



Utilization of biuret and urea as affected by feeding interval and energy level
by Jesse George Armitage

A thesis submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree of
MASTER OF SCIENCE in Animal Science
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Abstract:

Biuret, urea, and soybean meal were evaluated as sources of nitro-gen for steers fed wintering rations. Trial I utilized 36 steer calves in six feed treatments fed 126 days. Three supplements were formulated to contain 20% crude protein equivalent (CPE). One was a soybean meal control, and the other two provided one-third CPE from either biuret or urea. Three pens of steers were fed 0.91 kg of one of the three supplements per head per day every day (ED). The remaining three pens received 1.81 kg supplement per head per day every other day (EOD). All pens received the same quantity of chopped grass hay per day. Weight gains were 0.67, 0.62, 0.63, 0.60, 0.58, and 0.57 kg per day, respectively, for steers fed the soybean meal supplement ED and EOD, the biuret supplemented ED and EOD, and the urea supplemented ED and EOD. Weight gains, feed per kg gain or cost, per kg gain of the steers were not statistically significant by treatment.

Trial II was a metabolism study using three steers. Each steer was fed one of the three supplements, used in trial I. Digestibilities of nitrogen were greater for all steers fed ED as opposed to EOD. The urea supplement showed the greatest difference in nitrogen digestibility, in favor of ED feeding. Digestibilities of energy of non-protein nitrogen (NPN) supplements were higher when the supplements were fed to steers ED. Digestibilities of supplemental nitrogen and energy appeared to be conversely related for NPN supplements. As nitrogen retention increased, energy retention increased for steers fed NPN supplements. The steer fed the control ration showed a decrease in energy retention as nitrogen retention increased. The overall trend of trial II favored feeding steers NPN supplements ED rather than EOD for the greatest retention of energy. Steers fed the NPN supplements appeared to retain nitrogen and energy as well as the steer fed the control supplement when steers were fed ED.

Three steers were assigned to one of three iso-caloric, iso-nitrogenous rations for a metabolism study for trial III. Two of the rations contained urea at one-sixth and one-third of the CPE. The third ration was a soybean meal control. Energy retention and digestibility of all rations fed to steers, increased as the energy of the rations was increased. Digestibility of nitrogen decreased for the control and one-third CPE from urea-fed steers as energy consumption increased. Steers fed the control ration and the one-sixth CPE from urea ration showed increased nitrogen retention as energy increased while the steer fed the one-third CPE from Urea showed a decrease in nitrogen retention. Results of this trial indicated that one-sixth or one-third CPE of a 20% protein supplement may be supplied by urea. These supplements may be fed with straw as a source of roughage if ample readily-available carbohydrate is provided in the ration to insure maximum utilization of NPN.

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Jesse George Armitage

A thesis submitted to the Graduate Faculty in partial
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of

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ABSTRACT

Biuret, urea, and soybean meal were evaluated as sources of nitrogen for steers fed wintering rations. Trial I utilized 36 steer calves in six feed treatments fed 126 days. Three supplements were formulated to contain 20% crude protein equivalent (CPE). One was a soybean meal control, and the other two provided one-third CPE from either biuret or urea. Three pens of steers were fed 0.91 kg of one of the three supplements per head per day every day (ED). The remaining three pens received 1.81 kg supplement per head per day every other day (EOD). All pens received the same quantity of chopped grass hay per day. Weight gains were 0.67, 0.62, 0.63, 0.60, 0.58, and 0.57 kg per day, respectively, for steers fed the soybean meal supplement ED and EOD, the biuret supplemented ED and EOD, and the urea supplemented ED and EOD. Weight gains, feed per kg gain or cost per kg gain of the steers were not statistically significant by treatment.

Trial II was a metabolism study using three steers. Each steer was fed one of the three supplements used in trial I. Digestibilities of nitrogen were greater for all steers fed ED as opposed to EOD. The urea supplement showed the greatest difference in nitrogen digestibility, in favor of ED feeding. Digestibilities of energy of non-protein nitrogen (NPN) supplements were higher when the supplements were fed to steers ED. Digestibilities of supplemental nitrogen and energy appeared to be conversely related for NPN supplements. As nitrogen retention increased, energy retention increased for steers fed NPN supplements. The steer fed the control ration showed a decrease in energy retention as nitrogen retention increased. The overall trend of trial II favored feeding steers NPN supplements ED rather than EOD for the greatest retention of energy. Steers fed the NPN supplements appeared to retain nitrogen and energy as well as the steer fed the control supplement when steers were fed ED.

Three steers were assigned to one of three iso-caloric, iso-nitrogenous rations for a metabolism study for trial III. Two of the rations contained urea at one-sixth and one-third of the CPE. The third ration was a soybean meal control. Energy retention and digestibility of all rations fed to steers, increased as the energy of the rations was increased. Digestibility of nitrogen decreased for the control and one-third CPE from urea-fed steers as energy consumption increased. Steers fed the control ration and the one-sixth CPE from urea ration showed increased nitrogen retention as energy increased while the steer fed the one-third CPE from urea showed a decrease in nitrogen retention. Results of this trial indicated that one-sixth or one-third CPE of a 20% protein supplement may be supplied by urea. These supplements may be fed with straw as a source of roughage if ample readily-available carbohydrate is provided in the ration to insure maximum utilization of NPN.

INTRODUCTION

Much of the native range of Montana is deficient in protein during the winter grazing period. Commercial supplements have been fed to provide additional protein and energy to range livestock. Non-protein nitrogen (NPN) compounds such as urea have been substituted for a portion of the natural protein to reduce the cost of these supplements.

A common management practice in recent years has been to feed twice as many pounds of the supplement every other day rather than feeding a given amount daily. The practice of feeding every other day started as a labor and time saving strategem and is especially common in areas where winter grazing is feasible. Every other day feeding has been practiced for twelve years at the Montana State University Red Bluff Research Ranch located at Norris, Montana. This method of feeding protein supplements to stock cows being wintered on the range has greatly increased desirable livestock grazing patterns.

Research at Montana State University has shown urea and biuret to be utilized effectively in range supplements as well as in wintering and fattening rations.

Two questions have arisen from this management practice: 1) What is the effect on the utilization of non-protein nitrogen in supplements fed to cattle every day versus every other day? 2) Is ample energy supplied to utilize effectively the non-protein nitrogen in the supplements fed with low quality roughages? These questions inspired an

experiment to compare every day feeding versus every other day feeding of non-protein nitrogen supplements. A second experiment was designed to compare the utilization of non-protein nitrogen in conjunction with two energy levels.

LITERATURE REVIEW

History Of Non-Protein Nitrogen Research

The use of non-protein nitrogen (NPN) as a substitute for as much as one-third of the equivalent crude protein in protein supplements is not new. The discovery of nitrogen about 200 years ago brought about the first controlled experiments with nitrogen. Urea was discovered only a few years after nitrogen. After the synthesis of urea early in the nineteenth century, research on its use as a feed stuff began. The following excerpts from an excellent review by Stangel (1967) reveal the early history of non-protein nitrogens.

As early as 1891, Hagemann and Zuntz theorized that microorganisms in the rumen could synthesize bacterial protein from non-protein nitrogen compounds such as urea and that there were differences in food value and energy of cellulose, sugars, starch, and other carbohydrates. Digestibility was also shown to be affected by the addition of the carbohydrates. Voltz, from 1907 to 1920, obtained growth of lambs on a low-protein, semi-purified diet made up of starch, alkali-washed straw, inorganic salts and urea. He was one of the first to test the theory that non-protein nitrogen could be used by rumen microorganisms to form protein useful to the host animal.

Armsby (1911) published a comprehensive review of work on the utilization of non-protein nitrogen (NPN) by ruminants and non-ruminants. Facts concerning the role of rumen microorganisms in converting NPN to protein, their subsequent digestion by the host animal;

and the conversion to protein for milk and growth were deduced. He stated that the limiting factor in the utilization of the protein formed from NPN appeared to be the extent to which the protein could be formed rather than any inferior nutritive value of the protein. It was also noted that, in the presence of adequate protein, non-protein nitrogen usually failed to contribute to an increase in the production of nitrogenous constituents of the animal.

No real interest in non-protein nitrogen research took place in the United States for the next 20 years. The bulk of the research on the role of NPN in ruminant nutrition continued to be carried on by European workers, primarily German. The commercial success of the direct manufacture of ammonia from atmospheric nitrogen and the construction of a plant in Germany in 1913 to produce synthetic nitrogen products stimulated research in the use of these non-protein compounds as protein substitutes. It was not until the 1930's that Hart et al. (1938) published the results of the first intensive research in the United States on the use of urea and ammonium bicarbonate in ruminant rations. These researchers concluded that ruminants could use simple nitrogen compounds through the action of the rumen microorganisms. Commercial production of urea in the United States began during 1935, making urea available at prices which allowed its use by the feed manufacturer. There has been little doubt that urea became the only widely used NPN source because of its commercial availability in the

United States and Europe.

In 1940, the Executive Committee of the Association of American Feed Control Officials adopted a resolution providing for the use of no more than one-third of the total nitrogen in the ration from urea and ammoniacal nitrogen. Urea and ammonium bicarbonate were accepted sources of non-protein nitrogen.

Wegner et al. (1940) reported that readily available energy stimulated the disappearance of inorganic nitrogen. Both urea and ammonium bicarbonate were shown to be converted into bacterial protein. Feeding of high total nitrogen rations with a large percentage of natural protein resulted in poor utilization of urea. It was concluded, at this time, that: 1) the rate of conversion of urea nitrogen to protein in the rumen decreased when the protein level of the rumen contents exceeded 12 percent, 2) that urea was not excreted via the skin, 3) that urea was not retained as efficiently as casein and other protein sources, and 4) that urea in the ruminant ration exerted no adverse effect on the composition, flavor and NPN content of the meat and the milk.

The extended use of urea as a nitrogen source for cattle rations lagged much behind the work of Hart et al. (1939). However, under the stress of World War II, both the feed manufacturer and the farmer became familiar with the use of urea. Not until the early 1950's was evidence shown that urea could replace 25 to 33 percent of the protein

nitrogen in cattle feeds. Acceptance of this fact was not completely satisfying until the publication of research by Bell et al. (1953), Beeson et al. (1964), Garrigus (1964), Beeson and Horn (1967), and Conrad and Hibbs (1968).

Every year humans have demanded more high quality natural proteins. This demand has induced more pressure on the animal kingdom (ruminants) to utilize sources of low quality proteins and/or non-protein nitrogens. The ability for the microorganisms present in the rumen to convert non-protein nitrogen to protein for use by the ruminant has now become a widely proven and accepted fact. The question then is: which non-protein nitrogens may be fed?

Sources of Non-Protein Nitrogen

Uric acid was reported as a good source of non-protein nitrogen by Oltjen et al. (1968) and Oltjen (1969a). In the earlier work, this author reported cattle fed uric acid to have the highest nitrogen retention when compared to urea, biuret, and urea phosphate; urea phosphate had nitrogen retentions less than any of the other three non-protein nitrogens tested.

Cyanuric acid was shown to cause a conversion of a negative nitrogen balance to a positive nitrogen balance, when fed to sheep by Clark et al. (1965). Neither triuret, nor urea, nor biuret provided as great a difference in nitrogen balance as did cyanuric acid. All four non-protein nitrogen feeds caused an increase of hay consumption, with cyanuric acid having the most noticeable effect. Altona and Mackenzie

(1964) found cyanuric acid could be utilized by sheep when fed with maize and low quality supplements. These authors showed cyanuric acid to contain 32 percent nitrogen and to be non-toxic.

Davis et al. (1956) reported dicyandiamide fed to milk cows to have no effect on weight gains or feed consumption when compared to urea, soybean meal, and a low-protein control. Dicyandiamide reduced milk production more than urea. Both urea and dicyandiamide improved the utilization of feed when added to the low-protein control, but not significantly.

Repp, et al. (1955) reported ammonium formamide as an inferior product in lamb fattening rations. Ammonium propamide and urea gave equal weight gains at the 15 percent and 30 percent level of substituted nitrogen.

In vitro studies by Acord et al. (1966) and in vivo studies by Lewis (1962) show ammonium acetate, ammonium carbonate and ammonium phosphate to be equal to urea in promoting amino acid production. These NPN sources did not have as noticeable an effect on microorganisms growth as did casein.

Ammonium bicarbonate, in presence of soluble sugars, was shown by Hart et al. (1939) to be as effective as urea and slightly less favorable than casein. Urea supplied 43 percent of the total nitrogen and casein supplied 66 percent of the total nitrogen in their respective rations. Moreover, Wegner (1940) used in vitro studies to show

ammonium bicarbonate could be used as effectively as urea to promote micro-bacterial growth in the ruminant.

