



Cow Calf Technical Bulletin

Feeding Urea - On Purpose

Excerpts from Proceedings of the 2010 AFIA Liquid Feed Symposium

Despite the reservations still found among some producers, and even industry professionals, the liquid feed industry can feel good about feeding urea . . . on purpose. There are multiple reasons for inclusion of urea in a liquid formulation, including:

- Urea efficiently supplies ammonia-N to the rumen, helping meet a critical need of the fiber digesting bacteria;
- Urea is a highly concentrated crude protein source; this allows for low inclusion rates, leaving room in the formula or diet for other ingredients or feedstuffs;
- Urea is typically an economical source of crude protein;
- Liquid feeds offer unique opportunity to optimize utilization of dietary urea.

The nutritional value of urea in ruminant diets is its ability to contribute nitrogen for the formation of microbial cell protein. However, I have seen printed materials claiming that urea is metabolized too quickly in the rumen to be available for microbial protein formation. Luckily, research shows us this is not true. Research done at Oklahoma State University (Kropp et al., 1977) measured microbial nitrogen flow and protein synthesis in beef steers consuming dormant grass hay (3.1%CP) plus enough protein supplementation to take the overall diet to 10% protein. Treatments were soybean meal alone or combined with urea at levels to provide 0, 25, 50, or 75% of the

supplemental N. Microbial N flow did not differ between diets (10.1, 10.8, 9.7, and 10.6 mg/g DM, respectively), and protein synthesis increased with urea level (9.9, 10.4, 10.9, and 11.6 g/100 g DMI). Other studies have shown increases in bacterial N flow with increasing urea levels (Currier et al., 2004b; Köster et al., 1997), as well as improved microbial efficiency (Liang and Kerley, 2010).

When protein supplements are fed in conjunction with low-quality forage, the expectation is for significantly increased intakes of the base diet. Digestibility is often increased as well. The combination of these responses often contributes far more to the total nutrition of the animal than the supplement supplies directly. For urea to be a viable crude protein source in these situations, it is obvious it must trigger the same improvements. In some earlier Australian work (McLennan et al., 1981), crossbred steers given 60, 120 or 240 g of urea supplementation increased their intake of 4.25% CP rice straw an average of 14%. Similarly, wethers receiving a 4% CP fescue straw diet increased their voluntary consumption of forage 19% (Currier et al., 2004). And urea was shown to improve intake of low-quality native grass hay in late-gestation beef cows (Waterman et al., 2007).

In some cases, urea has also improved dry matter intake in feedlot cattle. In a study involving a steam-flaked corn/25% wet corn gluten feed diet, increasing the proportion of supplemental N coming from urea vs cottonseed meal caused a linear increase in DMI (Richeson et al., 2006). A similar trend was seen with steam-flaked corn/silage diets (Wagner et al., 2010). However, in a 90% corn ration (Duff et al., 2001), intakes were similar between treatments receiving soybean meal, urea, or slow-release urea as the supplemental protein source. And in a database of Brazilian research involving corn-based finishing diets, urea supplied in levels ranging from 0 to 2.26% of dry matter intake had no impact on DMI (Chizzotti et al., 2007).



Supplemental DIP also has the potential to improve ruminal, and therefore total tract, digestibility, although this impact is sometimes over-ridden by the decrease in retention time affiliated with increased intakes. In the fescue straw study mentioned above (Currier et al., 2004), urea supplementation increased utilization of dry matter, organic matter, NDF, and ADF in wethers. And in a companion paper (Currier et al., 2004b), similar NPN treatments improved total tract nitrogen digestibility in beef steers. When beef steer calves were fed a ground rice straw and molasses diet (White et al., 1973), supplementation with 1, 2, or 4% urea increased DMD from 44.7 to 47.7%, and crude fiber digestion from 47.2 to 56%. Urea also increased diet digestibility in beef cows (Waterman et al., 2007; Forero et al., 1980), sheep (Tudor and Morris, 1971), and in vitro (Liang and Kerley, 2010; Dixon, 1999). However, research done in steers receiving oat hay-based diets with 0 or 4% supplemental urea (Dixon, 1999) clearly showed that the magnitude of this response varies with forage type. In this study, 16 different roughages were placed in nylon bags and incubated in the rumen, then disappearance was measured. They found that in the samples placed in animals that did not receive urea, apparent digestibility was reduced 76-87% for straws, 40-80% for grass hay, and 23-40% for legume hay.

