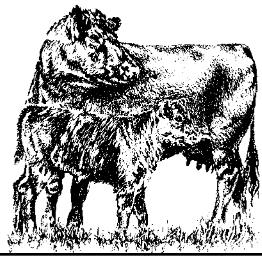

Western Beef Resource Committee *Fourth Edition*

Cattle Producer's Handbook

Nutrition Section 322

Urea in Range Cattle Supplements

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Rangeland beef production systems require cattle to harvest energy from range forages and convert that energy into a marketable beef product. As range forages mature, they become lower in nutritive value. When the forage protein content in cattle diets declines to less than about 7 percent, both forage intake and digestion are suppressed, and animal performance is reduced. Beef producers may provide supplemental protein to mediate deficiencies in the forage, so that forage intake and use are optimized.

According to the Standardized Performance Analysis summary for New Mexico cow-calf operations from 1991 to 2001, supplemental feed for grazing beef cows averages about $60 per cow each year, representing a substantial variable cost. Stocker cattle grazing dormant winter range usually are provided a protein supplement as well. The primary protein sources in these supplements are plant proteins, such as cottonseed meal and soybean meal.

Cattle producers may possibly reduce the cost of range supplements by replacing a portion of the plant protein with urea or other nonprotein nitrogen (NPN) sources. However, excessive NPN levels in the diet can impair animal performance, so NPN should be incorporated in moderation into range cattle supplements.

The objective of this fact sheet is to discuss the inclusion of urea and other NPN sources in protein supplements fed to grazing beef cattle. The paper also provides general recommendations regarding the level of NPN supplementation and the frequency of NPN-containing supplement delivery.

Nonprotein Nitrogen: How It Works

Beef cattle and other ruminant animals rely on ruminal microorganisms to break down fiber in forages into useful end products. These microorganisms require energy, protein, and other nutrients to grow and function properly. In addition to digesting forage, microorganisms use nitrogen from the animal's diet to produce protein. This microbial protein eventually flows out of the rumen to the small intestine where it can be absorbed and used by the animal as true protein.

The nitrogen used by the microbes to produce protein does not have to come from true protein; it can come from many nitrogen-containing compounds. For many types of microbes, especially those that digest fiber, ammonia is the preferred form of nitrogen. This ammonia may come from digesting true protein or from other ingredients that release ammonia in the rumen.

When cattle consume low-quality forages, nitrogen in the form of ammonia often is in limited supply. If the protein content of the forage diet is less than 7 percent, it is likely that the ammonia supply is inadequate for maximum microbial function. Protein supplements are fed to improve ammonia supply. Ammonia can come from "natural" protein sources, such as cottonseed meal and soybean meal, or from NPN sources that are converted to ammonia in the rumen.

The microbial need for ammonia is related to the amount of energy available from the diet. In order for ruminal microbes to effectively use ammonia, adequate energy must be available. Therefore, if the energy content of the diet is low, then ruminal ammonia requirements are low. If the ammonia concentration in the rumen exceeds the amount of energy available, microbes cannot use it efficiently, and the excess ammonia is absorbed across the rumen wall into the blood stream and transported to the liver.

Free ammonia in the blood is detoxified in the liver by converting it into urea and then excreting it in urine. If ammonia is absorbed from the rumen too rapidly and exceeds the liver's detoxification capacity, it passes into the main blood system and can cause death. The potential to oversupply ammonia is the chief concern when using

NPN sources to supplement diets low in energy, such as dormant range forage.

Despite this potential for toxicity, NPN sources almost always are less expensive per unit of nitrogen than plant protein sources. Crude protein is one way to express nitrogen content. A feed testing laboratory will analyze feeds for nitrogen content and then multiply that value by protein's average nitrogen content to estimate crude protein (e.g., total nitrogen x 6.25 = crude protein content).

Urea (a common form of NPN) contains the equivalent of 291 percent crude protein. This extremely high concentration makes urea and other NPN sources relatively inexpensive per unit of nitrogen.

NPN Sources in Range Supplements

Urea—Urea is the most commonly used NPN source in range supplements due to availability and low cost. Urea can be incorporated easily into dry and liquid feeds, and it dissolves rapidly in water. Because urea consumed by cattle is readily water soluble, it is rapidly broken down in the rumen by microorganisms to form ammonia. Ammonia can be easily provided by urea at a relatively low cost.

