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Response of Holstein cows to replacing urea with with a slowly rumen released urea in a diet high in soluble crude protein

A. Highstreet [a], P.H. Robinson [b,*], J. Robison [a], J.G. Garrett [c]

[a] Department of Animal Science, California State University, Fresno, CA 93740, USA
[b] Department of Animal Science, University of California, Davis, CA 95616, USA
[c] Quali Tech Inc., Longmont, CO 80503, USA

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ABSTRACT

Ruminants have the ability to utilize non-protein N compounds as N sources for rumen microbial protein synthesis. The objective of this experiment was to determine if use of a slowly rumen released urea could increase productive performance and/or decrease urinary N components of dairy cows when used as a replacement for urea in diets high in soluble crude protein (CP). Nitroshure, a slowly rumen released encapsulated urea, which is 0.9 urea and 0.1 fat according to the manufacturer, had measured ruminal *in sacco* N release of 72, 89 and 99% of at 0.5, 4 and 12 h of ruminal incubation respectively. Four pens of multiparous lactating cows on a commercial dairy were fed one of two total mixed rations (TMR) formulated to supply 5% of ration CP from urea or encapsulated urea. There were two pens of early lactation cows and two pens of mid-lactation cows. The two experiments (by stage of lactation) consisted of two four week periods, and pen treatments were reversed in each lactation group after the first period. All cows were fed twice daily to appetite with daily intakes recorded by pen. The TMR were sampled at the beginning and middle of the last week of each experimental period and analyzed for nutrients. Cows were milked 3 times daily with milk yield and components measured on one day from each milking at the end of each experimental period. Representative urine samples were collected from 22 to 25 cows per pen that voluntarily urinated (at the morning 'lock-up' of cows for reproductive examination) on day 25 of each experimental period, with feces collected from the first 20 of those cows that were identified 24 h later at the same time of the day. There were no differences in TMR nutrient analyses between the urea and encapsulated urea supplemented diets. Dry matter (DM) intake did not differ between treatments, but early lactation cows gained from encapsulated urea addition as evidenced by an increase in milk fat (0.068 kg/d, $P=0.01$) and protein (0.041 kg/d, $P=0.01$) output *versus* the urea group. Milk energy output also increased by 4.2 MJ/d ($P=0.01$) *versus* urea supplemented cows. No differences in milk production or components occurred in the mid-lactation group of cows, although numerical trends were similar to the differences in early lactation. Neither early nor mid-lactation cows had differences in urinary total, ammonia or urea N concentrations, or estimated urine output, due to treatment. Fecal digestibility of CP and neutral detergent fiber (aNDFom) were similarly unaffected by treatment in either group of cows. Feeding a slowly rumen released urea increased milk fat, protein and energy output in early lactation high producing dairy cows fed a diet high in soluble N, *versus* feeding an equivalent amount of urea on an N basis, but that it had little impact in mid-lactation cows. In contrast, substituting urea with a slowly rumen released urea had no impact on urinary N components, and calculated urinary output, of N compounds in either group of cows.

Abbreviations: ADF, acid detergent fiber; ADICP, acid detergent insoluble CP; CP, crude protein; DM, dry matter; MUN, milk urea N; NDF, neutral detergent fiber; SCC, somatic cell count; SG, specific gravity; TMR, total mixed ration; VFA, volatile fatty acids.

* Corresponding author. Tel.: +1 530 754 7565; fax: +1 530 752 0175.
E-mail address: phrobinson@ucdavis.edu (P.H. Robinson).

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1. Introduction

Ruminants have the ability to utilize non-protein N compounds as sources of N for rumen microbial synthesis. The amount of non-protein N, such as in urea, that can be used in diets is limited due to their rapid hydrolysis to ammonia in the rumen by microbial enzymes. Rumen ammonia and plasma urea levels generally peak 1 to 4 h post-feeding in meal-fed animals and decline thereafter (Gustafson and Palmquist, 1993). The very rapid degradation of most non-protein N forms to ammonia is often faster than the ammonia can be utilized by rumen microbes, resulting in ammonia being absorbed through the rumen wall as the ammonium ion (Satter and Roffler, 1975), which is converted to urea and subsequently excreted in urine. Slowly ruminally released urea compounds, as a replacement for urea in ruminant rations, have a long history in ruminant feeding. Biuret (Fonnesbeck et al., 1975) is likely the most widely researched slow release N compound historically, although others (*e.g.,* Huntington et al., 2006) have been examined in recent years. This interest in slowly rumen released N compounds primarily stems from their potential to slow ammonia release post-feeding, thereby decreasing peak ammonia concentrations in the rumen that lead to its inefficient utilization by ruminal microorganisms, and increased absorption from the rumen. This would also decrease the metabolic cost associated with converting ammonia to urea in the liver, while providing a steady supply of ammonia to rumen bacteria between meals.