For these responses to have value, they obviously need to be reflected in improved performance or efficiency. When late-gestation beef cows were supplied with 90% of their DIP requirement as NPN (Currier et al., 2004), they gained more weight pre-, and lost less weight post-, calving. The net result was an increase, vs. a decrease, in BCS over the course of the trial. Urea supplementation of beef steers receiving a low-quality diet reduced average daily weight loss from 0.33 lb/hd to less than 0.2 lb (McLennan et al., 1981). A related question is whether urea supports production responses as effectively as amino acid protein. In dairy replacement heifers, receiving 65 or 75% forage diets supplemented with soybean meal or NPN (Kononoff et al., 2006), there were no differences in daily gain, feed:gain, frame measurements or PUN due to supplemental protein source. Stocker calves grazing late season bermudagrass (Phillips and Horn, 1990) had equivalent gains with a plant protein supplement and NPN-containing molasses blocks and liquid feed. Body weight, BCS, and pregnancy rates were not affected by substitution of cottonseed meal for urea in supplements provided to Brangus cows (Cooke and Arthington, 2008). And in a database analysis involving DHIA records of more than 85,000 Michigan dairy cows (Ryder et al., 1971), feeding urea had no impact on reproductive efficiency, including calving interval and number of open cows.

On the other hand, the literature does include some less favorable results involving NPN supplementation. Cattle find urea unpalatable, and it can be difficult to get research animals to consume treatment levels when it is fed without other ingredients to mask the taste. In a trial involving lactating Hereford cows on dormant range (Forero et al., 1980), protein supplements varying in CP concentration and source were responsible for significant increases in forage intake and digestibility, and improvements in reproduction and body condition. The authors reported less weight loss and greater BCS for cows receiving a 40% all-natural CP supplement vs. one with 25% crude protein equivalents from urea, but the animals on the urea treatment only took in 59% of the supplement allocated to them. Similarly, Kropp and co-workers (1977) reported that DMD and OMD were not supported as effectively when urea substituted for 50 or 75% of supplemental N being provided solely by soybean meal in the control group. However, cattle in these two treatment groups were actually fed diets that were inadvertently lower in total protein.

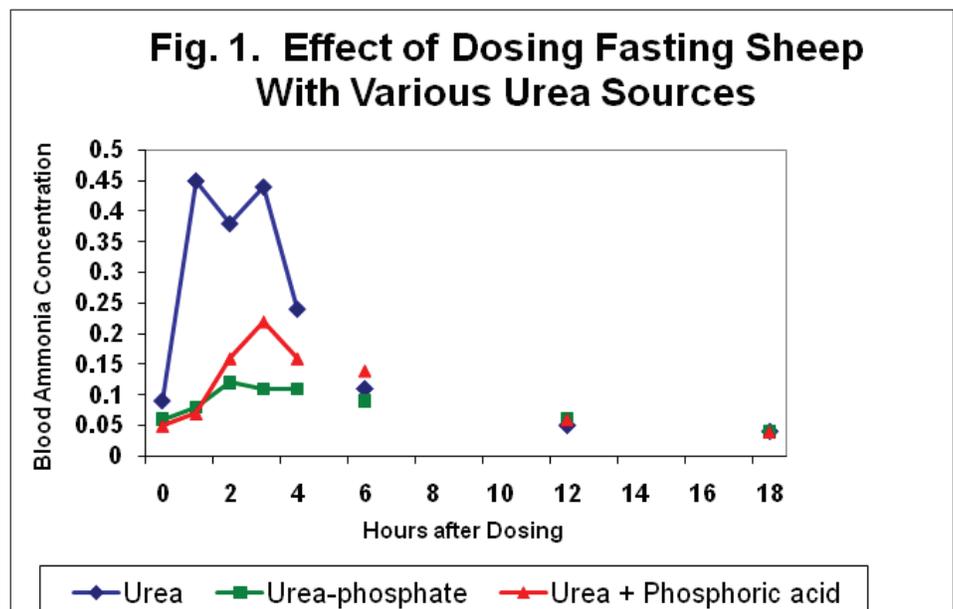
The addition of starch to a forage diet can lead to negative associative effects, including reduced intake and utilization of the forage itself. When starch inclusion increases in conjunction with urea in experimental diets, protein source effects can potentially be confounded by starch level. In the Kropp paper mentioned above, grain sorghum was fed at higher levels as urea inclusion went up. In a trial involving beef steers consuming very low-quality (2.4% CP) hay (Köster