Tillman and Swift (1953) reported that ammoniated condensed distillers molasses solubles, ammoniated molasses and urea in supplements were utilized as well as soybean oil meal when fed to sheep. Four years later, Tillman et al. (1957a, 1957b) reported ammoniated cane molasses to be poorly utilized and caused a negative nitrogen balance. In both reports, the ammoniated cane molasses caused adverse stimulation to rumen microflora.

As has been reported earlier, urea has been known as a non-protein nitrogen longer than any other compound. Because it has been so well known and so inexpensive to produce, urea has been the most popular of the non-protein nitrogen compounds. In recent years, a condensation product formed by heat and pressure on urea called biuret has come into being. Meiske et al. (1955) were some of the first to report biuret as a suitable nitrogen source.

Urea As A Nitrogen Source

Urea has been undoubtedly the most highly researched product of those compounds sought to be used as non-protein nitrogens. Morgan et al. (1922) stated that urea could not be used to replace any part of the protein of a ration for sheep. Sixteen years later the first work done in America by Hart et al. (1938) showed growing dairy calves could utilize urea when added to a 6 percent protein basal ration.

This study compared ammonium carbonate, casein, and urea. Urea gave gains of nearly twice as much as the basal ration and appreciably higher gains than ammonium carbonate. Casein yielded gains of 11 kg. more than did urea. Wegner et al. (1941) found urea could be utilized in ruminant rations up to 4.5 percent equivalent crude protein of a 12 percent equivalent crude protein ration when no linseed oil meal was present. When over 18 percent protein was present in a ration, the rate and extent of urea utilization was markedly reduced.

Palatability was found to be a problem by Briggs et al. (1947), when urea supplied 50 percent of the equivalent crude protein of a ration in later stages of fattening steers. McCall and Graham (1953) also found urea to be slightly less effective than natural protein when fed to fattening steers as 20 percent and 25 percent of the equivalent protein. No significant differences were present in carcass grades or dressing percentages. This same work indicated urea to be satisfactory as a protein substitute and comparable to cottonseed meal when supplying 25 percent of the total dietary nitrogen.

Lofgreen et al. (1947) fed a 10 percent protein ration in which 40 percent of the equivalent crude protein was from urea. This supplement was compared to linseed meal, urea plus methionine, and dried egg. No significant differences were found among the rations for weight gain, digestion of dry matter, or digestion of protein. Urea plus methionine fed at .02 percent of the ration increased

nitrogen retention above urea only and was comparable to the nitrogen retention of linseed meal. These authors stated that protein quality may be a factor to consider in the retention of dietary nitrogen. The insignificance of the effect of urea on protein digestion was shown by Colovos et al. (1963). On the other hand, Harris et al. (1943) showed more true protein to be present in the rumen of steers fed urea than those fed low protein control rations.

McCall and Graham (1953) showed non-protein nitrogens to be satisfactory protein substitutes in supplements when they replace 40 percent of the equivalent crude protein.

Nix and Anthony (1964) fed 17.5 percent urea in a 65 percent equivalent crude protein supplement to cattle at 454 grams per head per day. Significant increases in digestibilities of dry matter and protein over cottonseed meal supplements were observed. These authors stated that urea supplements were equal to cottonseed meal supplements when fed to beef cattle and were less expensive than natural protein supplements to feed.

In research by Lowry and McCormick (1969) urea was fed as 1.3 percent of the ration to finishing steers and was found to produce gains as efficiently as cottonseed meal. These authors revealed an increase in nitrogen digestibility when urea was substituted for cottonseed meal, although nitrogen retention was about equal for both rations. Bermuda grass hay plus urea yielded significantly ($P < .05$)

less average daily gain when fed to steers than did urea plus alfalfa hay at iso-nitrogenous levels.

Increases in cellulose digestion due to the addition of urea to rations have been reported by Egan and Moir (1965), Egan (1965a,1965b), Matrone et al. (1965) and Nix and Anthony (1964). These authors indicated an increase in consumption with increases of nitrogen. Egan (1965b) stated that sheep, duodenally infused with 4.5 grams nitrogen from either casein or urea, changed nitrogen retention from negative to positive. The sheep received oat straw (0.56 percent nitrogen) ad libitum as roughage. Gains and efficiency of sheep fed casein based diets were slightly higher than those fed urea based diets but not significantly, reported Matrone et al. (1965). Urea was nearly as effective as casein.

When Virtanen (1966) fed lactating milk cows adapted to .27 grams urea per kilogram body weight, 1.3 to 1.4 grams urea per kilogram body weight, milk production was significantly increased. Colovos et al. (1967) reported no significant difference in milk production or ration digestibilities when lactating dairy cows were fed 1.00, 1.25, or 2.50 percent urea in concentrates.

High-energy supplements containing 32 percent protein were fed to growing beef cattle by Perry et al. (1967). Urea at 22 to 23 percent of the supplemental nitrogen compared favorably with natural protein supplements. Growing cattle gained significantly slower: steers $P < .01$

and heifers (P405) when fed a 64 percent protein supplement containing urea, molasses, phosphoric acid and minerals yielded gains equal to the 64 percent urea supplement fed dry.

Oltjen and Bond (1967) maintained cows on an iso-caloric purified diet. Urea was the sole source of nitrogen. The cows were maintained on the diet for 38 to 49 months. The cows calved twice with no significant differences in weights of cows or calves when compared to natural protein diets. Fat and protein of milk were lower on purified diets.

No differences in nitrogen retention were witnessed by Freitag et al. (1968), when they compared soybean meal to urea and corn in supplements. Barth et al. (1968) showed nitrogen retention to be higher for cottonseed meal supplements than for urea supplements. The non-protein nitrogen supplement contained 15 percent urea. The authors attributed the difference in nitrogen retention between the cottonseed and urea supplements to the fact that silage was fed. The silage would have a low content of readily fermentable carbohydrates, which might not allow the urea supplement to be as well utilized as if higher levels of energy were fed.

In three of four trials for weight gain, feed efficiency, feed intake and carcass data, Clark et al. (1970) found urea comparable to soybean meal. Oh et al. (1969) supplemented low-quality range forage with urea alone, urea plus volatile fatty acids, urea plus caproic acid, and casein alone. All supplements increased voluntary feed consumption,

microbial activity, and dry matter digestibility over unsupplemented controls, but not significantly. These increases indicated that microflora of the rumen were capable of synthesizing their cellular components from urea as a source of nitrogen.

Nelson et al. (1955) did not recommend urea as a source of nitrogen for wintering heifers. Urea added to a 20 percent natural protein supplement to make a 40 percent equivalent crude protein supplement did not yield as high gains as the control supplement of 20 percent protein. Trace minerals added to the 40 percent supplement increased gain over the same supplement without trace minerals. Trace minerals had no effect when added to urea supplements in trials run by Pope et al. (1959). In fact, trace minerals added to urea supplements tended to reduce gains of fattening yearling steers. During these trials, soybean meal supplemented steers out-gained urea supplemented cattle.

The fact that urea may replace more natural protein for rations to be fed older cattle than those rations for younger animals was reported by Kirk et al. (1958). Urea replaced 40 percent of the nitrogen supplied by cottonseed meal in the control supplements. Calves fed the urea supplements exhibited increased feed consumption and a highly significant ($P < .05$) reduction in gains when compared to soybean meal. The same supplements fed to yearling cattle showed no differences in gain, feed consumption, or carcass characteristics.

Drori and Loosli (1959) added ethyl alcohol plus molasses or starch to urea based rations to form iso-caloric supplements. The ethanol plus molasses and starch supplements improved utilization of urea over the basal ration but were inferior to the soybean ration.

Sheep exhibited reduced consumption when fed over 6 percent urea in a ration, stated Coombe et al. (1960), even though large amounts of urea may be fed when spread over a 24 hour period. Nelson and Waller (1962) stated that urea supplements were always inferior to iso-nitrogenous supplements containing cottonseed meal for wintering beef cattle.

Oltjen et al. (1962a) found isolated soy protein to yield significantly faster ($P < .05$) gains than urea or casein with significantly greater ($P < .05$) feed efficiency. When urea furnished 98.7 percent of the nitrogen of a diet, the gains were 80 percent of that from isolated soy protein and 86 percent as good as soybean meal. These gains were considered satisfactory for urea by these authors. In other work, Oltjen and Putnam (1966) showed that nitrogen retention was significantly greater for isolated protein when the isolated soy protein or urea were the sole sources of nitrogen.

Soybean meal fed at 9 and 19 percent of the diet gave a significantly higher feed conversion than urea fed at 1.17 percent of the diet reported Clifford et al. (1967). Clifford and Tillman (1968) showed that urea as a sole source of nitrogen for lambs was

approximately 70 percent as good as soybean meal. Hoar et al. (1968) found lambs fed 1 percent urea to gain 16.5 to 19.5 percent less than those fed 7 percent soybean meal. These authors also found that raising the equivalent crude protein of a 8.04 percent ration to 9.54 percent equivalent crude protein by the addition of soybean meal, urea, or sodium nitrate, almost equalized the gains of lambs.

Williams et al. (1968) reported that range supplements containing urea did not maintain weight of wintering gestating cows as well as cottonseed meal supplements. Birth weights of the calves were unaffected, but gains of the calves from cows consuming the urea supplement were less than gains of the calves whose mothers were eating cottonseed meal supplements.

A trend was shown by Theurer et al. (1968) indicating that urea was inferior to natural protein diets fed to sheep. Oltjen et al. (1969b) made a similar statement that urea tended to reduce beef cattle performance when fed over an extended period of time. Bulls were found to utilize purified diets better than heifers.

Although the use of urea may not solve the world protein shortage, it has been agreed by the majority of authors that a limited amount of urea (25 to 33 percent of total nitrogen of a ration) could be utilized by ruminant microflora.

Biuret As A Source Of Nitrogen

Biuret, a condensation product of the manufacture of urea, has

become rapidly a popular source of non-protein nitrogen. Slow decomposition and lack of toxicity have been factors which have lead greater acceptance and usage of biuret.

Gaither et al. (1955) ran studies with sheep comparing urea and biuret. Two supplements were formulated. Thirty-three percent of the nitrogen in the supplements was supplied by urea or biuret. This work showed biuret nitrogen was retained as well as urea nitrogen. Rations containing 1 percent biuret were used by Berry et al. (1956) in comparison with cottonseed meal and urea. Gains and appetites of lambs and steers were depressed when biuret was fed rather than urea or cottonseed meal. The variable response of biuret indicated that biuret was not a dependable source of non-protein nitrogen.

Addition of nitrogen sources to rations fed to growing and fattening lambs was studied by Meiske et al. (1955). No differences in weight gains were observed when either soybean meal, urea, or biuret were added to a basal ration.

In vitro studies by Ewan et al. (1958) found biuret to depress digestibility of dry matter when compared to urea; however, this relationship was not significant. Anderson et al. (1959) researched urea, uramite, biuret, and soybean meal in supplements which supplied up to 67 percent of the total nitrogen in iso-nitrogenous, iso-caloric diets for lambs. All levels of biuret in rations reduced crude protein digestion. Levels of biuret up to 50 percent of the

total nitrogen did not alter the digestibilities or nitrogen utilization significantly. Purified soybean diets had significantly greater digestibilities than did urea, ureamite or biuret.

Hatfield et al. (1959) stated that biuret was not toxic and that growth, reproduction, and wool production were not adversely affected by feeding biuret as a source of non-protein nitrogen. However, digestion coefficients for nitrogen were significantly slower ($P < .01$) for biuret than for the urea and soybean meal rations. With lambs on low intake rations, nitrogen balance for biuret was significantly higher ($P < .05$) than urea. However, on high intake rations nitrogen balances for biuret were only slightly higher than those for urea. The animals consumed less feed when eating the urea and biuret rations. Biuret may be used as a source of non-protein nitrogen, stated Mackenzie and Altona (1964) and Hatfield et al. (1959).

Weldon and MacDonald (1962) compared urea and biuret in vitro. Nitrogen utilization of Pseudomonas aeruginosa was measured by cell reproduction. Glucose was the sole energy source. Generation time using biuret as a nitrogen source was about twice that when urea was used as the nitrogen source. Even thus, cell production was good in the biuret media.

Johnson and McClure (1963) stated that if ruminants use biuret it must be through the microflora. Microorganisms for utilization of biuret and urea were different, quoted Johnson and McClure (1964).

Even so, biuret was utilized nearly as well as urea in rations where each supplied 45 percent of the total nitrogen.

