utilization of urea was apparently poor in both supplements and not improved by extruding urea with grain.

A combination of U + B was almost as palatable as B alone (4.2% of the supplement refused), but weight loss of cows receiving U + B was not different from that of cows receiving B or U alone.

Treatment effects (U + B and EU) on condition loss of the cows was similar to those observed for cow weight loss. Treatment did not affect daily gain of the calf while on treatment ($P \approx .58$) or adjusted weaning weight of the calf ($P \approx .77$).

Trials 1 and 2 Pooled. Since a treatment x trial interaction was not detected ($P > .10$), treatments common to both trials 1 and 2 were pooled for analysis. Results of the pooled data are shown in Tables IX and X.

Cows fed the negative control supplement lost ($P \approx .001$) more winter weight and also more condition than those on the positive control. Weight and condition loss of cows fed NPN supplements were significantly ($P < .05$) greater than for the cows fed the positive control.

Cows fed B lost fewer kg weight ($P \approx .05$), less percent weight ($P \approx .07$) and less condition ($P \approx .06$) than cows fed U. Cows fed U refused 10.8% of the supplement and consumed 0.14 kg less than cows fed B. However, analysis of covariance (Snedecor and Cochran, 1967) showed the b and r values were approximately zero, so no adjustment for supplement intake was made.

The advantage for biuret may be due to slower hydrolysis which would provide an ammonia release at a rate more comparable to the rate of energy release from the mature forage. The advantage of biuret is in agreement with Tollett et al. (1969) and Raleigh and Turner (1968); however, other research indicates that nitrogen utilization from urea or biuret, when used to supplement low quality roughage, is not significantly different (Clanton, 1970; Turner and Raleigh, 1969; Turner, Raleigh and Phillips, 1970). In this trial biuret was more palatable than urea and was utilized more efficiently as indicated by weight and condition of cows.

The addition of the 40% dehydrated alfalfa to NPN supplements appeared to be beneficial, especially to the U supplement, as cow weight loss was less ($P \approx .013$) when 40% dehydrated alfalfa was added.

Palatability also appeared to be improved slightly (6.2 vs. 10.8% refusal). The B supplement was not significantly benefited by 40% alfalfa in terms of cow weight loss ($P \approx .49$); weight loss on B + U supplements with 40% alfalfa was comparable. Previous research has indicated that alfalfa improved the utilization of NPN (Karr et al.,1965; Nelson et al., 1957). Conrad and Hibbs (1968) found that a pelleted mixture of high levels of dehydrated alfalfa and urea could replace soybean meal in dairy rations without adversely affecting milk production. Clanton (1970) also found slightly improved steer gains when relatively high levels of dehydrated alfalfa (56 to 57 percent) were included in winter protein supplements.

Feed grade biuret (FGB) was not different ($P > .05$) than biuret in any trait measured ($P > .50$ for winter cow weight loss). Apparently the combination of NPN sources, including 15% urea, in FGB neither helped nor hindered cow performance.

The average daily gain of the calves while on treatment ($P \approx .58$) or adjusted weaning weight of the calf ($P \approx .77$) did not appear to be affected by the NPN supplements.

Trial 3. The results of trial 3 are shown in Table XI. Weight gain of heifers appeared to be only slightly ($P \approx .18$) affected by nitrogen source when the moderate quality hay was fed; calves that received the all natural protein supplement had the highest gain. There was a significant ($P \approx .014$) difference in treatments when harvested winter range grass was fed during the second phase of the experiment. The heifers consuming the natural 30% protein supplement lost ($P \approx .05$) less weight than the heifers receiving the urea containing supplements.

No significant ($P > .10$) treatment x phase interaction was detected so the two phases were pooled for statistical analysis; heifers fed the 30% natural supplement gained significantly ($P < .01$) more than the heifers fed either supplement. Gains of heifers fed the two urea supplements were not different ($P > .4$). Heifers fed the natural protein supplement maintained their condition during the trial while the two urea groups lost in condition ($P \approx .323$). Hay intake was not affected by supplement ($P > .5$) during either phase of the trial.

The extruding of urea with grain apparently failed to increase nitrogen utilization from urea as indicated by body weight and condition, in contrast with results of Tucker and Harbers (1972) and Tucker, Harbers and Smith (1972) but in agreement with Clanton (1970). Helmer et al. (1970) and Owen and Applemen (1970) observed increased milk production in dairy cows when the extruded mixture was compared with an equivalent amount of unprocessed urea-grain mixture in dairy cattle rations.

Biuret Adaptation Trial. The biuretolytic activity observed in the rumen fluid of steers supplemented with the positive control, B and B + alfalfa (40%) is shown in Figure 1. The shaded area of the figure indicates the days supplements were not fed. No appreciable hydrolysis of biuret was apparent on days 0 or 4. By day 6 it appeared that the biuret-fed steers were able to degrade a large amount of biuret with the amount degraded from the B supplement being significantly ($P < .05$) greater than that from the natural protein supplement. Adaptation was partially lost from not feeding the biuret supplements for nine continuous days after day 7. On day 17, one day after supplemental feeding was again initiated, in vitro hydrolysis of biuret was not markedly different ($P \approx .283$) for the three supplements.

The rumen contents from the animals receiving biuret were able to hydrolyze approximately 88% of the biuret (in 24 hr.) on day 49 although the animals were only supplemented 4 of the preceding 14 days. The steers fed the biuret containing supplements appeared to be well adapted and had the ability to degrade the major portion of biuret on days 49, 56 and 74 of the trial.