Animal feeding practices that reduce the amount of urea in urine have the potential to decrease ammonia emissions to the environment since urine urea is rapidly converted to ammonia in fecal/urine slurries due to the action of fecal and environmental ureases. Current dairy research in California, and other parts of the USA and Europe, is focused on decreasing the amount of dietary protein that appears in urine, while maximizing production of milk and its components.

The objective was to determine if use of a slowly rumen released urea product had the potential to increase production, and decrease urinary N excretion, of lactating dairy cows when used as a replacement for urea in diets that were high in levels of soluble N.

2. Materials and Methods

Nitroshure (Balchem Encapsulates, New Hampton, NY, USA), a fat encapsulated urea supplement with 2.55 equivalent CP, was used as a replacement for urea in rations of lactating dairy cows. Nitroshure or urea was blended into mineral premixes at Foster Commodities (Kingsburg, CA, USA) to achieve a feeding rate of 113.5 g/d/cow or 102.2 g/d/cow, respectively, or 47.5 g/cow/day of N from both urea and the encapsulated urea. The separate mineral premixes were bagged and coded by treatment.

2.1. Cows and Diets

Holstein cows on a commercial dairy farm near Tulare (CA, USA) were used in two experiments. This dairy was selected partly due to the high level of soluble CP in total ration CP (~40% of total CP). Cows were grouped according to production and days in milk (DIM) and randomly allocated to one of two pens within the early and late DIM groups, each holding ~180 cows with 160 free stalls with dry manure solids as bedding. Flush feed aprons had rubber mats on the floor and the pens were fitted with fans and bunk-line misters. Early lactation pens averaged 79 ± 3.1 DIM with 48.6 ± 0.87 kg/day milk production and mid lactation pens averaged 258 ± 6.5 DIM with 41.9 ± 0.58 kg/day of milk at the start of the study. The early and mid lactation pens were analyzed as separate experiments, which were completed concurrently and, in each experiment, cows were fed one of two TMR that were formulated to be the same relative to their ingredient and nutritional profiles, except that the mineral premix had either added urea or encapsulated urea. Pens were randomly assigned to either the urea or encapsulated urea treatments. The study was divided into two periods of 4 wks and, after the first period, treatments were reversed within pen. Only cows that remained in the same pen for both periods were used in statistical analysis as some cows entered and exited pens weekly under normal farm cow movement patterns.

Cows were fed a total mixed ration (TMR) twice daily, between 05:00 and 06:00 h and 11:00 and 12:00 h for *ad libitum* intake. The total amount of dry matter (DM) offered and refused was recorded daily using the Feed Watch (Valley Agriculture Software, Tulare, CA, USA) electronic data capture system.

2.2. Measurements

The TMR and individual dietary ingredients and premixes were sampled at the beginning and middle of the final week of each experimental period. The TMR was sampled from each pen by taking approximately 10 samples of about 2150 cm^3, at evenly spaced increments along the feed bunk as the TMR was being unloaded from the feed truck. Silages were collected by sampling approximately five locations from the silage face. Alfalfa hay was sampled with a 'Golf Club' forage probe (Sierra Testing Services, Acampo, CA, USA), and approximately 20 core samples were pooled to make up a sample. All other TMR ingredients, including the encapsulated urea, were sampled and bagged in plastic for transport to the University of California in Davis (CA, USA) for later analyses.

Cow health was monitored daily by dairy personnel and weekly by the experimentalists. Cows were milked three times daily between 04:00 and 06:00, 12:00 and 14:00, and 20:00 and 22:00 h, in both experimental periods, in a herringbone style milking parlor. Milk samples were collected on day 27/28 of each experimental period during the regularly scheduled monthly Dairy Herd Improvement Association (Tulare, CA, USA) milk test. Milk weights were recorded using the Waikato milk yield proportioning device that retains a known small proportion of the milk (i.e., 25 g/kg) into a calibrated flask from which total yield was read. A small representative sub-sample was drawn from the flask and preserved with 2-Bromo-nitropropane-1, 3-diol, capable of preserving milk for up to 3 d, for subsequent assay.

Urine samples were collected on day 25 of each experimental period from 22 to 25 cows per pen that voluntarily urinated at the normal morning 'lockup' for reproductive and