Clark et al. (1963) showed biuret to be as efficient as urea when judged by nitrogen retention, apparent nitrogen absorption, and stimulation of hay consumption. Biuret and urea were compared to each other on low protein, high roughage diets. Biuret was found to be more palatable than urea. Karr et al. (1965) indicated no significant differences in digestion of dry matter or nitrogen when urea was 3 percent of the ration and biuret was 3.5 percent of the ration.

Mies (1968) wintered steers on rations in which 1/2 the equivalent crude protein came from urea or biuret. No significance was shown in weight gains among urea, biuret, or soybean meal fed cattle. In another trial, soybean meal cattle responded more favorably ($P < .05$) than did the urea or biuret fed steers. With heifers, Mies (1968) showed urea or biuret fed at 2/3 of the equivalent crude protein to be significantly ($P < .05$) more efficient than a combination of 50 percent urea and 50 percent biuret. No effect on heifer gain or carcass characteristics was witnessed. In this study using 112 head of beef cattle, biuret was found to be equal to urea in gain production.

Raleigh and Oldfield (1968) reported no differences in calf birth weights from range cows that had been supplemented with biuret plus barley compared to barley, as a control, on high energy treatments. Biuret and cottonseed meal yielded significantly greater gain than urea

or low protein controls when fed in supplements to range cows, reported Turner and Raleigh (1968). Biuret and cottonseed meal also yielded a higher economic return. Moreover, Meiske and Goodrich (1969) pointed out and summarized that biuret could be used in conditions where urea breaks down too rapidly for efficient utilization of NH_3 , such as range conditions.

Effect Of Energy On Utilization Of NPNS.

Readily fermentable carbohydrates or other energy sources are important requisites for the proper utilization of non-protein nitrogen by rumen microflora. Early work by Honecamp et al. (1923) stated the importance of carbohydrates being present in low protein diets of milk cows when urea was fed at 150 to 200 grams per head per day. Mitchell and Hamilton (1932), Mitchell et al. (1940) and Hamilton (1942) reported that an increase in energy decreases digestibilities of crude fiber. Energy additions had the same effect on digestibilities of dry matter according to Burroughs et al. (1949). Hamilton (1942) and Burroughs et al. (1949) attributed the decreases in digestibilities of crude fiber and dry matter to the fact that micro-organisms had a greater affinity for the readily available carbohydrate than for the crude fiber of the ration. Mills et al. (1942) found urea to be utilized better with timothy hay when starch was added to the ration. The addition of casein to this diet caused a reduction in urea utilization.

Pearson and Smith (1943) stated that synthesis of protein from urea is microbial in steers and that starch stimulates this synthesis. Starch was shown to be superior to molasses for the stimulation of protein synthesis. However, a mixture of carbohydrates yielded better results than any of the individual components shown by Mill et al. (1944) and Williams et al. (1969a). Starch yielded the best utilization of urea with cellulose compared to xylan and pectin. Belasco (1956) stated, in summary, that different carbohydrates seem to have been utilized through different metabolic pathways. This evidence indicated better utilization of urea when a combination of carbohydrates was fed.

Oltjen and Putnam (1966) disclosed that the addition of starch to purified diets fed to steers significantly altered fecal and urinary nitrogen losses. Nitrogen sources for the iso-nitrogenous and iso-caloric diets were urea or isolated soybean protein. Isolated soybean protein rations had a significantly greater nitrogen retention than did the urea rations.

Feeding sheep 7 grams urea per head per day, Pierce (1951_b) found the addition of potato starch at 100 grams, 150 grams, and 200 grams per head per day to increase wool production, 7, 19, and 23 percent, respectively. In other studies by Pierce (1951_a), 15 grams urea per head per day fed to sheep with a low protein, high fiber diet did not alter wool growth. Wheat gluten, rather than urea, increased total

wool production 35 percent. When 15 grams urea and equivalent amounts of wheat gluten were added to the same low protein potato starch enriched diet, increases in total wool production of 32 percent and 64 percent, respectively, were witnessed. These authors stated that urea was utilized when fed with low protein, high carbohydrate rations. Lofgreen et al. (1951) found that increasing energy intake of dairy calves resulted in increases in nitrogen retention when moderate protein levels were fed but not with high protein rations. Corn used as energy yielded higher nitrogen retention than molasses according to Bell et al. (1951, 1953),

The fact that carbohydrates must be present to utilize urea has been shown by Chalmers and Synge (1954) and Kirk et al. (1958). They found simple sugars to be too soluble and too rapidly broken down for maximal utilization of urea. Celluloses and the hemicelluloses were broken down too slowly to add energy to the rumen. Starches yielded the best media for the utilization of urea in the ruminant. Fontenot et al. (1955) showed that increasing levels of cerelose, which is a highly soluble corn sugar, decreased nitrogen retention. Glucose, sucrose, or lactose had about equal influence on nitrogen utilization reported Gallup et al. (1954). With these simple sugars present in the rations, soybean meal ration efficiency was affected more than the urea ration efficiency, but not significantly. High levels of dextrose with cellulose inhibited cellulose digestion, but starch increased cellulose digestion according to Belasco (1956).

Availability of readily fermentable carbohydrates depressed roughage digestion when fed with urea rations in vitro reported Arias et al. (1951). Abundances of starch increased the utilization of urea and depressed cellulose digestion in studies by Hunt et al. (1954). Fontenot et al. (1955) found that a 50 percent increase in carbohydrates of a ration increased nitrogen retention 60 percent. Ellis and Pfander (1958) found by increasing cellulose levels of a ration that digestibility of ether extract increased significantly and linearly, while the digestibilities of organic matter, nitrogen-free extract, and total digestible nutrients were decreased. Daily urinary nitrogen was increased by increasing cellulose, while nitrogen balance was decreased. Elam et al. (1958) found that beef heifers fed medium levels of energy had significantly greater ($P < .01$) digestibilities of organic matter, nitrogen-free extract, and energy than did high energy (full fed) or low energy (maintenance) heifers. Smith et al. (1957) fed lambs urea in semi-purified rations containing corn cobs, wheat straw, bagasse pith, or oat-mill feed as energy sources. The source of roughage carbohydrate influenced the utilization of nitrogen of these rations in which urea supplied 67 percent of the total nitrogen. Nitrogen utilization with corn cobs was superior to wheat straw as roughage, while oat-mill feed and bagasse pith were inferior to both. Replacing various amounts of wheat straw with equal quantities of dextrose and starch increased the nitrogen utilization in urea-

containing lamb rations.

The addition of ethanol to molasses increased nitrogen retention over starch based rations that were iso-caloric. In contradiction to their own work, Drori and Loosli (1959) reported that starch and starchy concentrates, such as corn, favor nitrogen retention in urea fed ruminants more than other carbohydrates, such as the sugars in molasses. These researchers stated that ethanol may help improve urea utilization of low-quality, low-protein rations when no cereal grains are fed. Ethanol added to a ration at 11.4 milliliters per 454 grams dry matter yielded a slight increase in nitrogen utilization, according to Chalupa et al. (1964). In this case, ethanol was useful only as a source of energy. Drori and Loosli (1961) stated that the amount of starch or glucose in a urea ration may be responsible for the poor utilization of urea by ruminants. In this study with sheep, consumption was higher on soybean meal diets than either the glucose-urea ration or the starch-urea ration. These authors theorized that the levels of carbohydrate in a ration may be as important as the levels of urea.

Chalupa (1963) stated the limiting factor in nitrogen utilization from urea was to secure comparable rates of urea hydrolysis and microbial synthesis of protein which may necessitate the co-feeding of soluble energy sources. In vitro studies by Bloomfield et al. (1964) contended that nitrogen fixation from urea was a quantitative function of energy. For maximum assimilation, 55 grams carbohydrate should be

present for each one gram nitrogen. Nitrogen retention significantly improved (2 percent units) for every 100 kilocalories readily available carbohydrate in the ration and had an effect regardless of adaptation. The same effect took place with all-urea rations fed to lambs maintained McLaren et al. (1965_a). Optimal nitrogen-free extract to nitrogen ratio was found to improve linearly from 11:1 to 28:1 with no further improvement to 55:1.

Success of urea is dependent on composition of the carbohydrates fed, contend Conrad and Hibbs (1968). These authors indicated that approximately 1 kilogram readily available carbohydrate (2/3 starch) was needed per 100 grams of urea fed to adapted cattle. With this ratio of carbohydrate to urea, efficiency of urea was compared equally with plant protein, when milk production and body tissue were considered. Feed consumption increased when urea was fed above 0.45 grams per kilogram body weight. In contradiction, a review by Conrad (1968) reported a definite decrease in feed intake when cattle were fed 0.4 to 0.5 grams NPN per kilogram body weight.

Sucrose added to straw-urea rations for sheep had no effect on intake, revealed Faichney (1965). Crude fiber digestion was decreased as sucrose increased, because of competition for nitrogen. This author asserted that there was no need for added energy in the straw-urea rations. Milligan (1967) contradicted this statement. He showed that rumen microbes reproduced using NH_3 as the only source of nitrogen.

This author stated that only a small portion of the feed energy became available to the microbes and that energy was the limiting factor when microbes utilized NH_3 for production. McAtee et al. (1967) substantiated this work by feeding wethers. These authors found that 50 to 80 percent of the corn starch that was fed escaped rumen fermentation and was digested posteriorly to the rumen.

Campling, et al. (1962) infused intraruminally into dairy cows 75 grams or 150 grams urea. The infusion of either level increased the consumption of oat straw 40 percent. The addition of 500 grams sucrose to the urea had no further effect on consumption. At the 150 gram urea 500 gram sucrose level, dry matter digestion was improved from 40 percent to 53 percent over the 150 gram urea level.

Straw was used as a source of energy by Lofgreen and Christensen (1962) along with alfalfa. When straw replaced 1/2 the energy in the ration of beef steers, intake and gains were depressed, although reticulo-rumen fill was increased.

Barth (1962) reported that increasing readily available carbohydrates 50 percent in all-urea lamb rations from maintenance resulted in a linear increase in nitrogen utilization of approximately 60 percent

Oltjen et al. (1962_b) fed 4.2 percent urea with 30, 40, and 50 percent cellulose to sheep. Their work showed gains of sheep fed 30 percent cellulose to have been greater ($P < .05$) than those fed 50 percent cellulose. Sheep fed the 30 percent cellulose ration showed less ($P < .05$) feed per kilogram gain than those sheep fed 50 percent

cellulose ration.

Hemsley and Loir (1963) reported no necessity for readily available carbohydrate energy to enhance utilization of urea-supplemented, low-quality, cereal hay diets fed to sheep. Donefer et al. (1963), on the other hand, showed that as the barley content of the rations fed ewes was increased, the digestion of energy had a nearly linear increase. Conrad (1968) indicated nitrogen utilization to be a linear function of digestibilities of energy input regardless of body weight.

Starch substituted for roughage carbohydrate increased the rate of NH_3 utilization, according to Tagari et al. (1964) and impaired protein utilization. Lewis (1962) disagreed with this statement and reported the addition of starch to depress the liberation of NH_3 . Tagari et al. (1964) found that increases in starch of diets for sheep increased the ruminal concentration of amino acids. Starch added to the sheep rations increased protein digestion but, at the same time, decreased nitrogen retention in the body. Indicating that increased protein digestion did not mean an increase in protein utilization. Along this same line, Miller and Payne (1961) stated that on low energy diets with ample protein, a protein deficiency may appear because energy was preferential to protein and the protein was used for energy.

Stone and Fontenot (1965) indicated no significant differences in nitrogen retention among low, medium, and high energy natural protein rations fed to Angus steers. Digestibilities of dry matter, organic matter, energy and nitrogen-free extract significantly ($P < .01$) increased

with increased energy. Digestibility of crude fiber increased significantly ($P < .01$), also.

The heat increment was lower for 10 to 15 percent equivalent crude protein rations containing urea than for rations containing all natural protein. In this same research, Cock et al. (1966) indicated that energy digestion increased with an increase in dietary nitrogen when fed to ruminants.

Growth and reproduction of heifers fed high urea supplements (2/3 dietary N from urea) was compared to soybean meal supplements by Bond et al. (1967). The urea plus corn starch supplement was equal to soybean meal supplement when average daily gain of heifers was considered. Urea supplements caused slightly longer estrous cycles; however, no significant differences in conception rate or postparturate estrus were observed. In feeding urea, biuret or cottonseed meal supplements to cattle on native range, Turner and Raleigh (1968) showed a significant gain advantage with added energy of the high energy supplements. High energy supplements yielded a \$4.47 economic advantage over the low energy supplements. As urea increased up to 6 percent in range supplements, performance tended to decrease, according to Clanton et al. (1968).