Steers supplemented with all natural protein did not develop any appreciable amount of biuretolytic activity during the entire experiment and the amount of biuret degraded in the rumen fluid from the natural protein fed steers was significantly ($P < .01$) lower than the biuret fed steers from day 20 to the end of the trial. Biuretolytic activity found in the rumen fluid of the steers receiving the two biuret containing supplements was not significantly ($P > .10$) different for any of the sampling days.

The lack of biuretolytic activity in steers supplemented with natural protein is in agreement with Gilchrist et al. (1968) and Johnson and Clemens (1973). The rate at which biuretolytic activity was developed was faster than has been reported previously (Johnson and Clemens, 1973). Hatfield et al. (1959), Oltjen et al. (1969) and Tomlin et al. (1967) also report a longer rate of adaptation on low quality roughage diet as indicated by nitrogen balance. However, Clemens and Johnson (1973) and Wyatt (1973) recently found that marked biuretolytic activity was developed in 3 to 4 days in lambs fed high roughage diets. Schroder and Gilchrist (1969) found that a low level of dietary protein enhances the rate of adaptation; in this trial the low protein (3% CP) of the major portion of the steers' diet (dry range grass) may have facilitated the short adaptation period.

Clemens and Johnson (1973), Johnson and Clemens (1973) and Schroder and Gilchrist (1969) found a rapid loss of biuretolytic activity when biuret was removed from the diet; activity was lost in 4 days. It is not known why complete biuretolytic activity was not lost on day 17 of this trial as the steers had not received any supplemental biuret 9 of the previous 10 days. One possible explanation is that the steers had been fed biuret 24 hr. prior to sampling and the rumen microflora had developed biuretolytic activity following the last feeding of biuret. The hydrolysis of approximately 89% of the biuret after a 24 hr. *in vitro* incubation also was not expected on day 49 because of the previous intermittent and irregular feeding pattern.

These data indicate that complete biuretolytic activity was not lost during the intermittent feeding period or the rumen microflora were able to readapt to biuret at a faster rate than previously reported by Schroder and Gilchrist (1969). Clemens and Johnson (1973) suggest that once animals are adapted to biuret they may "readapt" faster than animals never previously fed biuret. These data also suggest that the cows in trial 1 and 2 had sufficient biuretolytic activity to utilize a large portion of the supplemental biuret which may explain why the weight and condition loss of the biuret supplemented cows was less than that of the cows supplemented with urea.

TABLE VI

INGREDIENT MAKEUP OF PROTEIN SUPPLEMENTS[a] (PERCENT)

	Supplement Number and Description											
	1	2	3	4	5	6A	6B	7A	7B	8	9	10
Ingredient	Negative control	Positive control	Feed grade biuret[b]	Biuret[c]	Urea	Biuret + MHA	Biuret + urea	Urea + MHA	Extruded grain-urea	Biuret + alfalfa	Urea + alfalfa	Extruded grain-urea
Milo	64.3	23.8	50.6	53.2	55.1	53.0	54.5	55.0	34.6	27.5	29.4	37.2
Soybean meal (44%)	16.0	57.5	21.3	19.3	18.8	19.2	18.9	18.9	18.9	10.5	10.1	17.8
Alfalfa, dehydrated	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	40.0	40.0	5.0
Molasses, blackstrap	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Wheat middlings	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Biuret	--	--	7.47	6.73	--	6.73	2.92	--	--	6.73	--	--
Urea	--	--	--	--	5.31	--	2.92	5.31	--	--	5.31	--
Extruded grain-urea[d]	--	--	--	--	--	--	--	--	25.5	--	--	24.12
Dicalcium phosphate	1.13	0.73	1.10	1.12	1.12	1.12	1.12	1.12	1.13	--	--	1.14
Monosodium phosphate	2.58	2.36	2.66	2.67	2.66	2.67	2.66	2.65	2.70	3.67	3.66	2.66
Sodium sulfate[e]	--	0.63	1.92	1.97	1.97	0.75	1.98	0.75	1.98	1.59	1.59	2.02
Trace minerals	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
MHA[f]	--	--	--	--	--	+	--	+	--	--	--	--
Crude protein[g]	15.41	28.40	29.31	29.07	28.57	28.79	29.79	29.53	30.79	28.75	28.03	28.89

[a] Negative control formulated to contain 15% protein; all other supplements formulated to contain 30% protein with NPN source contributing one-half ofprotein. Vitamin A added to supply 22,000 IU per kilogram.

[b] Approximate chemical composition (dry weight basis): biuret 60%, urea 15%, cyanuric acid 21% and total nitrogen 37%.

[c] Approximate chemical composition (dry weight basis): biuret 91.3%, urea 7.9%, cyanuric acid 0.8% and total nitrogen 37.1%.

[d] Formulated to contribute 5.31% urea in supplement. The remaining portion of the product was gelatinized grain.

[e] Formulated to supply 14:1 nitrogen:sulphur ratio.

[f] Methionine-hydroxy-analogue (MHA) provided 10 gm/head/day before calving and 20 gm/head/day after calving (made up 1.580 and 1.185% of mature cow and first-calf heifer supplements, respectively).

[g] By analysis, 90% dry matter basis.