et al., 1997), supplementation treatments were designed to supply 0, 25, 50 or 75% of DIP from urea, with pure corn starch used to keep diets isocaloric. The higher urea (and therefore starch) levels were affiliated with reductions in digestibility, but not intake. In the late seventies, a series of trials at Oklahoma State University (Rush and Totusek, 1976; Rush et al., 1976; Rush and Totusek, 1975) looked at supplementing beef cows and heifers consuming dormant range and prairie hay with different protein sources. Responses to urea were mixed, and evaluation of the less favorable results emphasizes management considerations we still recommend for urea supplements today: availability of forage should not be limiting; supplement intake needs to be adequate to supply the needed level of CP; free-choice intakes should not lead to excess or imbalanced consumption of supplemental nutrients; and, utilization is enhanced when urea supply is spread over time rather than pulse-dosed.

This final point has received considerable attention as a means to improve urea utilization. If the ruminal supply of ammonia—be it from NPN or deamination of protein or peptides—exceeds potential microbial uptake, the excess may move to the bloodstream. Once it reaches the liver, it is converted back to urea, which may be excreted or recycled. There is an energetic cost involved in this process, and urinary N obviously represents an irretrievable loss. Optimal efficiency of NPN utilization occurs when rumen supply closely matches microbial use. Efforts to modulate ammonia appearance in the rumen have included use of biuret, urea-phosphate, urea bound to calcium chloride, polymer coatings, and isobutylidene diurea (Taylor-Edwards et al., 2009; Forero et al., 1980), and simply changing the frequency of feed delivery (Currier et al., 2004; Romero et al., 1976; Tudor and Morris, 1971).

Early work at Cornell University (Perez, 1967) demonstrated the effectiveness of urea-phosphate, the salt formed by combining urea and phosphoric acid mole for mole. These researchers placed

urea or urea-phosphate directly in the rumen of fasted animals, and monitored rumen pH and blood ammonia post-dosing. There were striking differences (Fig. 1), suggesting the urea-phosphate was degraded more slowly, and utilized more efficiently. A similar trial done at Texas A&M University (Lichtenwalder and McClain, 1978) found comparable differences in rumen ammonia levels when steers were pulse-dosed with urea or urea-phosphate (Fig. 2).



A pair of trials, one in vitro and one in vivo (Arelovich et al., 2000), found that high levels of zinc supplementation (≥ 250 ppm diet DM) also appeared to retard ammonia release, as well as increase propionate production. However, when dietary zinc was raised to 470 ppm in the