Smith (1968) attacked the problem of energy availability and simultaneous NH_3 release in a different manner. Finely ground corn, sorgham, barley, or other starch was mixed with urea and then gelatinized with heat and pressure. This starch-controlled urea compound, called

Starea, had good handling and storage properties and, most important, released NH_3 more slowly than other conventional urea feeds. Starea compared favorably to soybean meal rations when fed to lactating dairy cows. Grain intake and milk production were similar for both rations. Conventional urea rations reduced both grain intake and milk production and caused the cows to lose weight. A starch-controlled urea product was superior to an equivalent amount of urea supplement and equal to the same quantity of soybean meal for lactating cows according to Deyoe et al. (1968).

High urea (15 percent urea) rations compared favorably to cottonseed meal based supplements when high levels of concentrate were fed, in work done by Barth et al. (1968). When steers were fed high-silage rations, cottonseed meal based supplements were superior to the high urea supplements.

Wilson et al. (1969) fed Angus-Holstein cows 150 percent of N.R.C. requirements for protein and 85 percent or 115 percent of N.R.C. requirements for energy. High energy significantly ($P < .01$) influenced cow weight loss, cow and calf condition, calf conformation score, and calf gain. Cows on high energy levels maintained their weight, while low energy level cows lost 54.4 kilograms, which was approximately 12 percent of the on test body weight. Optimum energy to urea ratios have been hard to find for range cattle on poor-quality forages, quoted Williams et al. (1969_b). These workers fed 1362 grams of a 21 percent

protein supplement containing 4 percent urea. Birth weights and weaning weights of calves from urea supplemented corn showed a trend to be lighter than those calves whose mothers received a cottonseed meal supplement. Simultaneous provision of adequate and readily available energy has been imperative for efficient utilization of peanut-cake and urea nitrogen for cattle according to Miara and Ranhotra (1969).

The general trend for most authors discussing non-protein nitrogen utilization by ruminants has been that a source of readily available carbohydrate is essential. Exact levels of energy to non-protein nitrogen as yet have not been well established, particularly for range cattle conditions. Probably the biggest factor to consider has been that of economics when using non-protein nitrogens as a portion of a ration.

Importance Of Adaptation Periods Of Ruminants To Non-Protein Nitrogen Feeds

Welsh et al. (1957) fed lambs non-protein nitrogen for 35 days. As days on trial increased, greater utilization of urea and biuret was observed. After 35 days, no further increase in utilization of nitrogen occurred. Urea levels of 25 to 45 grams per head per day caused a toxic effect to sheep, reported Coombe and Tribe (1958). With an adaptation period, no toxic symptoms occurred at urea levels of 100 grams per day in lambs. Positive nitrogen balances were observed in

steers, by Hatfield et al. (1959), after an 18 day adaptation to biuret. A drench containing 275 grams biuret was administered by stomach tube in this study. Nitrogen retention improved significantly with adaptation reported by Smith et al. (1960). Urea was fed to provide two-thirds of the total nitrogen of a ration composed basically of straw and molasses. Differences of 2 percentage units increase in nitrogen retention accompanied each 10-day collection period, reported Smith et al. (1960) and Chalupa (1968). No measurable changes occurred in digestibility of organic matter or crude fiber. Smith et al. (1960) and McLaren et al. (1965_a) reported a significant improvement of 3 percent in nitrogen retention for every 10-day collection period in their work with urea fed to lambs. Lewis (1960) stated that 7 days were necessary for organisms to adapt to large quantities of NH₃ in ruminants.

In vitro studies by Barth et al. (1961) indicated some adaptation of sheep to urea, up to 48 days. In vivo studies corresponding to the in vitro studies showed utilization of urea increased from 36 to 51 percent. Johnson and McClure (1963, 1964) found sheep to adapt to biuret when digestibilities were studied. No differences in nitrogen retention were observed with adaptation by Johnson and McClure (1965_a, 1965_b) and Schaadt et al. (1966). Campbell et al. (1963_b) reported a 3 to 4 week adaptation improved the utilization of biuret fed to ruminants. Clark et al. (1963) contended this period should be 6 to 8 weeks, when comparing biuret to urea in sheep rations. A two-week adaptation period was found ample by Smith (1968) for the starch

enriched urea product, Starea.

Significant increases in nitrogen retention were observed by Farlin et al. (1968) for an adaptation to biuret for 51 days. These authors stated that at least a 9-day adaptation period is essential. Clifford and Tillman (1968) indicated that during metabolism studies with sheep fed urea rations, urinary nitrogen increased sharply, then decreased after 10 days, indicative of the importance of at least a 10-day adaptation period to urea. An adaptation period of more than 19 days was associated with the accelerated conversion of ammonia to urea in the liver by Conrad (1968).

The addition of diethylstilbestrol (DES) to ruminants fed non-protein nitrogen has been beneficial in reducing adaptation time. Welch et al. (1957) indicated that DES reduced the adaptation period to urea and biuret from 35 days to 25 days. Biuret and urea utilization was improved more rapidly by the presence of DES in lambs, reported McLaren et al. (1959) and Karr et al. (1965). Mies (1968) observed DES implanted steers gained significantly ($P < .01$) more than non-implanted steers fed urea or biuret in fattening rations.

Frequency of feeding had no effect on urea utilization reported Dinning et al. (1949) and Blaxter et al. (1961). Dinning et al. (1949) fed range steers and range ewes a supplement in which urea supplied 25 or 50 percent of the total nitrogen. These authors found no differences in urea utilization when the animals were fed twice daily, daily, or on alternate days. Feeding Guernsey heifers urea rations

six times daily yielded slightly better nitrogen utilization than feeding two times daily, contended Campbell et al. (1963_a).

The overall indication of these studies was that at least a 10-day adaptation to non-protein nitrogen was essential before optimal performance could be expected by the ruminants to non-protein nitrogen feeds. Longer periods of 30 to 49 days may have been better for the most efficient utilization of non-protein nitrogen.

Additives To Non-Protein Nitrogen Diets

Although the requirements for microorganisms of the rumen are relatively simple, minerals were one of the important factors most often overlooked, stated Burroughs et al. (1951_a). Burroughs et al. (1951_b) confirmed that iron and phosphorus stimulated urea utilization, as did sodium, potassium, calcium, magnesium, chlorine, and sulfur. Conrad (1968) found the necessity for large amounts of phosphorus and sulfur in rations for optimum utilization of urea and NH_3 .

Trace minerals added to urea rations fed to heifer calves by Nelson et al. (1955) increased gains. Thomas et al. (1953) found no significant difference in weight gains of steers fed a soybean meal supplement over steers fed a urea supplement when trace minerals and phosphorus were added to both rations. Adequate phosphorus significantly increased gain of steers over steers fed low-phosphorus rations. Gossett et al. (1962) indicated no effect of trace minerals in fattening rations for steers. Pope et al. (1959) reported decreased gains with the addition of trace minerals. Oltjen (1962_b) stated that high mineral

levels significantly ($P < .05$) improved gains of lambs.

Sulfur may have been the single most important element considered as far as common commercial diets were concerned. Thomas et al. (1951) found the absence of sulfur to inhibit growth in lambs and especially wool growth. Poor urea utilization was indicated by a negative nitrogen balance which was positive after the addition of sulfur to the rations. Sulfur significantly ($P < .001$) improved gains and wool growth no matter what the source, according to Starks et al. (1954). Black et al. (1951), Hale et al. (1953) and Hunt (1954) all agreed that sulfur added to rations was beneficial to urea utilization.

Alfalfa meal was shown by Burroughs et al. (1950_a) to increase the digestibility of corn cobs in steer rations. This increase in digestibility was attributed to unidentified factors in alfalfa ash. Dyer and Roberts (1956) confirmed that alfalfa meal increased gains ($P < .01$) of pregnant heifers fed non-protein nitrogen rations. Alfalfa ash added to the same urea supplements also significantly ($P < 0.5$) increased gains. The effect of alfalfa meal and alfalfa ash was observed in weights of the calves from these heifers. Bell et al. (1953), Beeson et al. (1964), Beeson and Horn (1967), Garrigus (1964), and Conrad and Hibbs (1968) revealed urea utilization in supplements could be improved with the addition of dehydrated alfalfa meal. Biuret utilization was not increased as greatly as was urea utilization by the addition of dehydrated alfalfa meal (DEHY), according to Karr et al. (1965). Horn and Beeson (1969) show a significant ($P < .05$) increase in nitrogen retention of urea

nitrogen fed beef cattle when dehydrated alfalfa meal or distillers dried grains with solubles (DDGS) were present. Beeson (1969) remarked that two good sources of unidentified urea-protein factors were DEHY and DDGS, although others may have been just as acceptable.

Toxicity

Toxicity to non-protein nitrogen products has been a serious problem. Urea seems to have been the worst offender, while biuret showed little or no toxic problem. Gallup et al. (1953) fed adapted ruminants 100 grams of urea per 45.4 kilograms body weight with no ill effects. Levels of urea from 25 to 45 grams per day fed to unadapted sheep caused toxic symptoms in studies by Coombe and Tribe (1958). With adapted sheep, 100 grams per day were fed with no ill effects. Coombe et al. (1960) reported an ample supply of energy to reduce toxicity of urea. The starch-controlled product tested by Deyoe et al. (1968) was claimed to reduce the danger of toxicity.

Rumsey et al. (1969) infused 100 grams urea into adapted 454 kilogram steers by means of ruminal fistula. Toxicity occurred with recovery after the administration of 5 percent acetic acid drench.

Signs of toxicity were observed by Whitehair et al. (1955) and Fraser (1963) in steers that had eaten 20 grams urea per 45.4 kilograms body weight. Symptoms of uneasiness and incoordination progressed until staggering, muscular convulsion, increased respiration, excessive salivation, and bloat were observed. Death could follow 30 minutes to one hour after ingestion of the urea.

Mieske et al. (1955) and Berry et al. (1956) reported no toxic symptoms from biuret, a strong point in favor of feeding this compound rather than urea.

Although urea poisoning has been associated with the aforementioned symptoms, Warren (1962) observed similar symptoms in ruminants on spring pasture, high in non-protein nitrogen. Clark et al. (1951_a) also substantiated this effect with sudden increases in natural protein.

Whitehair et al. (1955) concluded that conditions that led to urea toxicity were as follows:

- a) starving or fasting cattle before feeding urea;
- b) animals with "hoggish" or aggressive appetities;
- c) unadapted animals;
- d) improperly mixed feed or feeds too high in urea;
- 3) high levels of urea fed with poor quality, high roughage rations.

METHODS AND PROCEDURES

Trial I - Nitrogen Source, Wintering Study

These experiments were conducted at the Montana State University Agricultural Experiment Station, Nutrition Center, Bozeman, Montana. All animals used in this trial were Angus-Hereford crossbred or Hereford steers from Red Bluff Research Ranch at Norris, Montana, the U. S. Range Livestock Experiment Station, Miles City, Montana and the campus at Montana State University, Bozeman. The calves were born the spring of 1969. Upon arrival at the Nutrition Center, all cattle were vaccinated for Blackleg, Malignant Edema, Para-Influenza 3, Infectious Bovine Rhinotracheitis, Enterotoxemia (Type D), and Bovine Virus Diarrhea. All calves were treated with Ruelene for grub control and later sprayed with Korlan for lice control. The steers were identified by individual eartag numbers.

Thirty-six steer calves were stratified by source, weight, and breed, and randomly assigned in groups of six to each of six pens. Calves were weighed on test after approximately two months of pre-conditioning. Individual initial and final weights were taken after an overnight shrink (15 hours) without feed and water. The cattle were weighed without shrink every 28 days from the initial weight to final weight.

The pens were located with the fence-line bunks under an open shed. Half of the pens were partially slotted, the other half of the six pens being concrete located on the south side of the open shed. The other

three pens were sloped concrete slabs, located on the north side of the open shed. Pens were 5.49 meters by 7.62 meters, allowing 6.97 square meters per calf. Water was available from thermostatically-controlled, electric, self-filling waterers. Salt was available ad libitum. Supplement was fed at the morning feeding on the days it was fed. Hay was fed twice daily.

Three supplements were formulated to contain 20 percent protein from soybean meal, biuret and urea. The control supplement was the soybean meal supplement. Biuret or urea provided one-third of the crude protein equivalent of the remaining two supplements (Table I).

TABLE I. SPECIFICATION OF SUPPLEMENTS FOR WINTERING STEERS

MSU Formula No.	608	609	610
<u>Ingredients:</u>		<u>Percent of Ration</u>	
Biuret	----	2.77	----
Urea	----	----	2.35
Barley	46.26	61.35	62.00
Soybean meal	23.25	5.25	5.00
Alfalfa, dehydrated	10.00	10.00	10.00
Wheat millrun	10.00	10.00	10.00
Molasses	6.50	6.50	6.50
Monodosium phosphate	3.00	3.00	3.00
Trace minerals	0.50	0.50	0.50
Gypsum	0.50	0.50	0.50
Limestone	----	0.15	0.15
Vitamin A ^a	x	x	x
	<u>100.0</u>	<u>100.0</u>	<u>100.0</u>

^a Vitamin A added to provide 15,000 I.U. per lb.