TABLE VII

SUPPLEMENT INTAKE AND COW AND CALF PERFORMANCE (TRIAL 1)

Item	Supplement Number and Description						
	1 Negative Control	2 Positive Control	4 Biuret	5 Urea	6A Biuret + MHA	7A Urea + MHA	Prob.[a]
No. cows	17	16	15	16	14	15	
Supplement consumed daily, kg	1.34	1.31	1.40	1.24	1.32	1.02	
Supplement refused, %	0	0	0	8.4	5.8	26.1	
Cow wt.							
Adj. initial, kg[b]	442	454	441	459	454	453	
Winter loss, kg	90.0 ± 4.4[c][i]	76.0 ± 4.5[j]	86.1 ± 4.7[ij]	91.2 ± 4.5[i]	88.5 ± 4.5[ij]	98.5 ± 4.7[i]	0.026
Winter loss, %[d]	20.3 ± 0.8[ijk]	16.6 ± 0.8[l]	17.2 ± 0.8[lm]	19.9 ± 0.8[jk]	18.9 ± 0.9[jm]	21.7 ± 0.8[k]	0.005
Summer gain, kg[e]	89.3 ± 4.5	92.4 ± 4.6	97.9 ± 4.8	90.9 ± 4.8	93.7 ± 4.9	93.6 ± 4.8	0.55
Condition score[f]							
Initial	5.00	5.23	4.87	5.13	5.29	5.00	
Winter loss	2.11 ± 0.21	1.77 ± 0.21	2.13 ± 0.22	2.35 ± 0.21	2.14 ± 0.23	2.42 ± 0.22	0.69
Calf performance							
Daily gain, kg[g]	0.51 ± 0.02	0.51 ± 0.02	0.51 ± 0.02	0.53 ± 0.02	0.50 ± 0.02	0.46 ± 0.02	0.75
Adj. weaning wt., kg[h]	201.3 ± 5.3	206.1 ± 5.4	205.3 ± 5.6	211.3 ± 5.4	209.2 ± 5.8	199.6 ± 5.6	0.79

[a]Probability that differences in means are due to chance.

[b]Initial weights of mature cows that calved before the treatment started were adjusted to a pregnant basis by the following formula: adjusted initial weight = actual initial weight + (calf birth weight x 1.9697) - 19.0.

[c]Standard error of the mean.

[d]Percent of adjusted initial weight lost while on treatment.

[e]Gain from end of treatment to the weaning date of calf.

[f]On a scale of 1 to 9 with 1 being the thinnest and 9 the fattest.

[g]Gain from birth to end of treatment.

[h]Adjusted to 205-day, steer equivalent basis.

[i,j,k,l,m]Means with different superscripts are significantly different ($P < .05$).

TABLE VIII

SUPPLEMENT INTAKE AND COW AND CALF PERFORMANCE (TRIAL 2)

	Supplement Number and Description						
Item	1 Negative Control	2 Positive Control	4 Biuret	5 Urea	6C Biuret + Urea	7C Extruded Grain-Urea	Prob.[a]
No. cows	19	20	16	19	18	18	
Supplement consumed daily, kg	1.31	1.35	1.31	1.16	1.24	1.04	
Supplement refused, %	0	0	0	12.33	4.20	21.58	
Cow wt.							
Adj. initial, kg[b]	507	509	499	512	506	523	
Winter loss, kg	152.0 ± 5.4[ci]	132.1 ± 5.3[j]	147.4 ± 5.9[ij]	161.8 ± 5.9[i]	153.1 ± 5.5[i]	159.3 ± 5.5[i]	0.004
Winter loss, %[d]	29.5 ± 0.8[i]	25.6 ± 0.8[j]	29.1 ± 0.9[i]	31.4 ± 0.8[i]	29.7 ± 0.8[i]	31.3 ± 0.8[i]	0.001
Summer gain, kg[e]	73.5 ± 4.7[i]	53.8 ± 4.3[j]	66.0 ± 4.8[ij]	75.3 ± 4.4[i]	71.0 ± 4.5[i]	77.3 ± 4.7[i]	0.005
Condition score[f]							
Initial	5.53	5.35	5.25	5.58	5.83	5.94	
Winter loss	2.91 ± 0.23[ij]	2.27 ± 0.23[k]	2.81 ± 0.25[ijk]	3.43 ± 0.23[jk]	3.50 ± 0.24[il]	3.55 ± 0.24[l]	0.002
Calf performance							
Daily gain, kg[g]	0.54 ± 0.03	0.61 ± 0.03	0.60 ± 0.03	0.54 ± 0.03	0.54 ± 0.03	0.49 ± 0.03	0.58
Adj. weaning wt., kg[h]	203 ± 5.4	201 ± 5.0	199 ± 5.6	201 ± 5.2	203 ± 5.3	198 ± 5.4	0.77

[a] Probability that differences in means are due to chance.

[b] Initial weights of mature cows that calved before the treatment started were adjusted to a pregnant basis by the following formula: adjusted initial weight = actual initial weight + (calf birth weight x 1.9697) - 19.0.

[c] Standard error of the mean.

[d] Percent of adjusted initial weight lost while on treatment.

[e] Gain from end of treatment to the weaning date of calf.

[f] On a scale of 1 to 9 with 1 being the thinnest and 9 the fattest.

[g] Gain from birth to end of treatment.

[h] Adjusted to 205-day, steer equivalent basis.

[i,j,k,l] Means with different superscripts are significantly different ($P < .05$).

