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REVIEW: Urea Feeding to Dairy Cattle: A Historical Perspective and Review

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ABSTRACT

Urea has been fed in ruminant rations for more than 100 yr. Its use in dairy cattle rations has fluctuated with protein and urea prices, with various values used in different formulation systems, and with mixed to negative experiences in experiments and field situations. In many studies, rations were not isocaloric when urea was added, and intake reduction occurred because of high dietary levels of urea. Some studies concluded that cows disliked the flavor or odor of urea, or that there was some metabolic component. A series of studies revealed that cows did not dislike the flavor or odor of urea per se, that they could identify different levels of urea in rations, that they developed a conditioned negative aversion to urea when urea was fed at higher levels and for several exposures, and that 135 g/cow daily did not reduce DMI. In older studies, and in even more recent ones, this level of urea intake has been exceeded by 50 and up to 300% with a corresponding DMI decrease, even when fed in TMR. Urea use has also been limited because of in vitro studies showing no benefit to adding urea if ammonia levels are at 5 mg/mL or dietary CP is at 13%. However, several in vivo and in situ studies have shown the optimal rumen ammonia level to be between 17 and 25 mg/mL when DM disappearance and nonammonia-N flow are the determining measurements. Several studies have shown that oils, especially more unsaturated oils, defaunate or reduce protozoa, which can increase microbial protein synthesis efficiency but reduce DMI. In one study, the authors speculated that addition of urea could be beneficial to counteract reduced rumen ammonia and pH. Although there is some belief that addition of urea to higher nitrate-containing diets exacerbates the situation, studies do not support this contention. A large-scale field study and a long-term feeding study did not show any meaningful negative effects on reproduction when feeding urea. Synchronizing rumen N available with carbohydrate fermentation has a theoretical benefit, but a recent review found this did not occur, most likely because of N recycling and because of the adaptability of rumen microorganisms to asynchronous N and energy supply. Various commercially processed urea products have been developed, but few studies have been published showing that the processing and feeding objectives were achieved. Adding urea sources to ensiled forages has increased final N content and reduced protein degradation of the silage. When urea was also added in the concentrate, no negative effects were seen if total supplemental NPN was less than 20% of total dietary N. Classic ammonia toxicity from too much dietary urea being provided in a short period is most closely related to rumen pH because urea hydrolysis elevates rumen pH, which then allows more rapid absorption of the now greater levels of rumen ammonia into the blood. Traditional recommendations for feeding urea to dairy cows have been excessive. More reasonable recommendations would be for not more than 1% in the concentrate, approximately 135 g/cow daily, and not more than 20% of total dietary CP coming from added urea-NPN sources.

Key words: dairy cattle, feeding, intake, level, urea

INTRODUCTION

German workers (Ehrenberg et al., 1891; Zuntz, 1891) determined that urea could be used to replace a portion of protein in ruminant rations. As recently as 1937, it was not widely recognized that urea is converted to proteins in amounts of any great significance to ruminants (Reid, 1953). Reid (1953) concluded from his extensive literature review that 1) conversion of urea to protein is mediated by the microorganisms of the rumen and reticulum, which subsequently avail the host animal of their protein content; 2) a low level of protein and high level of starch in the ration favor urea utilization; 3) bacteria may prefer highly soluble and readily hydrolyzable protein rather than urea in the ration; 4) sugars and cellulose are

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inferior to starch as sources of energy for ruminal microorganisms; 5) application of in vitro to in vivo experiments may be misleading because the characteristics and kinds of microorganisms may be different in vitro after even relatively short periods; 6) older calves have faster growth rates with urea, whereas calves as young as 2 mo of age have been shown to use some urea-N; 7) addition of methionine or S has improved the retention of N by lambs fed urea-containing rations; 8) rendering urea hydrolysis more slowly to minimize ammonia wastage may be a fruitful approach; 8) urea is somewhat inferior for dairy and beef calves fed rations containing 12% or more of protein equivalent, of which three-fourths of the N is supplied by conventional protein sources; 9) a level of 1% urea in the concentrate ration of fattening calves may be unpalatable and may reduce feed intake; 10) urea may provide up to 25% of the N in rations containing 12% protein equivalent for fattening lambs and for pregnant or lactating ewes; 11) urea N may provide up to 27% of required N from the standpoint of milk yield or reproductive behavior or general health; 12) urea may provide up to 3% of the concentrate ration or up to 1% of the total ration for milking cows from a practical standpoint; 13) small quantities of urea undiluted by feed (116 g in cattle and 10 g in sheep) and introduced suddenly into the rumen resulted in rapid onset of toxicosis, whereas 180 to 272 g urea was consumed daily by beef calves or cows without toxicosis when fed along with hay or corn silage; 14) cattle refuse to consume enough feed to be harmed because of the unpalatability of urea; 15) when urea is fed at satisfactory levels affecting protein replacement, palatability does not appear to be noticeably reduced; 16) molasses may improve palatability of urea-containing rations; and 17) because urea has no energy value for animals, feeds containing urea must be fed at a slightly higher rate to provide both N and digestible nutrients equivalent to those provided by conventional feed. This review addresses studies conducted since the 1953 review by Reid, and is directed toward urea use in dairy cattle diets.