Each of the six pens of cattle was randomly assigned to one of six feeding regimes. Three pens of cattle were fed 0.91 kg supplement per

head per day once a day, with each pen receiving one of the three supplements. The remaining three pens received 1.81 kg of one of the supplements per head on every other day. Grass hay was chopped through a 5.5 cm screen in a hammermill, and fed to all pens daily, the amount being controlled by the pen consuming the least. Using this procedure, all cattle consumed equal quantities of feed on a two-day basis. Protein of all rations was calculated to be equal to NRC requirements for normal growth for steers on a long term basis.

All pens of cattle were allowed 28 days on their particular feed regime for an adaptation period prior to being weighed on test, January 20, 1970. The steers were shrunk and weighed after they were fed 98 days and 126 days on this wintering ration; they were weighed off test May 26, 1970. The steers had an average weight of 227 kg on test and an average weight of 286 kg off test.

Trial II - Nitrogen Source, Metabolism Study

A metabolism study was conducted to supplement the study of every day or every other day feeding of supplements with different sources of nitrogen. Steers used in the study were born in the fall of 1968 and were from one herd. They were vaccinated for Blackleg and Malignant Edema and drenched with Thiobenzole for internal parasite control. Three steers, weighing approximately 240 kg were randomly assigned to receive one of the three supplements described in Trial 1. The steers, previously adapted to non-protein nitrogen feeds, were

allowed a 10-day adjustment period to the supplements and placed in the metabolism stalls. Seven additional days were allowed to adjust to the stalls and stabilize intake and excretion. The stalls were similar to those used by Nelson et al. (1954).

The sequence of feeding for the three phases of the metabolism study was as follows: 1) 0.91 kg supplement every day plus grass hay (basal ration) 2) 1.82 kg supplement every other day plus basal and 3) basal ration only. The basal (grass hay only) ration was fed last in the sequence of metabolism studies to allow continuity in the feeding of non-protein supplements. If the digestibility of basal ration had been studied first, the necessity to re-adapt the steers to their respective non-protein supplements for a second time would have been time-consuming. The basal ration study provided a basal nitrogen balance. The nitrogen balance of the supplements was then determined by differences between the hay ration, and the hay and supplement rations as described by Crampton and Harris (1969).

Steers were fed 80 percent grass hay (basal) and 20 percent supplement in a ration calculated to be slightly above the net energy maintenance requirement reported by Gill (1968). Steers were fed to gain 0.14 kg per head per day according to their net energy requirements calculated from their metabolic body size (weight $^{0.75}$ kg). The total equivalent crude protein intake was calculated to equal that suggested by NRC for normal growth of steers. Values for the feeds were

TABLE II. PROTEIN REQUIREMENTS, NET ENERGY REQUIREMENTS, CALCULATED PROTEIN INTAKE, AND CALCULATED NET ENERGY INTAKE FOR STEERS FED A MAINTENANCE RATION EVERY DAY (ED) AND EVERY OTHER DAY (EOD). Trial II

Steer no.	Supplement no.	Source of Supplemental Nitrogen	Feeding interval	Weight	Protein	Energy	Supplement	Basal	Total	Supplement	Basal	Total	Energy
				kg	g	kcal	g	g	g	g	g	g	kcal
97	---	Basal	ED	243.6	636	4750	---	4120	4120	---	334	334	4750
	608	Soybean	ED	247.7	636	4560	908	3632	4538	182	368	545	4560
	608	Meal	EOD	235.9	636	4680	923	3690	4613	185	373	558	4680
92	---	Basal	ED	217.7	636	4360	---	3780	3780	---	306	306	4360
	609	Biuret	ED	215.9	636	4340	864	3456	4320	173	350	523	4340
	609		EOD	216.4	636	4400	865	3459	4324	173	350	523	4400
94	---	Basal	ED	249.9	636	4840	---	4200	4200	---	340	340	4840
	610	Urea	ED	230.9	636	4800	956	3824	4790	191	387	478	4800
	610		EOD	248.1	636	4860	958	3833	4791	192	388	480	4860

^a Protein requirements were taken from National Research Council for normal growth of steers. Energy requirements were taken from net energy values reported by Don R. Gill (1968) for maintenance of steers.

from values given by Harris and Crampton (1968) for net energy for maintenance (NE_m) and reproduction (NE_p). The steers were fed 19.6 g supplement plus approximately 3.5 kg basal per kg body weight per day.

Steers were fed their respective supplement once daily and received the roughage in two (equal) feedings, morning and evening. Feed samples were taken at each feeding and stored in glass jars until they were subjected to proximate analysis. Analyses for protein, ether extract, crude fiber, ash, moisture, and energy were performed in accordance with Clanton (1961) and A.O.A.C. (1960). The procedure of Clanton (1961) was used for collection, feeding, and sampling. Steers were assumed adapted when daily excretions were constant. A seven-day collection period was used. The steers were weighed before being placed in the stalls for each collection period and again when they were removed from test. Feces and urine were weighed and samples taken once a day at the morning feeding. A one percent sample of urine was taken and acidified and refrigerated. A five percent fecal sample was taken and stored in the presence of thymol and immediately frozen. Nitrogen, ash, and specific gravity were determined on urine samples. Urine was absorbed on cellulose blocks for determination of gross energies with the Parr adiabatic calorimeter (Clanton 1961). Sub-samples of the composite samples of the feces were oven-dried at 60° C for 72 hours for nitrogen, ether extract, crude fiber, ash, and gross energy determination according to A.O.A.C. (1960).

Trial III - Nitrogen Source, Energy - Metabolism Study

The same three steers used in trial 2 were fed three semi-purified diets, in an attempt to correlate urea utilization with energy level. Steers weighed approximately 172 kg when put on test, and were randomly assigned to one of three iso-nitrogenous, iso-caloric, semi-purified diets. A 30-day acclimation period was used prior to the start of the test, to accustom the animals to their respective rations and the metabolism stalls.

Semi-purified diets were calculated and formulated to meet NRC requirements for normal growth of steers weighing 172 kg supplying 635.6 g crude protein and 12,800 kcal digestible energy.

Ration 1, the control, contained ground Campana barley (10 percent protein), soybean oil meal (48.8 percent crude protein), Argo corn starch, and Mazola corn oil as its energy source. In ration 2, one-sixth of the equivalent crude protein was supplied by urea, the remainder from soybean meal and barley. Argo corn starch and Mazola corn oil were added to equalize digestible energy. In ration 3, one-third of the equivalent crude protein was supplied by urea and the remainder came from barley and soybean oil meal, while Argo corn starch and Mazola corn oil were added to make the ration iso-caloric. Barley straw was the source of roughage for all rations. The rations were calculated to supply 100 percent of the NRC requirements for protein. Iso-nitrogenous rations containing two energy levels (low

and high) were fed. Energy was calculated to equal 90 percent of the NRC requirements on the low energy intake and 110 percent of NRC requirements on the high energy level on a gross energy basis. Mono-sodium phosphate and calcium carbonate (limestone) were added to each ration to supply 125 percent NRC requirements for calcium and phosphorus in the rations. Calcium Carbonate Company trace minerals (ruminant) were supplied at 2.25 g per head per day. Vitamins A and D were added to supply 30,000 I.U. and 6,000 I.U. per head per day, respectively. Salt was supplied at 10 g per head per day as recommended by NRC. Each steer received 0.91 kg of the grain mixture and 1.81 kg chopped hay per day as shown in Table III.

TABLE III. SPECIFICATIONS OF RATIONS FOR WINTERING STEERS^a

	Low Energy			High Energy		
	Control	1/3 C.P.E. from urea	1/6 C.P.E. from urea	Control	1/3 C.P.E. from urea	1/6 C.P.E. from urea
Ingredients:	<u>Percent of Ration</u>			<u>Percent of Ration</u>		
Barley	55.0	62.2	70.4	53.9	62.0	69.2
Soybean meal	41.0	31.1	21.0	40.1	29.8	20.6
Urea	----	1.4	2.7	----	1.3	2.5
Corn starch	1.0	1.0	1.0	1.0	1.0	1.0
Mono-sodium phosphate	0.4	0.5	0.6	0.4	0.5	0.6
Calcium carbonate	0.7	0.9	1.0	0.6	0.8	0.9
Trace mineral	0.1	0.1	0.1	0.1	0.1	0.1
Mazola corn oil	1.4	2.4	2.7	4.3	4.9	5.5
Salt	0.5	0.5	0.5	0.5	0.5	0.5
	<u>100.0</u>	<u>100.0</u>	<u>100.0</u>	<u>99.9</u>	<u>100.9</u>	<u>100.9</u>

^a Vitamins A and D were added to provide 30,000 I.U. and 5,000 I.U. per head per day.

RESULTS AND DISCUSSION

Trial I - Nitrogen Source, Wintering Study

Steers in Trial I initially weighed 227 kg. The average final weight for the steers was 285.3 kg. Average daily gain of steers fed soybean meal, biuret or urea either every day or every other day ranged from 0.54 to 0.66 kg per day during the 98-day period as shown in Table IV. The results of Trial I are shown in Tables IV and V.

TABLE IV. WEIGHT GAINS AND FEED CONSUMPTION OF STEERS FED SUPPLEMENTS WITH AND WITHOUT NON-PROTEIN NITROGEN AND FED EVERY DAY (ED) OR EVERY OTHER DAY (EOD), January 20, 1970 to April 28, 1970 - 98 days

Lot No.	5	18	23	17	11	6
MSU Formula No.	608		609		610	
	Soybean Meal		Biuret		Urea	
Feeding Interval	ED	EOD	ED	EOD	ED	EOD
No. steers	6	6	6	6	6	6
Av. weights, kg						
Initial	225.0	227.3	228.2	225.4	224.1	230.4
Final	289.4	288.5	286.2	285.8	279.4	282.5
Gain	64.4	61.2	58.1	60.3	55.3	52.2
Daily gain	0.66	0.63	0.59	0.62	0.57	0.54
Av. daily ration, kg						
Supplement, 20% protein	0.91	0.91 ^a	0.91	0.91 ^a	0.91	0.91 ^a
Hay	5.74	5.74	5.74	5.74	5.74	5.74
Salt	0.03	0.03	0.03	0.03	0.03	0.03
Av. daily feed, kg	6.68	6.68	6.68	6.68	6.68	6.68
Kg feed/100 kg gain	1014.2	1068.5	1131.2	1084.6	1179.1	1252.6
Feed cost/100 kg gain, \$ ^b	41.03	43.21	44.04	42.22	44.42	48.88

^a These figures are reported on an average daily feed consumption. This level was actually fed at twice the quantity on alternate days.

^b Feed prices: MSU No. 608, \$80.15/ton; MSU No. 609, \$70.07/ton; MSU No. 610, \$70.64/ton; Hay \$30.00/ton; Salt, \$25.00/ton.

Steers fed the soybean meal supplement every day were the highest gaining cattle. These steers gained 0.66 kg per day which was 0.03 kg per day greater gain than the steers fed the soybean meal supplement every other day. Steers fed the biuret supplement every other day showed an average daily gain of 0.62 kg per day which was slightly lower than 0.63 kg per day gain of the steers fed soybean meal supplement every other day. Steers fed the biuret supplement every other day and every day showed an average daily gain of 0.62 kg per head per day, and 0.59 kg per head per day, respectively, for the 98-day trial.

Steers fed the urea supplement had the poorest gains of all treatments. Average daily gains were 0.57 kg and 0.54 kg per day, respectively, for steers fed the urea supplement every day and every other day.

The gains of steers fed the control ration were 11 percent greater than steers fed biuret every day but only 1.5 percent greater than steers fed the biuret supplement every other day. Control steers also gained 16 percent greater than steers fed the urea supplement every day and 17 percent more than those steers fed the same supplement every other day.

Feed consumption per 100 kg gain was least for the lot of steers having the highest average daily gain. Average feed requirements were 1014.2, 1068.5, 1084.6, 1131.2, 1179.1 and 1252.6 kg per 100 kg gain, respectively, for steers fed soybean meal every day and every other

day, biuret every day and every other day, and urea every day and every other day for the 98-day trial. These figures showed the steers fed the soybean meal supplement every day to be 5.3 percent more efficient than the next most efficient group, the steers fed soybean meal supplement every other day. Steers fed the biuret supplement every other day were 1.5 percent less efficient than the steers fed the soybean meal supplement every other day. When fed every day, the steers fed the soybean meal consumed 11.5 and 16.2 percent less feed per kg gain than the steers fed the biuret supplement or the urea supplement, respectively. Steers fed the urea supplement every other day were the least efficient group. These steers consumed 17.2 percent more feed per kg gain than the steers fed the soybean meal supplement every day.