TABLE IX

SUMMARY OF SUPPLEMENT INTAKE AND COW AND CALF PERFORMANCE (TRIALS 1 AND 2)

	Supplement Number and Description							
	1	2	3	4	5	8	9	
Item	Negative control	Positive control	Feed grade biuret	Biuret	Urea	Biuret + alfalfa	Urea + alfalfa	Prob.[a]
No. cows	36	36	36	31	35	34	31	
Supplement consumed daily, kg	1.32	1.33	1.34	1.34	1.19	1.33	1.26	
Supplement refused, %	0	0	1.29	0	10.8	0	6.2	
Cow wt.								
Adj. initial, kg[b]	476	484	466	471	489	492	493	
Winter loss, kg	122.2 ± 3.4^{cij}	104.3 ± 3.4^{k}	113.8 ± 3.4^{i}	116.8 ± 3.6^{i}	126.7 ± 3.5^{j}	113.2 ± 3.5^{ik}	114.0 ± 3.6^{ik}	0.0006
Winter loss, %[d]	24.9 ± 0.6^{ijk}	21.2 ± 0.6^{l}	23.7 ± 0.6^{k}	24.0 ± 0.6^{ik}	25.5 ± 0.6^{i}	23.0 ± 0.6^{jk}	23.1 ± 0.6^{jk}	0.0001
Summer gain, kg[e]	81.8 ± 3.1^{i}	72.6 ± 3.1^{ij}	79.3 ± 3.1^{ij}	81.9 ± 3.3^{ik}	83.6 ± 3.1^{i}	72.9 ± 3.1^{j}	78.4 ± 3.3^{ij}	0.073
Condition score[f]								
Initial	5.28	5.31	4.92	5.06	5.37	5.53	5.58	
Winter loss	2.58 ± 0.16^{ij}	2.00 ± 0.16^{k}	2.39 ± 0.16^{ik}	2.48 ± 0.17^{ij}	2.90 ± 0.16^{i}	2.50 ± 0.16^{j}	2.68 ± 0.17^{ij}	0.009
Calf performance								
Daily gain, kg[g]	0.78 ± 0.02	0.80 ± 0.02	0.76 ± 0.02	0.76 ± 0.02	0.78 ± 0.02	0.79 ± 0.02	0.51 ± 0.02	0.58
Adj. weaning wt., kg[h]	204 ± 3.9	203 ± 3.8	198 ± 3.8	202 ± 4.1	206 ± 3.9	206 ± 3.9	200 ± 4.2	0.77

[a]Probability that differences in means are due to chance.

[b]Initial weights of mature cows that calved before the treatment started were adjusted to a pregnant basis by the following formula: adjusted initial weight = actual initial weight + (calf birth weight x 1.9697) - 19.0.

[c]Standard error of the mean.

[d]Percent of adjusted initial weight lost while on treatment.

[e]Gain from end of treatment to the weaning date of calf.

[f]On a scale of 1 to 9 with 1 being the thinnest and 9 the fattest.

[g]Gain from birth to end of treatment.

[h]Adjusted to 205-day, steer equivalent basis.

[i,j,k,l]Means with different superscripts are significantly different ($P < .05$).

TABLE X

DIFFERENCES AND PROBABILITIES ASSOCIATED WITH WINTER WEIGHT LOSS OF COWS (TRIALS 1 AND 2 POOLED)

	Supplement											
	Negative control		Positive control		Feed grade biuret		Biuret		Urea		Biuret + alfalfa	
Item	d	Prob.[a]	d	Prob.	d	Prob.	d	Prob.	d	Prob.	d	Prob.
Urea + alfalfa	8.16	.104	9.71	.054	0.23	.5	2.72	.5	12.66	.013	.82	.5
Biuret + alfalfa	8.98	.071	8.89	.083	.59	.5	3.54	.488	13.47	.007		
Urea	4.49	.362	22.35	.001	12.88	.008	9.93	.049				
Biuret	5.44	.288	12.43	.014	2.95	.5						
Feed grade biuret	8.39	.090	9.48	.051								
Positive control	17.87	.001										

[a]Probability that differences in means are due to chance. Determined by students' t test.

TABLE XI

PERFORMANCE AND HAY INTAKE OF HEIFERS (TRIAL 3)

Item	Supplement 2 Positive control	Supplement 5 Urea	Supplement 10 Extruded grain-urea	Probability[a]
	Phase 1 - Prairie hay (5% CP)			
No. heifers	9	9	9	
Initial wt., kg	233	235	234	
Wt. gain (44 days), kg	30.8 ± 1.5[c]	28.1 ± 1.5	26.3 ± 1.5	0.178
Hay intake (5 days), kg	8.39	8.79	8.91	
	Phase 2 - Harvested winter range grass (3.9% CP)			
Wt. loss (44 days), kg	0.45 ± 1.9[d]	8.16 ± 1.9[e]	9.07 ± 1.9[e]	0.014
Hay intake (5 days), kg	6.68	6.37	6.24	
	Phase 1 and 2 combined			
Wt. gain (93 days), kg	29.0 ± 1.8[d]	19.5 ± 1.8[e]	16.3 ± 1.8[e]	0.001
Condition score[b]				
Initial	3.33	3.11	3.22	
Loss	0 ± 0.30	-0.44 ± 0.30	-0.66 ± 0.30	0.323
Hay intake (10 days), kg	7.58	7.58	7.55	

[a]Probability that differences in means are due to chance.
[b]On a scale of 1 to 9 with one being the thinnest and 9 the fattest.
[c]Standard error of mean.
[d,e]Means with different superscripts are significantly different ($P < .05$).