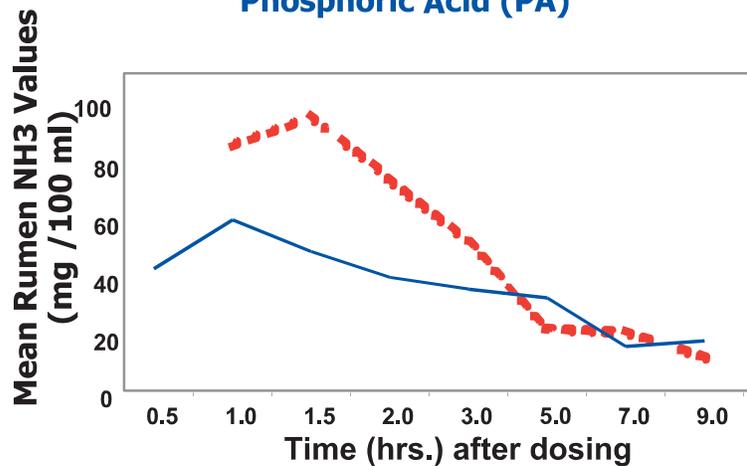
diet, there was a tendency to reduce digestible DMI, driven by numerical drops in DMI and DMD. The use of a slow-release urea (SRU) has also been evaluated in feedlot diets. A series of experiments at Oklahoma State University (Owens et al., 1980) demonstrated a more uniform ammonia release, as well as fewer palatability problems, with the SRU vs. urea. However, there were no improvements in DMD or N retention relative to the unprotected urea.

An additional focus has been matching ammonia release to energy availability, and attempts have been made to improve urea utilization in this way using combinations of urea/starch, urea/cellulose, urea/fatty acids, and urea/molasses (Forero et al., 1980). Molasses has been shown to dramatically reduce the amount of ammonia moving to the bloodstream after urea was placed in the rumen (Lichtenwalner and McClain, 1978b; Fig. 3). Other factors that may impact urea utilization include rumen pH, as it impacts rumen wall permeability (Johnson, 1976); dietary protein, as a source of urea cycle substrates (Lichtenwalner & McClain, 1978); sulfur, as needed for microbial formation of some amino acids (McLennan et al., 1981); and, animal adaptation to urea.

Liquid feeds offer the opportunity to incorporate several of these mechanisms for enhancing urea utilization:

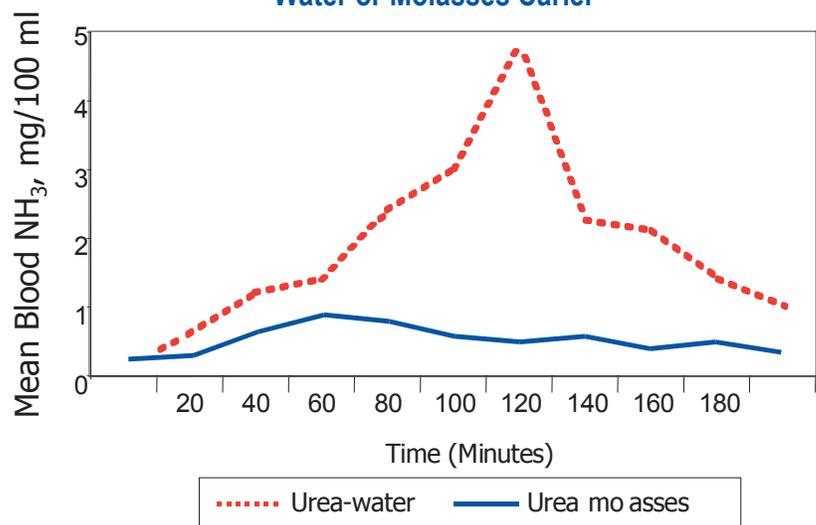
- Use of highly palatable ingredients such as molasses to mask potential palatability issues;
- Modulated ammonia release, through both feeding behavior and use of urea-phosphate or urea bound to calcium chloride;
- Simultaneous delivery of an appropriate source of energy and other microbial nutrients (i.e., molasses) with the urea.

Mean Rumen Ammonia Values after Dosing With Urea (15 g per 100 lbs. BW), With and Without Phosphoric Acid (PA)



*Perez et al., 1967
Cornell University*

Mean Blood Ammonia Values After Dosing With Urea (27 g per 100 lbs. BW), Using a Water or Molasses Carrier



*Lichtenwalner and McClain, 1978
Texas A&M University*

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