When feed cost per 100 kg gain was considered, the soybean meal supplement fed every day showed the cheapest gains at \$41.03 per 100 kg gain. Although steers fed the biuret supplement every other day were ranked third in feed efficiency, they were ranked second in economy of gain because the biuret supplement was appreciably cheaper than the soybean meal supplement. Steers fed the urea supplement had the highest cost per 100 kg gain, which was \$48.88, for any of six treatments. Steers fed biuret every day and urea every day showed cost of gain to be similar at \$44.04 and \$44.42 per 100 kg gain, respectively. Cost of gain for the steers fed the soybean meal supplement every other day was \$43.21 per day while cost of gain for steers fed biuret every

other day was nearly \$1.00 cheaper at \$42.22 per 100 kg gain for the 98-day wintering trial.

The steers remained on test for another 28-day weigh period, a final shrink weight being taken at the end of 126 days. Average final weight for the steers fed the same wintering ration for 126 days was 303.7 kg shown in Table V. Average daily gains of the steers fed for the 126 days were not appreciably different from the gains of the same steers fed the 98-day period. These differences were only 0.01 kg per day except for the steers fed the biuret supplement.

There was a definite change in average daily gains of steers fed the biuret supplement from the 98-day weights (Table IV) to the 126-day weights (Table V). At 98 days, steers fed every day gained 0.59 kg per day and 0.62 kg per day when fed every other day. Feeding the steers the biuret supplement every day for 126 days yielded an average daily gain of 0.63 kg per head per day and 0.60 kg per head per day when fed every other day. This change in tendency of the average daily gain can be attributed to the low average daily gain of steers fed every other day for their last weigh period (Table VI).

Steers fed the urea supplement every other day had a rather high average daily gain of 0.82 kg per head per day for the last 28-day period (Table VI). This high gain caused these steers to have a final average daily gain of 0.57 kg per head per day which was nearly equal

to the 0.58 kg per head per day average daily gain of the steers fed the urea supplement every day. Average daily gain for the steers fed soybean meal every day and every other day were, 0.67, and 0.62 kg per head per day, respectively. Steers fed supplements every day appeared to gain faster than steers fed the same supplements every other day when they were wintered for 126 days.

TABLE V. WEIGHT GAINS AND FEED CONSUMPTION OF STEERS FED SUPPLEMENTS WITH OR WITHOUT NON-PROTEIN NITROGEN EVERY DAY (ED) OR EVERY OTHER DAY (EOD). January 20, 1970 to May 26, 1970 - 126 days

Lot No.	5	18	23	17	11	6
MSU Formula No.	608		609		610	
	Soybean Meal		Biuret		Urea	
Feeding Interval	ED	EOD	ED	EOD	ED	EOD
No. steers	6	6	6	6	6	6
Av. weights, kg						
Initial	225.0	227.3	228.2	225.4	224.1	230.4
Final	309.4	305.7	307.5	300.7	297.1	301.6
Gain	84.4	78.5	79.4	75.3	73.0	71.2
Daily gain	0.67	0.62	0.63	0.60	0.58	0.57
Av. daily ration, kg						
Supplement, 20% protein	0.91	0.91 ^a	0.91	0.91 ^a	0.91	0.91 ^a
Hay	5.92	5.92	5.92	5.92	5.92	5.92
Salt	0.03	0.03	0.03	0.03	0.03	0.03
Av. daily feed, kg	6.86	6.86	6.86	6.86	6.86	6.86
Kg. feed/100 kg gain	1024.4	1102.0	1089.4	1148.4	1184.1	1214.3
Feed cost/100 kg gain, \$ ^b	42.27	44.37	42.28	44.59	46.05	47.21

^a These figures reported on an average daily feed consumption. This level was actually fed at twice the quantity on alternate days.

^b Feed prices: MSU No. 608, \$80.15/ton; MSU No. 609, \$70.07/ton; MSU No. 610, \$70.64/ton; Hay \$30.00/ton; Salt \$25.00/ton.

Feed per 100 kg gain was 1024.4, 1102.0, 1089.4, 1148.4, 1184.1 and 1214.3 kg, respectively, for steers fed soybean meal, biuret or urea supplements every day and every other day (Table V). As was found in the 98-day trial, the most efficient steers were those fed the soybean meal supplement every day because their gains were larger than the steers on the other treatments and their feed consumption was equal to that of steers of the other treatments. Throughout the trial, the amount of grass hay consumed by the steers in lot 6 limited the hay fed to the steers in the other five lots.

Gains of steers fed the control ration were 5.4 percent greater than steers fed the biuret supplement and 13.5 percent greater than steers fed the urea supplement when all groups of steers were fed every day. Steers fed the biuret supplement every day gained 1.4 percent more than steers fed the soybean meal supplement every other day. Steers fed the biuret supplement every other day gained nearly 7 percent more than those steers fed the urea supplement every day. Average daily gains of the steers were 6.8, 5.1 and 2.3 percent greater for the soybean meal, biuret, and urea supplements, respectively, when fed every day as opposed to every other day.

Feed consumed per kg gain was 5.3 percent less for the steers fed the soybean meal supplement every day than for the steers fed the biuret supplement every day. Steers fed the urea supplement consumed 15.6 percent more feed per kg gain than steers fed the control supplement

every day for the 126 day trial. The most inefficient steers were those fed the urea supplement every other day. These steers consumed 18.5 percent more feed per kg gain than the steers fed the control supplement. When steers were fed the biuret supplement every other day, they consumed 12.1 percent more feed per kg gain than the steers fed the soybean meal supplement. These steers were more efficient than either of the urea supplemented groups of steers. Steers fed the soybean meal, biuret, or urea supplements every day versus every other day consumed 7.6, 5.4, and 2.6 percent less feed per kg, respectively, for the 126 day trial.

Cost trends followed the same pattern for 126 days as for 98 days. Average daily gain and cost per 100 kg gain were inversely proportional. Steers fed the soybean meal supplement and biuret supplement showed costs per 100 kg gain that were nearly equal at \$42.27 and \$42.28 per 100 kg, respectively. Steers fed the soybean meal supplement and biuret supplement every other day and the urea supplement every day and every other day showed feed cost per 100 kg gain of \$44.27, \$44.59, \$46.05 and \$47.21, respectively. The cost of the biuret is not considered in the price per ton of the MSU 609 supplement which tends to make it more economically competitive than it would be in reality; therefore, cost figures in this trial may not be as meaningful as would be desired.

TABLE VI. AVERAGE DAILY GAIN OF STEERS FED SOYBEAN MEAL, BIURET AND UREA SUPPLEMENTS EVERY DAY (ED) AND EVERY OTHER DAY (EOD) GIVEN BY WEIGH PERIOD. Trial I, January 20, 1970 to May 26, 1970 - 126 days

Lot No., Supplement Feeding Interval	Days on test	Control		Biuret		Urea	
		ED ^c kg	EOD ^c kg	ED kg	EOD kg	ED kg	EOD kg
12/2369 ^a							
1/20/70 ^b		0.44	0.43	0.54	0.60	0.40	0.59
2/17/70 ^c	28	0.98	0.96	0.91	0.94	0.98	0.60
3/17/70	56	0.73	0.53	0.57	0.58	0.53	0.68
4/14/70	84	0.22	0.27	0.20	0.16	0.07	0.16
4/38/70	98	0.75	0.86	0.79	0.96	0.79	0.82
5/12/70	112	0.82	0.71	0.81	0.77	0.64	0.82
5/26/70	128	0.60	0.54	0.73	0.29	0.60	0.54

a. Began feeding respective supplement for adaptation period.

b. Weighed on test.

c. All weights taken on an overnight shrink off water except those obtained on 2/17/70 and 3/17/70.

Although the average daily gains of the steers fed soybean meal, biuret or urea supplements seemed to be different, analysis of variance indicated no significant differences ($P > .05$) in average daily gains, feed efficiency or feed cost per 100 kg gain after the steers had been on test for 98 or 126 days. No significant differences was shown ($P > .05$) when the aggregate of every day and every other day within a supplement group was compared. Because the steers within each lot were group fed, a statistical analysis of feed per unit gain of individuals was not possible.

Although results of this trial showed no statistically significant differences among treatments in weight gain, feed efficiency or feed cost per kg gain, steers fed the soybean meal supplement gained more than those fed the supplement containing biuret and those steers fed biuret gained slightly more than those steers fed urea. Feed efficiencies of treatment groups reflected the same trend; steers fed the soybean meal supplement required 4.3 percent less feed per kg gain than those steers fed biuret and 11.8 percent less than those steers fed urea for the 126-day trial.

The calculated protein intake and actual protein intake and average daily gain for a 98- and 126-day wintering period are presented in Table VII.

TABLE VII. NRC REQUIREMENTS CALCULATED PROTEIN LEVEL, ACTUAL PROTEIN AND AVERAGE DAILY GAIN OF 227 kg WEANLING CALVES FED TO GAIN 0.45 kg PER DAY. Trial I.^a

Treatments		Protein Required NRC	Protein Calculated Intake	Actual Protein Fed	Percent of NRC Require- ment	Average Daily Gain
		kg	kg	kg	%	kg
Control						
Supplement 608	ED ^b	0.59	0.57	0.60	101.5	0.67
	EOD ^c	0.59	0.59	0.60	101.6	0.62
Biuret						
Supplement 609	ED	0.59	0.59	0.61	103.1	0.63
	EOD	0.59	0.59	0.61	103.1	0.60
Urea						
Supplement 610	ED	0.59	0.59	0.60	101.5	0.58
	EOD	0.59	0.59	0.60	101.5	0.57

^a Average daily gain from January 20, 1970 to May 26, 1970 - 126 days

^b Every day.

^c Every other day.

The proximate chemical analyses of the feed ingredients used in Trial I are presented in Table VIII.

TABLE VIII. PROXIMATE ANALYSIS OF FEED UTILIZED IN WINTERING CALVES IN TRIALS I AND II^a

Feed	Mois- ture %	Eq. Crude Protein %	Ether Extract %	Ash %	Crude Fiber %	Gross Energy kcal/kg
Control Supplement 608	9.2	18.0	2.3	11.0	7.8	3615
Biuret Supplement 609	9.5	19.4	2.7	8.3	8.5	3764
Urea Supplement 610	8.7	18.0	3.4	8.2	8.0	3788
Grass Hay	8.1	7.6	1.8	7.5	29.3	3843

^a Analysis by Chemistry Station, Montana State University.

Trial II - Nitrogen Source, Metabolism Study

Data taken from the results obtained in nitrogen balance and digestion trials with steers on maintenance rations are presented in Table IX.

Total nitrogen intake and energy intake per kilogram body weight was similar for all steers except those fed the basal ration. Nitrogen intake for steers on the basal ration was less than those fed the basal plus supplement rations because all rations were calculated to be isocaloric and no supplemental nitrogen was added to the basal ration.

Table X shows that apparent digestibilities of nitrogen and ether extract for the total ration decreased as the feeding interval changed from every day to every other day. Energy digestibilities decreased slightly as the feeding interval increased. Crude fiber digestibility increased slightly when the control ration was fed every other day rather than every day. The biuret and urea supplemented rations had decreased crude fiber digestibilities as the feeding interval went from every day to every other day. The biuret supplemented ration had a small decrease in digestibility of NFE when fed every other day rather than every day, while the control ration and urea ration increased in digestibility of NFE.

Apparent digestibilities of the supplement calculated by difference showed nitrogen digestibilities to favor every day feeding; however, the nitrogen digestion of the control supplement was slightly greater on

the every other day feeding regime as shown in Table XI. The steers fed biuret showed apparent digestibilities of nitrogen for the supplement fed every day to be 6.4 percent greater than when fed every other day. The apparent digestibility of the urea supplement was 3.2 percent greater when fed to a steer every day rather than every other day.

Digestibilities of energy of the biuret and urea supplements were much higher when the supplements were fed every other day. The steer fed the biuret supplement every other day showed apparent digestibility of energy 2.3 times greater than when the supplement was fed every day. Apparent digestibility of energy for the urea supplement fed to a steer every other day was 1.8 times greater than when the supplement was fed every day. Apparent digestibilities of supplemental nitrogen and energy appear to be inversely related for the non-protein nitrogen supplements. No observation could be made for the control ration because of the negative energy balance for the steer fed every other day. Digestibilities of ether extract and crude fiber for the supplements were not compared because negative balances occurred.