Urea is broken down rapidly, and dormant forages are digested slowly. Therefore, there has been some concern that the rapidly released ammonia supplied by urea will exceed its potential use by the microorganisms in the rumen of cattle grazing low-quality, slowly digested forages. This potential asynchrony may lead to large amounts of ammonia entering the bloodstream and has generated interest in other NPN forms and sources that may release ammonia more slowly than urea.

Slow-Release NPN—The rate of ammonia release from NPN sources can be influenced both by the physical form of the NPN-containing feed and the specific ammonia-releasing molecule. In recent years, several products have been developed in which urea is bound in a slow-release complex. It is common among products of this nature to combine urea with starch from grain or with molasses through treatment with heat and chemicals. These products are designed to decrease the rate at which ammonia is released from urea in the rumen in an attempt to improve the synchrony of nitrogen availability in the rumen with digestible energy from forages. These products should lessen the danger of ammonia toxicity.

Biuret is an NPN-containing molecule (two urea molecules bound together) that releases ammonia in the rumen at a slower rate than urea, which minimizes the possibility of ammonia toxicity. The slower release of ammonia also improves the synchronization of nitrogen availability with the slow release of fermentable energy from forages and, potentially, yields more efficient microbial growth in the rumen. Unlike urea, an adaptation period is required for ruminants to use biuret at maximum efficiency.

Although theoretically attractive, there is conflicting evidence regarding the importance of synchronized nitrogen and energy release for effective low-quality forage use. In short, the added cost of incorporating biuret or other slow-release forms of urea into range supplements, coupled with inconsistent research findings about the added benefit of slow-release nitrogen sources, limits the appeal of incorporating these products into range supplements.

NPN Level Included in Range Supplements

Since NPN sources generally are less expensive per unit of nitrogen than true protein sources, substituting NPN for true protein can lower the cost of protein supplements. However, animal performance must meet expectations to capitalize on this savings. Excess NPN concentration may reduce animal performance because of poor palatability (cattle refuse to eat some or all of the supplement), wasted ammonia, or ammonia toxicity. Optimizing NPN concentration is, therefore, a key to successfully using these ingredients. This section will summarize research findings to help cattle producers establish an optimum NPN level to include in range supplements fed to cattle consuming low-quality forage.

Dietary crude protein can be categorized into two parts: (1) that which is degraded in the rumen by microorganisms (ruminally degradable protein) and (2) that which escapes the rumen without being altered by the microbes (ruminally undegradable protein/escape protein). High protein feedstuffs of plant origin, such as cottonseed meal and soybean meal, generally contain 55 to 70 percent ruminally degradable protein, with the remaining 30 to 45 percent of the crude protein being escape protein.

In situations where there is an adequate amount of low-quality forage available and the objective is to stimulate or sustain forage intake, meeting ruminally degradable protein requirements should be the first priority. This provides ruminal microbes with adequate nitrogen, which increases forage digestion and use.

NPN is completely degraded in the rumen and only supplies ruminally degradable protein. The most appropriate way to determine the optimal amount of NPN in a protein supplement is to evaluate the proportion of the total ruminally degradable protein urea supplies.

Cow Supplements

Many experiments have been conducted to evaluate the effect of increasing NPN levels in protein supplements on cow performance. In several experiments, gestating beef cows showed differences in body condition change when consuming low-quality forage and fed supplements with different NPN amounts (Fig. 1). NPN levels are expressed as proportions of the ruminally degradable protein in the supplement and are compared to body condition changes of gestating cows supplemented with

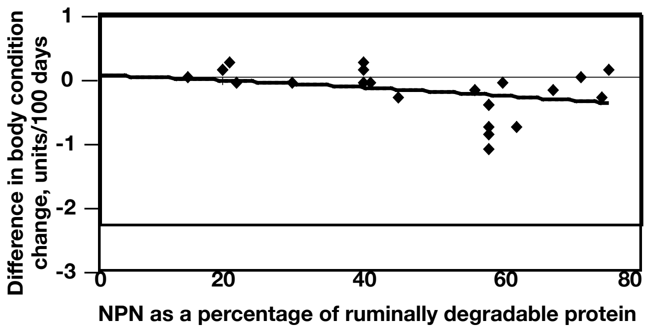

Fig. 1. Relative difference in body condition change between cows fed supplements with the same crude protein content but differing NPN levels.

the same amount of crude protein in a 100 percent true (“natural” = 0 in Fig. 1) protein supplement.

Body condition change describes how the cows responded to the supplements over time. A positive change indicates that cows improved in condition, while a negative change shows that cows lost body condition.