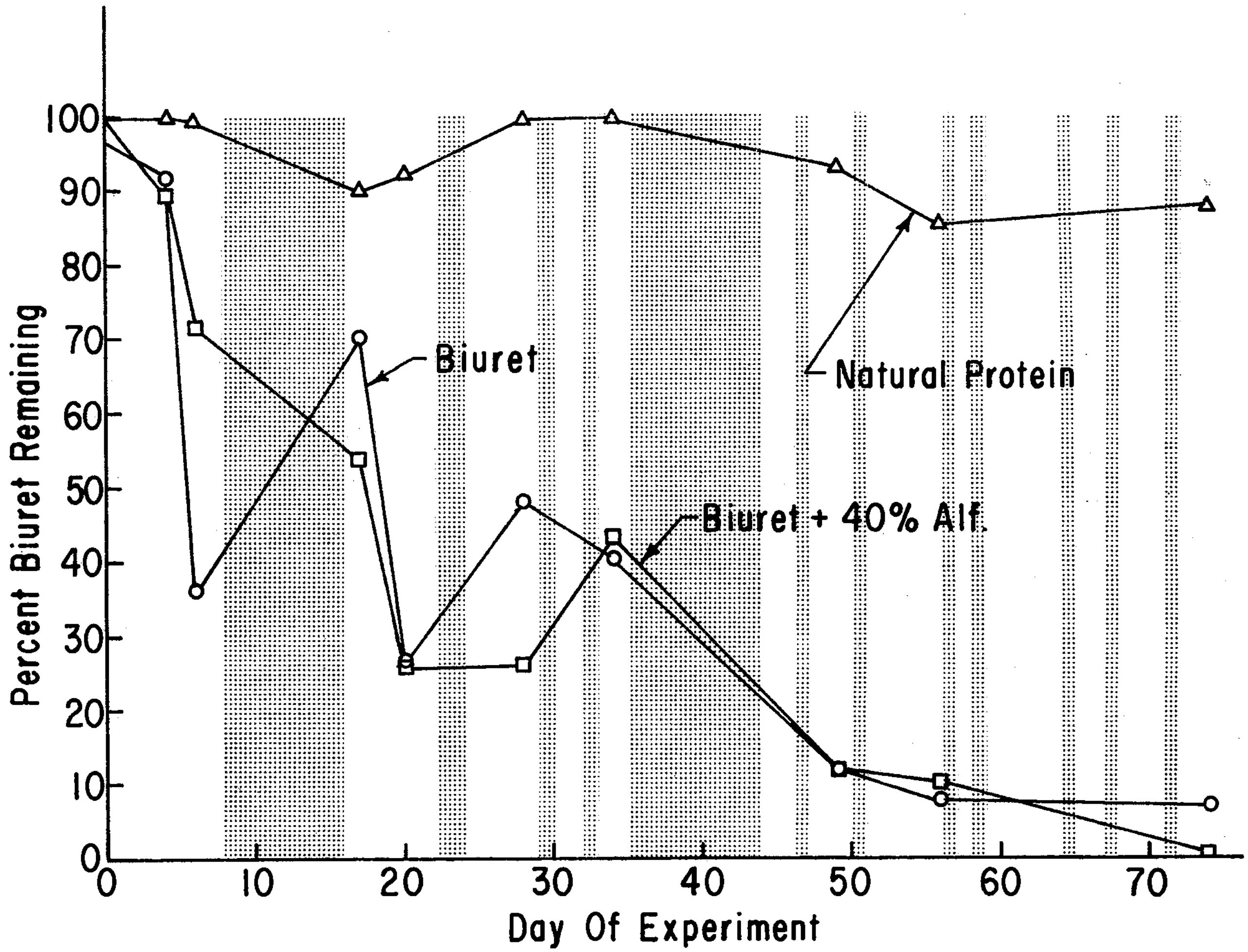

Figure 1. Biuretolytic Activity of Steers Fed Range Supplements Containing Natural Protein, Biuret and Biuret + 40% Alfalfa

CHAPTER V

EFFECTS OF FREQUENCY OF INGESTION OF HIGH-UREA WINTER SUPPLEMENTS BY RANGE CATTLE[1,2]

Summary

Three trials were conducted to compare self-feeding and hand feeding (six and three times per week) of a high urea (one-half of protein equivalent) protein supplement to cattle grazing dry native winter range grass. Salt was used to limit intake of the self-fed supplement. Pregnant-lactating cows, yearling heifers and weanling heifer calves were used in trials 1, 2 and 3, respectively.

Winter weight loss was not significantly affected by frequency of feeding in any trial. Condition loss of cows and performance of calves from birth to end of winter or to weaning were not significantly affected in trial 1. High weight loss and low rebreeding performance of cows indicated that the utilization of urea was low in all treatments.

Feeding observations indicated that cows (trial 1) that were self-fed or hand-fed six or three times per week consumed supplement 3.4, 1.0 and 3.1 times in a 24-hr. period for a total of 34, 12 and 62 minutes,

[1]Journal Article of the Agricultural Experiment Station, Oklahoma State University, Stillwater.

[2]The author wishes to express his appreciation to Dr. R. K. Johnson and Dr. J. V. Whiteman for assistance in statistical analysis; to Bill Sharp and Ray Heldermon for their care of the experimental animals and to Nipak, Inc., Pryor, Oklahoma, for providing urea.

respectively. Similarly, yearling heifers (trial 2) consumed supplement 3.0, 1.0 and 2.9 times in a 24-hr. period for a total of 49, 8 and 112 min. Heifer calves (trial 3) were more reluctant to consume supplement; they consumed aupplement 2.2, 1.6 and 3.9 times in a 24-hr. period for a total of 28, 37 and 74 min.

Introduction

Cattle grazing low quality forage do not require daily supplementation with natural protein supplements, but can be fed larger quantities two or three times per week with no sacrifice in performance (McIlvain and Shoop, 1962; Nelson and Furr, 1961; Nelson, Kromann and Watkins, 1965; Pope, Nelson and Campbell, 1963). Many protein supplements now fed to range cattle contain urea; therefore, it is important to determine the effects of the frequency of feeding of urea-containing supplements. Feeding urea frequently in a 24-hr. period appeared to increase its utilization over feeding an equal amount once daily (Bloomfield, et al., 1961; Campbell et al., 1963). However, performance apparently was not adversely affected when urea supplements were fed less frequently than daily (Dinning, Briggs and Gallup, 1949; Tollett et al., 1969). Consumption patterns of grazing cattle receiving urea supplements, which may help explain the efficiency of NPN utilization, have not been reported.