Negative nitrogen balances were observed in steers fed all rations (Table IX). Nitrogen retention was greater for steers when the basal ration was supplemented daily with any of the three protein supplements than for steers fed only the basal ration. Steers fed the urea or biuret supplements every day had greater nitrogen retention than when the same steers were fed the supplements every other day.

TABLE IX. AVERAGE DAILY FEED INTAKE, AVERAGE DAILY NITROGEN INTAKE, AVERAGE DAILY NITROGEN EXCRETION, AVERAGE DAILY NITROGEN RETENTION, AVERAGE ENERGY INTAKE, AVERAGE DAILY ENERGY EXCRETION AND AVERAGE DAILY ENERGY RETAINED BY STEERS FED SOYBEAN MEAL, BIURET AND UREA SUPPLEMENTS EVERY DAY (ED) AND EVERY OTHER DAY (EOD).

Trial II

Steer No.	Supplement No.	Source Supplemental Nitrogen	Feeding Interval	Average Daily Feed Intake		Daily Intake		Daily Excretion		Daily Retention	
				Feed/W ^{0.75}	kg Supplement	Nitrogen	Energy	Nitrogen	Energy	Nitrogen	Energy
				gm	gm	mg	kcal	gm	kcal	gm	kcal
97	Basal	----	ED	----	4120	18.8	5789	28.5	2874	- 9.7	2915
	608	Soybean	ED	908	3620	25.6	6155	30.9	2769	- 5.3	3386
	608	meal	EOD	923	3690	27.6	6565	33.3	2875	- 5.7	3690
92	Basal	----	ED	----	3790	19.2	5944	32.4	2997	-13.0	2947
	609	Biuret	ED	864	3456	28.6	6770	34.2	2881	- 5.6	3889
	609		EOD	865	3459	28.6	6740	36.2	3189	- 7.6	3551
94	Basal	----	ED	----	4200	18.5	5753	25.5	2581	- 7.0	3172
	610	Urea	ED	956	3824	28.9	7052	34.0	2936	- 5.1	4116
	610		EOD	958	3833	27.0	6579	32.9	2938	- 5.9	3641

TABLE X. APPARENT DIGESTIBILITIES OF RATIONS FED STEERS WHEN SOYBEAN MEAL, BIURET AND UREA SUPPLEMENTS WERE FED WITH GRASS HAY (BASAL RATION) EVERY DAY (ED) OR EVERY OTHER DAY (EOD). Trial II

Steer No.	Supplement No.	Source of Supplemental Nitrogen	Feeding Interval	Apparent Digestibilities of Total Ration				
				Nitrogen %	Ether Extract %	Crude Fiber %	Nitrogen Free %	Energy %
97	Basal 608	----	ED	45.9	20.5	57.1	63.3	52.9
	608	Soybean meal	ED	57.4	49.9	55.8	62.2	59.4
			EOD	58.5	40.8	56.5	69.9	59.5
92	Basal 609	----	ED	45.1	0.57	60.4	66.1	52.1
	609	Biuret	ED	60.5	50.8	56.9	70.0	59.5
			EOD	58.1	37.9	54.1	68.9	56.9
94	Basal 610	----	ED	49.4	22.4	59.0	64.8	58.7
	610	Urea	ED	60.6	60.4	57.3	64.9	62.0
			EOD	55.2	50.6	60.8	68.9	58.6

TABLE XI. APPARENT DIGESTIBILITIES OF SUPPLEMENTS CONTAINING SOYBEAN MEAL, BIURET OR UREA FED TO STEERS EVERY DAY (ED) AND EVERY OTHER DAY (EOD) AND CALCULATED BY DIFFERENCE. Trial II

Steer No.	Supplement No.	Source of Nitrogen	Feeding Interval	Nitrogen %	Ether Extract %	Crude Fiber %	Nitrogen-free Extract %	Energy %
97	608	Soybean meal	ED	90.3	---- ^a	---- ^a	76.3	60.9
	608		EOD	91.7	----	----	----	----
92	609	Biuret	ED	94.3	----	66.4	95.6	42.0
	609		EOD	87.9	----	----	91.5	96.7
94	610	Urea	ED	86.2	----	69.6	77.0	40.9
	610		EOD	73.0	----	----	93.7	74.4

^a Indicates negative differences were found and therefore no values were calculated.

A relationship between nitrogen retention and gross energy retention was observed for steers fed urea and biuret supplemented rations. As nitrogen retention increased, energy retention increased. The steer fed the control ration showed a decrease in energy retention as nitrogen retention increased.

When supplemental nitrogen retention was viewed as a percentage of the basal ration, the steer fed the biuret supplement retained 9 percent more nitrogen on the average than the steer fed the control supplement and 31 percent more nitrogen retained than the steer fed the urea supplement (Table XII). The energy retention of steers fed the same supplements followed a similar pattern to the nitrogen retention. The steer fed the biuret supplement retained an average of about 4 percent more energy than did the steers fed either the control

TABLE XII. PERCENT RETAINED NITROGEN AND RETAINED ENERGY OF SOYBEAN MEAL, BIURET AND UREA SUPPLEMENTS FED TO STEERS WHEN COMPARED TO THE BASAL DIET FED EVERY DAY (ED) VS EVERY OTHER DAY (EOD). Trial II

Steer No.	Supplement No.	Source of Nitrogen	Feeding Interval	Daily Intake				Daily Retention			
				% Basal Nitrogen	% Supplemental Nitrogen	% Basal Energy	% Supplemental Energy	% Basal Nitrogen	% Supplemental Nitrogen	% Basal Energy	% Supplemental Energy
97	608	Soybean meal	ED	36		6		45	7	16	
	608		EOD	47	6	13	7	43		27	9
92	609	Biuret	ED	49		14	1	57	26	32	10
	609		EOD	49	0	13		49		20	
94	610	Urea	ED	56	7	23	7	27	14	30	31
	610		EOD	46		14		16		15	

or urea supplements. All steers showed greater nitrogen retention when fed every day as compared to every other day. This nitrogen retention varied from 0.4 g per 100 kg body weight per day for the control steers to 20.0 g nitrogen per 100 kg body weight per day for the biuret supplemented steer. The urea supplemented steer showed a difference in nitrogen retention of 0.8 g per kg body weight per day in favor of every day feeding. The nitrogen retention differences were 7, 26, and 14 percent greater in favor of every day feeding for the control biuret and urea supplements, respectively.

Energy retention of the steer fed the control supplement was 9 percent greater when the supplement was fed every day versus every other day. The steers fed the biuret and urea supplements, however, showed differences in energy retention of 10 and 31 percent, respectively, in favor of every day feeding.

The overall trend of Trial II favored feeding non-protein nitrogen supplements to steers every day rather than every other day for best utilization of nitrogen and energy of the ration. The steers fed the biuret or urea supplements appeared to retain nitrogen and energy nearly as well as the steer fed the control supplement when fed supplement every day. This trend favoring more frequent feeding of non-protein nitrogen supplements, would be in agreement with the findings of Dinning et al. (1949). Increased nitrogen utilization in conjunction with increased energy retention of the non-protein nitrogen

rations was similar to results reported by Conrad (1968), who stated that nitrogen utilization was a linear function of digestibility of energy.

Trial III - Nitrogen Source, Energy Level - Metabolism Study

Data taken from the results obtained from the digestion study with steers on a low and high energy wintering ration are presented in Tables XIII and XIV.

This trial was designed to feed 100 and 125 percent of NRC requirements for energy; however, steers refused to eat rations formulated with high levels of corn starch or corn oil which were used to control energy levels. All rations were reformulated to suit the palatability of the steers when they were fed the high energy level rations. The low energy ration was formulated to contain the least amount of energy possible using the same ingredients as were used in the high energy ration. Low and high energy rations were approximately 90 and 110 percent of the NRC requirements, respectively.

Apparent digestibilities of ether extract, nitrogen-free extract, and gross energy of rations fed to steers showed increases of 7.6, 4.4, and 3.2 percentage units, respectively for the soybean meal ration, the one-sixth crude protein equivalent (CPE) ration and the one-third CPE ration when varied from low energy rations to high energy rations (Table XV). This marked increase was observed for rations of all nitrogen sources. Apparent digestibility of ether extract increased more (8 percent) for the one-sixth crude protein equivalent (CPE) from urea ration than for either the soybean meal ration or the one-third CPE from urea ration. The steer fed the soybean meal (control) ration

showed an increase of 6.3 percent for apparent digestibility of ether extract, while the steer fed the one-third CPE from urea ration showed an increase of 8.0 percent for apparent digestibility of ether extract.

Steers fed the soybean meal ration, the one-sixth CPE ration and the one-third CPE from urea ration showed increases of 5.8, 2.9, and 4.9 percent, respectively, for NFE when the energy level was increased.

Apparent digestibility of energy for all rations fed to steers increased when the energy consumption increased. The steers fed soybean meal and one-sixth CPE from urea rations had increased digestibilities of energy of 2.5 and 2.6 percent, while the steers fed one-third CPE from urea showed an increase of 4.9 percent for apparent digestibility of energy.

The apparent digestibility of crude fiber of all rations fed to steers decreased slightly when the energy of the rations was increased. This data is in agreement with research reported by Mitchell and Hamilton (1932), Hamilton (1942) and Faichney (1965); who state that addition of readily available carbohydrates to a ration reduces apparent digestibility of crude fiber.

Nitrogen apparent digestibility decreased greatly for the soybean meal ration and the one-third CPE from urea ration as energy was increased. Apparent digestibility of nitrogen decreased 6.4 percent for the steer on the soybean meal ration and 3.2 percent for the steer fed the one-third CPE from urea ration when energy increased. The apparent

digestibility of nitrogen for the steers fed one-sixth CPE from urea did not change significantly when the energy level increased.

Nitrogen retention for the steer fed the soybean meal ration increased 5 percent when the energy level was increased even though total nitrogen intake decreased 5.8 percent. The steer fed the one-sixth CPE from urea ration had increased nitrogen retention of 0.6 g per 100 kg weight per day or, in other words, an increase of 3.6 percent as energy increased. This steer had a net nitrogen intake decrease from the low energy ration to the high energy ration of 4.4 percent. A negative nitrogen retention was shown for the steer fed the one-third CPE from urea ration when the energy level was increased. Nitrogen retention decreased 10.1 percent while nitrogen intake decreased 10.8 percent. Although the steer fed the one-third CPE from urea ration showed a decrease in nitrogen retention as energy increased, he also showed greater nitrogen retention per gram nitrogen intake on the high energy ration than the other steers on all other rations.

Lofgreen et al. (1951) found similar results in their work with dairy calves; as energy increased, nitrogen retention increased with rations containing moderate levels of protein. Fontenot et al. (1965) indicated that nitrogen retention was appreciably increased as carbohydrates were increased in urea based rations. Steers fed the soybean meal ration and the one-sixth CPE from urea ration showed increases

in nitrogen retention of about 1 g per 100 kg body weight as the energy level of the ration was raised.

Energy retention of steers fed all rations increased as energy intake increased. For each one percent increase in energy intake, the steers fed all rations showed an increase of nearly 2 percent in energy retention.

The results of this trial indicate that one-sixth or one-third of the equivalent crude protein of a 20 percent protein supplement may be supplied by urea. These supplements may be fed with straw as a source of roughage if ample readily available energy is present in the ration to insure maximum utilization of the non-protein nitrogen.

Proximate analysis of rations fed in Trial III are shown in Table XVI.

TABLE XIII. AVERAGE DAILY INTAKE, AVERAGE DAILY NITROGEN INTAKE, AVERAGE DAILY ENERGY INTAKE, AVERAGE DAILY NITROGEN EXCRETION, AVERAGE DAILY ENERGY EXCRETION, AVERAGE DAILY NITROGEN RETENTION, AVERAGE DAILY ENERGY RETENTION FOR STEERS FED SOYBEAN MEAL OR UREA RATIONS AT LOW OR HIGH ENERGY LEVELS. Trial III.