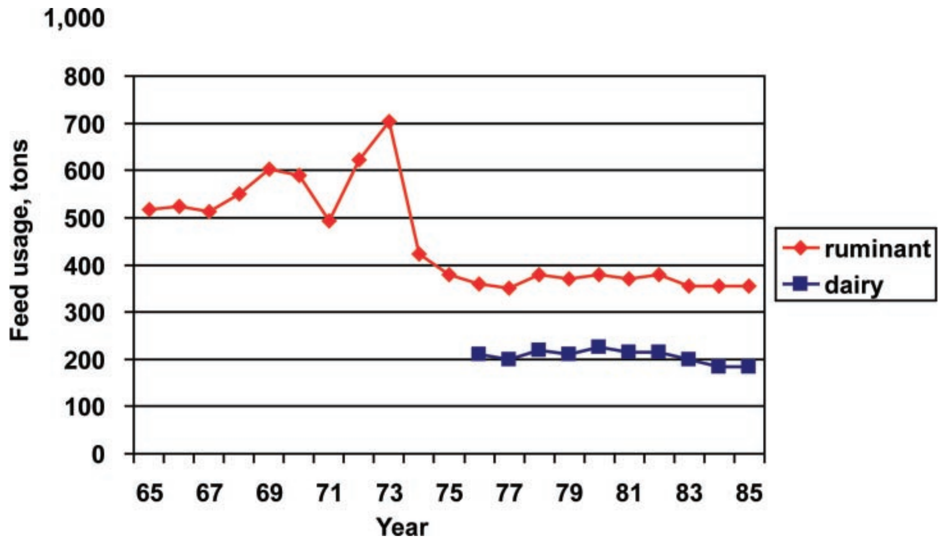

Figure 1. Annual US estimates of urea from 1965 to 1985 for feed used by ruminants and for dairy cattle as a subcategory [Allen and Devers (1975), and industry estimates].

Feed Use

Estimated amounts of annual US feed-grade urea use [Allen and Devers (1975), and industry estimates] provide insights into factors influencing urea use for ruminants (Figure 1). Urea use, particularly for dairy cattle, has had a tarnished history because of misuse, an image of usefulness only in low-cost feeds, a perceived relationship with nitrate poisoning, and some falsehoods (Adams, 1961). Feed-grade ruminant urea tonnage increased from 1965 to 1970, declined until 1972, and then reached a peak in 1973. A rapid decrease ensued until 1975, after which urea use was similar through 1985. Dairy use appeared to be the predominant category for ruminant use based on data from 1975 to 1985. The rapid peak in use in 1973 coincided with very high protein meal prices that reached $300 to $400/ton. It is likely that excessive or improper urea use, or both, then resulted in poor results for several dairy farms. Unfortunately, data on feed-grade urea use for dairy cows or ruminants are not available after 1985.

Urea Use Formulation Systems

In 1973, another significant event occurred with the publication in a popular dairy magazine of an article stating that cows producing more than 22.7 kg milk/cow daily could not utilize urea when the ration already contained 12% protein (Roffler and Satter, 1973). During that same period, it is likely that there were numerous negative experiences by many dairies that had felt forced to use urea because of the very high protein costs. When these dairy managers also read that their good cows could not use urea, and when this idea was reinforced by many others who had adopted that recommendation, the negative image of urea was further reinforced. This was countered by some researchers (Bartley, 1976; Huber, 1976a,b; Conrad, 1977) not in concert with the recommendations of Roffler and Satter (1973), but their work was viewed with some suspicion because they were involved with the following processed urea-containing products: Starea, Dehy-100, and Pro-Sil, respectively.

In the early 1970s, several other systematic approaches to formulation emerged, which further restricted or eliminated the use of urea. In the soluble protein system (Sniffen, 1974), urea was considered to be a 100% soluble N source, whereas in the urea