The purpose of this study was to determine the effects of frequency of feeding high-urea supplements on performance and supplement consumption patterns of cattle grazing dry winter range grass.

Experimental Procedure

Three trials were conducted during two winters with cows and calves being utilized the first year (trial 1) and replacement heifers the second (trials 2 and 3). Urea supplements were (1) self-fed, (2) fed six times per week, and (3) fed three times per week.

The trials were conducted on native range in Central Oklahoma. The predominant forage is of the tall prairie type with climax species consisting of little bluestem (Andropogon scorparius), big bluestem (Andropogon gerardi), Indian grass (Sorghastrum nutans) and switch grass (Panicum virgatum). Since these grasses are dormant during the winter, the major portion of the diet consisted of dry weathered grass. Abundant forage was available in all pastures in all trials. Prairie hay was fed on a few days when ice or snow covered the grass.

The ingredient makeup of the protein supplement (Table XII) was formulated to contain, on a 90% dry matter basis, 30% crude protein (with urea furnishing one-half of the crude protein equivalent), 1.25% phosphorus, and 0.5% calcium; the supplement had a calculated nitrogen sulfur ratio of 14:1. Crude protein and dry matter of the supplements were determined in both trials by A.O.A.C. procedures.

Crude protein (dry matter basis) was 30.7% and 30.9% for the supplements fed in trial 1 and trials 2 and 3, respectively. Salt was added to the self-fed supplement at a varying level as needed; the level was adjusted on a weekly basis to limit intake to the desired level. The hand-fed supplement in trial 1 was originally pelleted in a 1.91 cm (3/4 in.) range cube and fed on grass; due to difficulty in manufacturing the large cube, a smaller 1.59 cm (5/8 in.) cube was made and fed in bunks the latter half of the trial. The hand-fed supplement in trials 2 and 3 was fed in meal form in bunks. Cattle fed supplement three times per week received supplement daily for several days, but were completely switched to three times per week feeding within two weeks.

The amount of self-fed supplement consumed was determined weekly and an equal quantity was fed to the hand-fed cattle the following week, providing a uniform supplement intake for all treatments through each trial.

Supplement consumption patterns were determined for each group of cattle during two 24-hour periods in early March, near the end of the winter supplementation period. Self-feeders were observed for 24 continuous hours; time of day and duration of supplement feeding of each animal were recorded. Group-fed cattle were observed from time of feeding until the total supplement was consumed.

Trial 1. Fifty-one Angus x Holstein cows 4 and 5 years of age were randomly allotted into six groups; the groups were randomly assigned to the three treatments which were imposed during a 123-day wintering period from November 19 to March 21. The groups were rotated among experimental pastures to minimize effects of pasture differences. Average calving date was January 15. Cows were exposed to Hereford bulls for 96 days, February 1 to May 8.

Cows were weighed after being withheld from feed and water for approximately 6 hr. beginning at daybreak. Condition of cows was estimated at the beginning and end of winter supplementation; condition scores were on a scale of 1 to 9 with 1 being the thinnest and 9 the fattest. Calves were weighed at birth, end of winter supplementation and weaning. Weaning weights were adjusted to a 205-day steer, mature dam basis.

Trials 2 and 3. Forty-two Charolais x Hereford and Charolais x Angus replacement heifers approximately 20 months old and 48 weanling Hereford and crossbred (Hereford x Angus-Holstein, Charolais x Hereford or Angus) heifers, approximately 10 months old were utilized in trials 2 and 3, respectively. Heifers in each trial were blocked according to breed and randomly allotted to the three treatments. Trials 2 and 3 were conducted during a 133-day period from November 9 to March 22. Heifers were weighed after being withheld from feed and water overnight (12 to 14 hr.).

The data in trial 1 was analyzed by analysis of variance as described by Snedecor and Cochran (1967) for a one way classification with unequal numbers in each treatment. Only cows that had weaned calves were used in the analysis. In trials 2 and 3, least squares analyses were conducted for a two-way classification and with unequal numbers per treatment. The F-test was employed to test for differences between treatments in all trials.

Results and Discussion

Trial 1. Amount of supplement consumed, cow weight change, condition scores of cows and rebreeding performance are shown in Table XIII. At the initiation of the trial the salt level of the self-fed mixture was 28.8%; this salt level limited daily supplement intake to 1.36 kg. After a majority of the cows had calved, during the latter part of the wintering period, the salt level was lowered to 25.0%; this salt level allowed the daily supplement intake to increase to 1.94 kg. Although winter weight loss was lowest for self-fed cows (24.8%) and slightly higher for those fed six times per week than those fed three times per week (28.0 vs. 27.2%), cow weight loss was not significantly affected ($P > .1$) by treatment. Loss of condition, as indicated by condition score change, was similar for all groups and also not significantly affected ($P > .1$) by treatment. Rebreeding performance, not affected ($P > .1$) by treatment, was poor in all groups (67 to 75%), consistent with excessive weight loss which occurred in all treatments.

Performance of calves is shown in Table XIV. Daily gain of calves from birth to end of winter ($P \approx .14$) weaning weight ($P \approx .18$) and condition score of calves at weaning ($P > .1$) did not appear to be markedly affected by treatment.

