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Mini Review Article

Slow-Release Urea for Dairy Cows: A Commercial Contemplation or a Futile Fantasy?

Akbar Nikkhah*

Chief Highly Distinguished Professor and Scientist, National Elites Foundation, Iran

* ***Corresponding author:*** Akbar Nikkhah, Chief Highly Distinguished Professor and Scientist, National Elites Foundation, Iran. Email: anikkha@yahoo.com

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ABSTRACT

Modern dairy cows are dependent on viable protein sources to maintain adequately high and persistent milk production. However, qualified protein sources, such as soybean meal are usually high and not easily available. Feed-grade urea (FGU) has been utilized in dairy diets for decades to help economically. Some portions of dietary nitrogen are a point in this case. Nonetheless, FGU can be considered as a potential source of microbial protein, only if adequate timely fermentable nitrogen sources are supplied to the rumen microbes for successful microbial protein synthesis. In addition, FGU has a rapid degradation rate in the rumen, which may cause microbial toxicity and excessive ammonia and urea production, leading to environmental issues. It means that the effective use of FGU would be challenging. Accordingly, by improving rumen synchrony and metabolism and cow performance such limitations can be overcome through the development of slow-release urea (SRU). However, compared with FGU recent studies do not fully support the practical and economic effectiveness of SRU, towards improved cow metabolism and performance. More experiments particularly with varying dietary fermentable energy sources are required to conclusively decide if SRU may be a practical contemplation towards increased dairy production sustainability or it is just an expensive useless fantasy.

1. Introduction

Modern high-producing ruminants depend on quality protein sources to maintain super production records. Plant protein sources, such as soybean meal, cottonseed meal, rapeseed meal, canola meal, and other oilseed meals are commonly used in dairy diets to supply rumen degradable proteins and some parts of rumen undegradable proteins[1]. Nevertheless, these plant proteins may be high-priced and not easily available. As a result, to cope with the limitations of plant protein meals, feed-grade urea (FGU) has been utilized in dairy rations for decades[1].

However, high rates of FGU (100-270 g/d/cow) are usually rapidly degraded in the rumen, likely causing ammonia toxicity and excessive urea production by the cow. This leads to reduced nitrogen efficiency and jeopardized environmental quality. As such, slow-release urea (SRU) has been developed to possibly overcome these challenges. When urea is mixed within or covered by a matrix to allow the gradual release of nitrogen in the rumen, SRU may reduce the risk of toxicity and decrease the dry matter intake[1-4].

2. Feed Efficiency, Rumen Ecology, and Animal Performance

Previous studies on supplemental urea have used high-forage diets, where inadequate timely fermentable carbohydrates may not have allowed for effective utilization of supplemental urea by the rumen microbes and the host dairy cow[2,3]. Moreover, excessive dietary inclusion of supplemental urea may disturb the rumen environment and reduce dietary energy efficiency to incorporate nitrogen into microbial protein[1,3].

Nevertheless, in a recent systematic and meta-analysis study, Simoni et al.[4] investigated cows that produced 32.9 ± 5.7 L/d of milk, 3.46 ± 5.0% of fat, and 3.11 ± 0.2% of protein with an intake of 22.1 ± 3.45 kg of dry matter. The

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average diet composition was 1.65 ± 0.07 Mcal of net energy for lactation (NEL), 16.4 ± 1.45% crude protein (CP), 30.8 ± 5.91% neutral detergent fiber (NDF), and 23.0 ± 4.62% starch. The average supply of FGU was 209 g/cow/day, while the average supply of SRU was 204 g/cow/day. Overall, compared to the control diet (true protein) feeding FGU and SRU did not affect nutrient intake and digestibility, Nitrogen (N) utilization, milk yield, and composition[4]. The FGU reduced the acetate proportion (61.6 versus 59.7 mol/100 mol) and the SRU reduced the butyrate proportion (12.4 versus 11.9 mol/100 mol) compared with the control group. Ruminal ammonia-N concentrations were 8.47 mg/dL, 11.5 mg/dL, and 9.3 mg/dL for control, FGU, and SRU, respectively, demonstrating some increase by supplemental urea[4]. Urinary nitrogen excretion increased from 171 to 198 g/d in control versus the two supplemental urea treatments. The findings of Simoni et al.[4]'s meta-analysis study suggested that the inclusion of SRU or FGU at an average rate of 204.6 g/d and 209.8 g/d reduced milk urea nitrogen and tended to reduce fat-corrected milk yield and milk protein yields[4]. However, these production effects were likely attributed to lower energy intake in the supplemental urea treatment diets. Notably, no obvious and practical differences were detected between FGU and SRU[4]. As such, it was concluded that in the conditions of the selected experiments, the lower cost of FGU may justify the partial replacement of true protein meals with FGU. Additionally, it was recommended that in light of similarities in FGU and SRU in performance and due to the higher cost of SRU, usage of SRU cannot be justified in the current feeding practices and conditions of the selected experimental papers[4]. In other words, since FGU costs is lower, the usage in total mixed rations for high-producing dairy cows may be warranted[4].

The replacement of conventional FGU with SRU in the diet of finishing cattle or steers in feedlots also did not offer any advantages in performance criteria and carcass traits in a recent meta-analysis study[5].

3. Environmental Concerns

Environmental contamination, which concerns the researchers, is one of the possible negative impacts of feeding highly degradable protein sources, such as FGU, unprocessed soybean meal, and other sources of rumen degradable proteins[6,7]. As such, SRU might be an adequate substitute for soybean meal, non-protein Nitrogen (NPN) sources, and other protein meals. The SRU might have the potential to enhance rumen efficiency and functionality and reduce emissions from low carbon feed[7,8]. However, these aspects need to be studied extensively before recommending SRU for concrete on-farm use.

4. Future Research Opportunities

Despite the above results and meta-analysis conclusions, the need for future experiments may be justified. Experiments with varying extents and rates of ruminal fermentable carbohydrates and starch from different processed cereal grains (e.g., barley and wheat versus corn and sorghum) under different dietary forage feeding conditions (hay versus silage) are required to enable practically conclusive guidelines on feeding SRU versus FRU in dairy diets. The findings of such experiments will permit researchers to conclusively decide whether SRU would be a commercial contemplation or just a high-cost futile fantasy for sustainable dairy industries worldwide.

5. Conclusion

Slow-release urea (SRU) has been presented to dairy diets to possibly improve nitrogen and energy utilization productivity, reduce ammonia toxicity, prevent decreased dry matter intake, and probably improve the production and reproduction performance of high-merit dairy cows. However, recent systematic studies and reviews do not support the effectiveness of SRU compared to the conventional FGU for high-producing dairy cows. The same has been true for feedlot cattle. However, more trials with different sources of starch and rumen fermentable energy from various cereals or differently processed grains in a variety of forage feeding systems are to be carried out preferably. Future studies would enable conclusive statements on the effectiveness of SRU versus FGU for dairy cows. Then, the world dairy industry may be able to conclude if SRU would be a practical contemplation or is just a costly vain fantasy for high-producing dairy cows.

Declarations

Competing interests

The authors have declared that no competing interests exist.

Authors' contributions

This study was conceptualized, strategized, developed, reviewed, and ultimately written and edited by Akbar Nikkhah. The final manuscript was checked by the author.

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Availability of data and materials

Data from the study are available according to a reasonable request.

Ethical considerations

The author has made necessary ethical considerations (e.g., plagiarism, consent to publish, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancy).

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