Steer No.	Supplement	Energy Level	Supplement	Av. Daily Intake			Av. Daily Excretion		Av. Daily Retention	
				Basal	Nitrogen	Energy	Nitrogen	Energy	Nitrogen	Energy
				/100 kg	/100 kg	/100 kg	/100 kg	/100 kg	/100 kg	/100 kg
				Weight	Weight	Weight	Weight	Weight	Weight	Weight
				g	g	kcal	g	kcal	g	kcal
97	Soybean meal	Low	1804	3367	48.5	8978	28.5	4099	20.0	4879
		High	2141	3211	45.7	9388	24.7	4067	21.0	5321
92	1/6 CPE from Urea	Low	1806	3290	49.3	9163	32.5	4253	16.8	4910
		High	2155	3020	47.6	9780	30.2	4215	17.4	5565
94	1/3 CPE from Urea	Low	1808	3134	47.4	8362	25.5	4024	21.9	4338
		High	2150	3229	42.3	9686	22.6	4122	19.7	5564

TABLE XIV. APPARENT DIGESTIBILITIES OF SOYBEAN MEAL AND UREA RATIIONS CONTAINING LOW AND HIGH ENERGY FED TO STEERS. Trial III

Steer No.	Supple-ment	Energy Level	Apparent Digestibilities				
			Nitrogen	Ether Extract	Crude Fiber	Nitrogen-free Extract	Energy
			%	%	%	%	%
97	Soybean meal	Low	77.1	72.3	50.3	66.4	57.6
		High	70.7	78.6	49.6	72.2	60.2
92	1/6 CPE from Urea	Low	76.6	74.3	49.0	67.1	57.6
		High	76.3	83.0	44.9	70.0	60.1
94	1/3 CPE from Urea	Low	77.0	72.2	44.3	64.2	54.6
		High	73.8	80.2	43.4	69.1	59.5

TABLE XV. PERCENT HIGH ENERGY RATION VARIED FROM LOW ENERGY RATION FOR NITROGEN INTAKE, ENERGY INTAKE, NITROGEN RETENTION AND ENERGY RETENTION FOR STEERS FED SOYBEAN OR UREA RATIIONS CONTAINING LOW OR HIGH ENERGY LEVELS. Trial III

Steer No.	Supple-ment	Energy Level	Daily Intake		Daily Retention	
			Nitrogen	Energy	Nitrogen	Energy
			%	%	%	%
97	Soybean meal	Low				
		High	- 5.8 ^a	4.6	5.0	9.1
92	1/6 CPE ^b from Urea	Low				
		High	- 4.4	6.7	3.6	13.3
94	1/3 CPE from Urea	Low				
		High	-10.8	15.8	-10.1	28.3

^a Negative figures indicate that the high energy rations gave values that were less than those for the low energy rations.

^b Crude protein equivalent.

TABLE XVI. PROXIMATE ANALYSIS OF RATIONS FED TO STEERS ON WINTERING RATIONS. Trial III

Supple- ment	Energy Levels	Proximate Analysis ^a					Crude Fiber	Gross Energy kcal/kg
		Moisture %	Protein %	Ether Extract %	Ash %	Fiber %		
Soybean meal	Low	9.8	26.8	3.2	5.0	4.0	4134	
	High	8.9	21.2	7.4	3.9	2.6	4415	
1/6 CPE from Urea	Low	9.7	26.8	3.3	5.1	3.8	4138	
	High	8.3	21.3	7.9	3.7	2.8	4275	
1/3 CPE from Urea	Low	9.6	27.3	3.9	4.8	4.0	4143	
	High	8.5	20.3	7.4	3.5	2.6	4734	
Basal (straw)		11.5	3.8	2.1	7.4	35.2	3115	

^a Analysis done by Chemistry Station, Montana State University.

SUMMARY

The effect of feeding steers a wintering ration of a 20 percent crude protein equivalent supplement every day, or every other day was studied. One-third of the crude protein equivalent of two of the supplements was supplied by biuret or urea. The third supplement, the control, contained soybean meal. Weight gains, feed intake, and feed efficiency were used to assess the value of every day versus every other day feeding of the protein supplements.

In Trial I, 36 steer calves were fed a wintering ration for 126 days. The steers were fed grass hay plus an averaged of 0.91 kg supplement per head per day. Weight gains were 0.67, 0.62, 0.63, 0.60, 0.58 and 0.57 kg per day, respectively, for steers fed the soybean meal supplement every day and every other day, the biuret supplement every day and every other day, and the urea supplement every day and every other day for the 126 day trial. Analysis of data showed that no statistical differences in weight gain, feed consumption or feed efficiency of the steers occurred among the sources of nitrogen in the supplement when fed every day or every other day for 98 days or 126 days. The trend, however, favored feeding steers the soybean meal, biuret and urea supplements, in that respective order, on an every day basis versus every other day feeding.

Trial II utilized three steers in metabolism stalls to study nitrogen and energy balances of steers fed the same rations as the steers in Trial I. Apparent digestibilities for the supplements fed

steers were also calculated.

Apparent digestibility of nitrogen was greater for non-protein nitrogen supplements when the steers were fed every day as opposed to every other day. Energy digestibilities were higher when the non-protein nitrogen supplements were fed every other day rather than every day. Negative nitrogen balances were shown for all rations by all steers. However, steers fed the biuret and urea supplements retained more nitrogen when they were fed every day rather than every other day. Nitrogen retention of steers fed the non-protein nitrogen supplements increased as energy retention increased.

The trend of Trial II seems to be in favor of feeding the biuret and urea supplements every day rather than every other day for best utilization of the nitrogen and energy of the rations. Steers fed biuret and urea based supplements retained nitrogen as well as the steers fed the soybean meal supplement when the supplements were fed every day.

In Trial III, steers were fed a ration containing low and high energy with soybean meal, one-sixth crude protein equivalent from urea, and one-third crude protein equivalent from urea as nitrogen sources. The apparent digestibility of nitrogen decreased for steers on the soybean meal ration and the one-third CPE from urea ration as energy increased. Apparent digestibility of nitrogen, for the steer fed the one-sixth CPE from urea ration, did not change significantly

when the energy levels of the ration was increased. Apparent digestibilities of energy for steers fed all rations increased as energy consumption increased. These increases in the values ranged from 2.5 to 4.9 percent from the soybean meal control ration to the one-third CPE from urea ration.

Negative nitrogen retentions were shown for three steers fed all rations. However, nitrogen retention for all steers increased as energy was increased from the low energy level to high energy level for all three rations. The steer fed the one-third CPE from urea ration retained most nitrogen per g nitrogen intake per 100 kg weight when compared to steers fed both energy levels of the soybean meal rations, one-sixth CPE from urea ration and the low energy one-third CPE from urea ration. Energy retention for steers fed all rations increased as energy consumption increased.

The results of this trial indicated that one-sixth and one-third CPE from urea of a 20 percent protein supplement may be fed with straw to steers with as good a result as soybean meal. The data indicated that better utilization of nitrogen and energy occur if ample energy is supplied to the ration in the form of readily available carbohydrates.

APPENDIX

APPENDIX TABLE I. WEIGHT GAINS AND FEED CONSUMPTION OF STEERS FED SUPPLEMENTS WITH OR WITHOUT NON-PROTEIN NITROGEN AND FED EVERY DAY (ED) OR EVERY OTHER DAY (EOD) January 20, 1970 to April 28, 1970 - 98 days.

Lot No.	5	18	23	17	11	6
MSU Formula No.	608		609		610	
	Soybean Meal		Biuret		Urea	
Feeding Interval	ED	EOD	ED	EOD	ED	EOD
No. steers	6	6	6	6	6	6
Av. weights, lbs.						
Initial	496	501	503	497	494	508
Final	638	638	631	630	616	623
Gain	142	135	128	133	122	115
Daily gain	1.45	1.38	1.31	1.36	1.25	1.18
Av. daily ration, lbs.						
Supplement, 20% protein	2.00	2.00 ^a	2.00	2.00 ^a	2.00	2.00 ^a
Hay	12.65	12.65	12.65	12.65	12.65	12.65
Salt	0.07	0.07	0.07	0.07	0.07	0.07
Av. daily feed, lbs.	14.72	14.72	14.72	14.72	14.72	14.72
Feed/cwt. gain, lbs.	1014.2	1068.5	1131.2	1084.6	1179.1	1252.6
Feed cost/cwt gain ^b (\$)	18.65	19.64	20.02	19.19	20.81	22.22

^a These figures are reported on an average daily feed consumption. This level was actually fed at twice the quantity on alternate days.

^b Feed prices: MSU No. 608, \$80.15/ton; MSU No. 609, \$70.07/ton; MSU No. 610, \$70.64/ton; Hay \$30.00/ton; Salt, \$25.00/ton.

APPENDIX TABLE II. WEIGHT GAINS AND FEED CONSUMPTION OF STEERS FED SUPPLEMENTS WITH OR WITHOUT NON-PROTEIN NITROGEN AND FED EVERY DAY (ED) OR EVERY OTHER DAY (EOD) January 20, 1970 to May 26, 1970 - 126 days.

Lot No.	5	18	23	17	11	6
MSU Formula No.	608		609		610	
	Soybean Meal		Biuret		Urea	
Feeding Interval	ED	EOD	ED	EOD	ED	EOD
No. steers	6	6	6	6	6	6
Av. weights, lbs.						
Initial	496	501	503	497	494	508
Final	682	674	678	663	655	665
Gain	186	173	175	166	161	157
Daily gain	1.48	1.37	1.39	1.32	1.28	1.25
Av. daily ration, lbs.						
Supplement 20% protein	2.00	2.00 ^a	2.00	2.00 ^a	2.00	2.00 ^a
Hay	13.06	13.06	13.06	13.06	13.06	13.06
Salt	0.07	0.07	0.07	0.07	0.07	0.07
Av. daily feed, lbs.	15.13	15.13	15.13	15.13	15.13	15.13
Feed/cwt. gain, lbs.	1024.4	1102.0	1089.4	1148.4	1184.1	1214.3
Feed cost/cwt. gain (\$)	18.76	20.17	19.22	20.27	20.93	21.46

^a These figures reported on an average daily feed consumption. This level was actually fed at twice the quantity on alternate days.

^b Feed prices: MSU No. 608, \$80.15/ton; MSU No. 609, \$70.07/ton; MSU No. 610, \$70.64/ton; Hay, \$30.00/ton; Salt, \$25.00/ton.

APPENDIX TABLE III. AVERAGE DAILY GAIN OF STEERS FED SOYBEAN MEAL, BIURET AND UREA SUPPLEMENTS EVERY DAY (ED) AND EVERY OTHER DAY (EOD) GIVEN BY WEIGH PERIOD. Trial 1, January 20, 1970 to May 26, 1970 - 126 days.

Lot No.	Days on Test	Control		Biuret		Urea	
		ED	EOD	ED	EOD	ED	EOD
		1bs	1bs	1bs	1bs	1bs	1bs
12/23/69 ^a							
1/20/70 ^b		0.96	0.95	1.19	1.32	0.89	1.30
2/17/70 ^c	28	2.17	2.12	2.00	2.07	2.16	1.33
3/17/70	56	1.61	1.16	1.25	1.28	1.16	1.49
4/14/70	84	0.48	0.60	0.43	0.35	0.17	0.36
4/28/70	98	1.65	1.89	1.75	2.12	1.75	1.81
5/12/70	112	1.80	1.56	1.78	1.69	1.42	1.82
5/26/70	128	1.33	1.20	1.60	0.63	1.33	1.19

^a Began feeding respective supplement for adaptation period.

^b Weighed on test.

^c All weights taken on an overnight shrink off water except those taken on 2/17/70 and 3/17/70.

APPENDIX TABLE IV. INITIAL AND FINAL WEIGHTS OF INDIVIDUAL STEERS FED SOYBEAN MEAL, BIURET, AND UREA SUPPLEMENTS EVERY DAY (ED) AND EVERY OTHER DAY (EOD).
 Trial I. January 20, 1970 to April 28, 1970 - 98 days and January 20, 1970 to May 26, 1970 - 126 days.

Steer No.	Weight (lbs.)			Steer No.	Weight (lbs.)		
	Initial	Final 98-Day	Final 126-Day		Initial	Final 98-Day	Final 126-Day

Supplement 608, Soybean meal

<u>Lot 5 - Fed Every Day</u>				<u>Lot 18 - Fed Every Other Day</u>			
141	498	627	680	67	483	604	644
159	497	628	670	160	510	627	677
161	498	646	688	163	498	592	626
168	484	608	642	86	487	629	663
100	500	637	679	33	510	629	741
201	499	683	733	972	516	670	695

Supplement 609, Biuret

<u>Lot 23 - Fed Every Day</u>				<u>Lot 17 - Fed Every Other Day</u>			
84	516	651	704	88	488	621	648
85	507	630	680	156	543	711	752
89	530	652	717	158	452	544	587
152	483	603	646	162	523	640	660
946	492	643	683	164	516	665	693
731	491	605	637	87	469	600	635

Supplement 610, Urea

<u>Lot 11 - Fed Every Day</u>				<u>Lot 6 - Fed Every Other Day</u>			
82	478	573	621	151	474	598	641
165	450	547	588	153	539	691	732
166	512	654	682	154	510	572	608
167	495	622	659	155	505	621	660
918	563	709	752	157	481	587	623
57	464	591	625	943	538	669	727

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