Feeding observations (Table XV) revealed that self-fed cows consumed 2.29 kg of supplement (not including salt) in 3.4 separate feedings in a 24-hr. period. A total of 34 min. was spent eating supplement, an average of 10 min. per feeding. Cows fed six times per week consumed a similar amount of supplement in 12 min. of uninterrupted feeding. Cows fed three times per week received 4.54 kg per feeding during the feeding observations. They did not eat the entire amount at one feeding, but ate supplement very slowly for 10 to 20 min., then grazed for a period of time before returning for more supplement. They ate supplement 3.1 times and required 62 min. feeding time during 8.2 hr. to consume the entire amount. A large amount of cow variation was noted in feeding time. Competition among cows appeared to be a major factor determining the length of supplement feeding time; only one mineral-type wind directional feeder which accommodated one or two cows at a time was used per group of 8 to 9 cows.

Trials 2 and 3. Supplement intake and weight loss of heifers in trials 2 and 3 are shown in Table XVI. The amount of salt required to limit intake to 1.33 kg daily in trial 2 ranged from 28.3% (early in winter) to 20.4% (late in winter). Less salt (26.9 to 6.2%) was required to limit intake to 0.89 kg daily for the younger heifers in trial 3.

Weight change of heifers was not affected ($P > .3$) by treatment in either trial. Since a significant treatment x trial interaction was not detected ($P \approx .4$), means from the two trials were pooled; again, weight change was not affected by treatment ($P \approx .57$).

Feeding observations (Table XVII) indicated the supplement intake patterns for the yearling heifers in trial 2 were similar to those of mature cows in trial 1. Self-fed heifers consumed 1.42 kg of supplement in 3.1 feedings in a 24-hr. period for a total of 49 min., an average of 15.8 min. per feeding. Heifers (those fed six times per week) hand-fed a similar amount consumed the entire offering in 8 min. Heifers fed three times per week ate slowly and required 112 min. feeding time in 2.9 feedings during 7.6 hours to consume the entire amount (3.18 kg).

The urea-containing supplement was less palatable for the younger heifers in trial 3 as evidenced by the lower salt level required in the self-fed supplement. Also, in contrast to cows and yearlings in trial 1 and 2, the calves fed six times per week did not consume the entire offering immediately after feeding but required 1.6 feedings and 7.9 hr. They apparently tired of the urea-containing supplement because early in the winter the supplement was consumed more quickly. Heifers fed three times per week in trial 3 ate more frequently (3.9) than those in trial 2, but similarly required a long time (9.7 hr.) to consume the offering.

Discussion. The failure of frequency of ingestion of NPN-containing supplements to influence body weight change is in agreement with data reported by Clanton (1970) and Tollett et al. (1969); Oltjen, Burns and Ammerman (1973) found that daily gains were improved, although not significantly, by feeding urea-containing supplements daily versus feeding a comparable amount three times per week. In contrast, several researchers (Bloomfield et al., 1961; Dinning et al., 1949; Campbell et al., 1963; Gibbons, 1958) found improved urea utilization with more frequent intake. Urea was fed as often as six (Campbell et al., 1963; Gibbons, 1958), or 16 (Bloomfield et al., 1961) times daily vs. once or twice daily, whereas in the research reported herein, maximum frequency achieved was about three times daily. This suggests that ingestion three times daily is not sufficient, but Dinning et al. (1949) noted an improvement with twice daily compared to alternate day feeding, and Knight and Owens (1973) reported increased nitrogen balance with 1 and 3 hr. but not 12 hr. infusions of a given quantity of urea into the rumen of sheep on a low energy diet. Perhaps the level of urea relative to carbohydrates in the supplement was too low for appreciable urea utilization at any frequency of ingestion (Bloomfield, Muhrer and Pfander, 1958; Williams, Whiteman and Tillman, 1969). Low utilization of urea was indicated by better weight and rebreeding performance by the same cows on the same range when fed a similar amount of supplement (Totusek, Sharp and Rush, 1972), and by better weight performance of comparable heifers on the same range fed a supplement containing only natural protein the previous winter (Rush et al., 1973).

The slow intake of the larger quantities of supplements fed three times per week suggests that the taste of urea limited the supplement intake or that a possible feedback mechanism functions in cattle that have been adapted to urea and stops them from consuming toxic levels (Martz et al., 1973).

These trials indicate that the frequency of ingestion (ranging from three times per day to three times per week) of urea-containing supplements by range cattle has little influence on apparent urea utilization as indicated by weight changes of the cattle. This is unfortunate because the frequent ingestion of supplements represents a technique that can be easily accomplished by producers under range conditions. The comparable performance of cattle fed relatively large amounts of urea-containing supplements three times per week, as well as their freedom from urea toxicity, is also noteworthy. This was apparently due to the slow and intermittent ingestion of the supplements, and provides little basis for past recommendations that urea-containing supplements should not be fed less frequently than daily. The need for good management in feeding urea-containing supplements, especially to unadapted cattle, should continue to be emphasized. The overriding consideration that urea at best may be poorly utilized by cattle subsisting on dry range grass should not be overlooked, and may minimize the importance of decisions relative to frequency of feeding.

TABLE XII

INGREDIENT MAKEUP OF SUPPLEMENT

Ingredient	Percent of Formula[a]
Milo	55.10
Soybean meal, 44%	18.79
Alfalfa, dehydrated	5.00
Molasses, blackstrap	5.00
Wheat middlings	5.00
Urea (45% N)	5.31
Dicalcium phosphate	1.12
Monosodium phosphate	2.66
Sodium sulfate	1.97
Trace minerals	.05
Vitamin A[b]	+

[a]Salt was added to the supplement to control intake for the self-fed treatment.

[b]Added to supply 22,000 IU/kg supplement.