Interestingly, when NPN constituted 40 percent or less of the ruminally degradable protein in the supplement (e.g., not more than about 10 percent equivalent crude protein from NPN in a 38 percent crude protein cottonseed meal-based supplement), replacing ruminally degradable true protein had little effect on body condition change. These findings demonstrate that more costly protein sources can be replaced without affecting body condition, as long as NPN supplies less than 40 percent of the ruminally degradable protein when the supplement is fed daily to gestating cows.

Research from Kansas has indicated that when supplements fed to gestating beef cows contained as much as 60 percent of the ruminally degradable protein as urea (e.g., 14 percent equivalent crude protein from NPN in a 30 percent crude protein supplement), there was limited influence on subsequent calf performance.

When supplementing prepartum cows, a conservative target NPN level is 25 percent of the ruminally degradable protein, which would be approximately 33 pounds of urea per ton in a 28 percent crude protein cottonseed meal-based supplement or 43 pounds of urea per ton in a 38 percent crude protein cottonseed meal-based supplement. The example (Table 1) shows that a relative savings in supplement cost of 8 to 12 percent may be achieved when urea replaces 25 percent of the ruminally degradable protein in 28 and 38 percent crude protein supplements formulated using cottonseed meal, wheat middlings, soybean hulls, molasses, and urea.

It is important to note that limited research is available specifically evaluating NPN inclusion in supplements to beef cows after calving or during the breeding season, so caution should be exercised when formulating NPN-containing supplements for lactating cows. Nevertheless, a conservative target level of NPN in protein supplements to postpartum cows grazing low-quality forage is 15 percent of the ruminally degradable protein.

In Table 1, the 15 percent NPN level is achieved by including urea at 20 and 25 pounds per ton in 28 and 38 percent protein supplements, respectively, to yield cost savings of 5 to 7 percent. This would be about 2.9 and 3.6 percent equivalent crude protein from NPN in the 28 and 38 percent protein supplements, respectively.

Stocker Supplements

Research also has been conducted to evaluate optimal levels of urea in protein supplements fed to growing calves on winter native rangelands in Nebraska. In four experiments, calves were fed 1.5 pounds of a 40 percent protein, soybean meal-based range supplement formulated to contain 0, 25, or 50 percent of the ruminally degradable protein as NPN. The supplement was delivered daily. Average daily gains were .57, .55, and .42 pound per day for each treatment, respectively, over the 112- to 126-day treatment. The researchers noted a marked decline in rate of gain when urea was

Table 1. Example of the savings associated with including urea at 15 or 25 percent of the ruminally degradable protein in 28 and 38 percent crude protein supplements.

Crude protein content		**28%**			**38%**	
NPN[a], % of ruminally degradable protein	**0**	**15**	**25**	**0**	**15**	**25**
Equivalent crude protein from NPN, %	**0**	**2.9**	**4.8**	**0**	**3.6**	**6.3**
Cottonseed meal, lb	1,000	850	700	1,775	1,500	1,300
Wheat middlings, lb	500	500	500	125	375	557
Soyhulls, lb	450	580	717	0	0	0
Molasses, lb	50	50	50	100	100	100
Urea, lb	0	20	33	0	25	43
$/ton[b]	**$143**	**$138**	**$131**	**$185**	**$172**	**$163**
Savings from NPN Inclusion		**5%**	**8%**		**7%**	**12%**

[a]NPN = nonprotein nitrogen.
[b]Cottonseed meal at $180/ton; wheat middlings at $70/ton; soybean hulls at $80/ton, molasses at $125/ton, urea at $250/ton; all formulations include $15/ton for processing and are calculated without including freight.

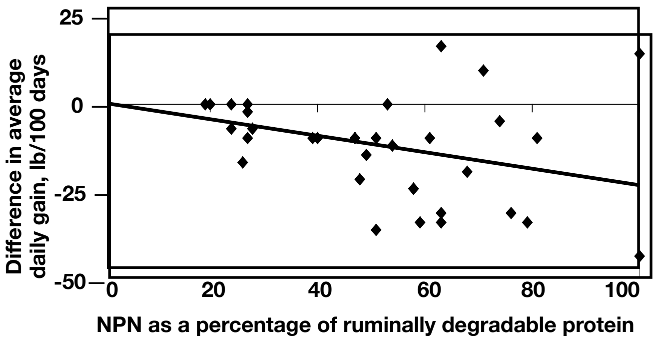

Fig. 2. Relative difference in average daily gain for growing cattle fed supplements with the same crude protein content but differing NPN levels.

increased from 3 to 6 percent of the supplement, which was equivalent to increasing NPN concentration from 25 to 50 percent of the ruminally degradable protein in the supplement.