TABLE XIII

SUPPLEMENT INTAKE, COW WEIGHT, COW CONTITION SCORE AND REBREEDING PERFORMANCE (TRIAL 1)

	Frequency of Feeding			
	Self-fed	Six times per week	Three times per week	SE[a]
No. cows	16	18	17	
Supplement/cow daily, kg	1.49[d]	1.51	1.54	
Weight				
Initial, kg	528	515	503	
End of winter, kg	397	371	366	
Winter loss, kg[b]	131	144	137	11.5
Winter loss, %	24.8	28.0	27.2	
Condition score[c]				
Initial	5.19	5.17	4.94	
End of winter	1.81	1.78	1.47	
Change[b]	-3.38	-3.39	-3.47	0.42
Cows rebred				
No.	12	12	12	
%[b]	75	67	71	

[a]Approximate standard error of the mean based on 17 animals per treatment.

[b]Treatment differences were not significant (P > .1).

[c]On a scale of 1 to 9 with 1 the thinnest and 9 the fattest.

[d]Kilograms of supplement consumed. In addition, 0.58 kg of salt was consumed/head/day.

TABLE XIV

PERFORMANCE OF CALVES (TRIAL I)

	Frequency of Feeding			
	Self-fed	Six times per week	Three times per week	SE[a]
No. calves	16	18	17	
Avg. birth date	Jan. 6	Jan. 16	Jan. 23	
Birth weight, kg[b]	35.4	36.7	38.1	
Wt., end of winter, kg	91.6	90.7	87.5	
Daily gain, winter, kg[c]	0.77	0.85	0.87	0.03
Weaning wt., kg[cd]	254	269	270	4.74
Condition score[d], weaning[ce]	6.38	6.39	6.53	0.20

[a]Approximate standard error based on 17 animals per treatment.

[b]Heifer calves adjusted to bull equivalent by multiplying actual birth weight by 1.048.

[c]Treatment differences were not significant ($P > .1$).

[d]Weaning weight adjusted to 205-day, steer, mature dam basis.

[e]On a scale of 1 to 9 with 1 the thinnest and 9 the fattest.

TABLE XV

FREQUENCY AND DURATION OF SUPPLEMENT CONSUMPTION (TRIAL 1)[a]

	Self-fed	Six times per week	Three times per week
Eating time/head/day, min.	34	12	62
No. times ate/day	3.4	1.0	3.1
Avg. eating time/feeding, min.	10.1 ± 5.7[b]	12.1 ± 4.3	20.0 ± 10.5
Time supplement available	24 hr.	12.1 min.	8.2 hr.
Supplement consumed during 24-hr. observation, kg	2.29	2.27	4.54

[a]Mean of two 24-hour observations.
[b]Standard deviation.

TABLE XVI

SUPPLEMENT INTAKE AND PERFORMANCE OF HEIFERS (TRIALS 2 AND 3)

	Self-fed	Six times per week	Three times per week	SE[a]
		Trial 2		
No. heifers	15	14	13	
Daily supplement intake, kg	1.33	1.33	1.33	
Initial wt., kg	398	396	394	
Final wt., kg	357	356	347	
Weight loss, kg[b]	41	39	47	8.1
Weight loss, %	10.4	9.9	12.0	
		Trial 3		
No. heifers	16	16	16	
Daily supplement intake, kg	0.89	0.89	0.89	
Initial wt., kg	235	235	236	
Final wt., kg	203	194	199	
Weight loss, kg[b]	32	41	37	6.5
Weight loss, %	13.8	17.5	15.5	

[a]Standard error of mean based on 14 and 16 animals per treatment for trials 2 and 3, respectively.

[b]Treatment differences were not significant (P > .1).

TABLE XVII

FREQUENCY AND DURATION OF SUPPLEMENT CONSUMPTION (TRIALS 2 AND 3)[a]

	Frequency of Feeding		
	Self-fed	Six times per week	Three times per week
		Trial 2	
Eating time/head/day, min.	41	8	112
No. times ate/day	3.1	1.0	2.9
Avg. eating time/feeding, min.	15.8 ± 16.1[b]	8.0 ± 0.7	38.6 ± 20.4
Time supplement available	24 hr.	8 min.	7.6 hr.
Supplement consumed during 24-hr. observation, kg	1.42	1.59	3.18
		Trial 3	
Eating time/head/day, min.	28	37	74
No. times ate/day	2.2	1.6	3.9
Avg. eating time/feeding, min.	13.0 ± 6.8	23.1 ± 9.5	18.8 ± 9.7
Time supplement available, hr.	24	7.9	9.7
Supplement consumed during 24 hr. observation, kg.	0.64	1.04	2.12

[a]Mean of two 24-hr. observations.
[b]Standard deviation.

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APPENDIX

TABLE XVIII

PERCENT OF BIURET REMAINING AFTER 8 AND 24 HOURS OF *IN VITRO* FERMENTATION IN THE BIURET ADAPTATION TRIAL, CHAPTER IV

Day	0		4		6		17		20		28		34		49		56		74	
Hour	8	24	8	24	8	24	8	24	8	24	8	24	8	24	8	24	8	24	8	24
Supplement																				
Pos. Control	107.7	101.6	97.9	105.5	99.1	99.8	99.5	93.3	98.9	97.4	101.2	100.3	106.1	111.9	99.5	96.8	96.5	85.5	93.3	88.3
Biuret	103.3	115.4	89.2	89.3	96.1	72.3	81.1	53.9	99.4	27.8	76.3	48.8	93.5	40.1	72.1	11.7	74.2	8.5	75.7	7.99
Biuret + Alf. (40%)	105.2	97.5	94.5	91.1	85.2	36.4	101.7	70.1	79.5	26.3	85.9	26.3	88.8	43.7	68.3	11.5	79.8	10.0	79.7	0.4

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