The performance difference between calves fed the supplement with no urea and calves fed the supplement containing 3 percent urea (NPN supplying 25 percent of the ruminally degradable protein) was negligible, totaling only about 2.5 pounds per head over the entire treatment period. These results and those from other trials that evaluated the influence of including NPN in protein supplements on growing animal performance relative to 100 percent true protein supplements are compiled (Fig. 2).

When NPN constitutes more than about 25 percent of the ruminally degradable protein in supplements fed to growing cattle consuming dormant forage, the suppression in performance may offset the cost savings associated with including NPN in the supplement. A conservative target for including NPN in protein supplements fed to stockers grazing low-quality forage is 15 percent of the ruminally degradable protein in the supplement.

Frequency of NPN Supplement Delivery

The frequency at which a protein supplement can be delivered to cattle grazing low-quality forages without causing negative effects on performance has a dramatic influence on labor requirements and the supplement's economic value. Research conducted at New Mexico State University to evaluate delivery frequency of high-protein supplements (41 percent protein) revealed no significant reduction in replacement heifer performance when 10.5 pounds of supplement were fed one time per week vs. 3.5 pounds of the same supplement fed three times per week (3.5 pounds x 3 feedings/week = 10.5 pounds). Also, transportation and labor costs were reduced by about 60 percent with less frequent delivery.

No research is available that evaluates animal performance when protein supplements containing an appreciable amount of NPN are delivered only once per week. However, recent research from Kansas evaluated daily vs. three times per week delivery of 40 percent crude protein supplements with 0, 15, 30, or 45 percent of the ruminally degradable protein supplied by urea. These supplements were fed to prepartum beef cows grazing low-quality tallgrass-prairie forage, such that all cows were fed a total of 28 pounds per week.

Kansas researchers concluded that including urea in a 40 percent protein supplement equivalent to or less than 15 percent of the ruminally degradable protein appears to be compatible with supplementing less frequently than every day. Based on current knowledge, protein supplements with NPN replacing more than 15 percent of the ruminally degradable protein should not be fed less frequently than every day.

Nitrogen to Sulfur Ratio

When NPN replaces true protein in a supplement fewer amino acids are supplied because NPN does not contain amino acids. More specifically, NPN does not provide sulfur that is needed for ruminal microorganisms to synthesize certain amino acids. A nitrogen to sulfur ratio (N:S) of 10:1 has been reported to be adequate for ruminal microorganisms to synthesize these amino acids. This means, in a ton of supplement, 1 pound of sulfur is needed for every 10 pounds of nitrogen.

A 2-year statewide survey by New Mexico State University has shown that native forages generally range from 0.04 to 0.26 percent sulfur, with the majority of samples containing between 0.08 and 0.11 percent sulfur. When native range forage is dormant, we can expect it to be about 5 percent protein and 0.8 percent nitrogen (crude protein is 16 percent nitrogen; 5 percent x 0.16 = 0.008 or 0.8 percent). So, the forage's expected N:S ratio would be 10:1 (0.8:0.08). That means that the grazed forage is in balance so the supplement also should be in balance.

Range supplements that include urea or other NPN sources should contain at least one unit of sulfur for every 10 units of nitrogen. However, if water sources are high in sulfur, the N:S ratio in the supplement is less critical.

Conclusions

Urea and other NPN sources can be used in range supplements and have the potential to reduce the cost of supplementing cattle grazing low-quality forage. However, the concentration of crude protein in the supplement and forage species also may impact the level of supplemental NPN that can be fed while maintaining performance. Slow-release sources and forms of NPN may reduce the potential for ammonia toxicity, but they generally are more expensive than urea.

When formulating NPN-containing range supplements, the target NPN level should be based on the class of cattle (cows vs. stockers), production stage (prepartum vs. postpartum), delivery frequency (daily vs. alternate days or twice weekly), and sulfur content of the water and forage supply.

Recommendations

- A conservative target level for including NPN in protein supplements for gestating cows or stockers grazing low-quality forage is 25 percent of the ruminally degradable protein in the supplement *when fed daily.*
- A conservative target level for including NPN in protein supplements *delivered three times per week or less* to cows or stockers grazing low-quality forage is 15 percent of the ruminally degradable protein in the supplement.
- *Postpartum* protein supplements should be formulated so that NPN supplies not more than 15 percent of the ruminally degradable protein in the supplement.
- Range supplements that include urea or other NPN sources should contain at least one unit of sulfur for every 10 units of nitrogen, unless water sources are high in sulfur.

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