Synchronization of Ruminal Degradation of Supplemental Carbohydrate with Pasture Nitrogen in Lactating Dairy Cows

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ABSTRACT

Twelve Holstein cows in early to midlactation (8 fitted with ruminal cannulas) were used to test the hypothesis that the synchronization of the rate of ruminal degradation of supplemental carbohydrate and N from fresh pasture would increase the amount of N retained for growth and milk production. A concentrate based on ground shelled corn was fed either at the time that pasture was fed at 0900 and 1700 h (synchronous) or 4 h after pasture was fed at 1300 and 2100 h (asynchronous). The crossover design included a 6-d adjustment period and a 10-d milk sampling period. Nitrogen balance was determined during the last 5 d of each period. Cows fed the synchronous diet had a lower mean ruminal pH. Peak ammonia concentration at 3 and 5 h after pasture feeding in the morning was reduced by approximately 33% of values obtained from cows fed the asynchronous diet. The diurnal pattern of blood urea N concentration was similar to that of ruminal ammonia, but mean daily concentrations of blood urea N did not differ between diets. Nitrogen retained for milk production and growth was not influenced by diet, and no differences in milk production, composition, or efficiency were observed. Based on changes in ruminal concentrations of ammonia, synchronous ruminal release of supplemental carbohydrate with pasture N appeared to improve the capture of ruminal N; however, these changes were transient and did not change the N status or performance of dairy cows.
(**Key words**: pasture, nitrogen, carbohydrate, dairy cows)

Abbreviation key: **ASYND** = asynchronous diet, **BUN** = blood urea N, **RDN** = N effectively degraded in the rumen, **RDOM** = OM effectively degraded in the rumen, **RDTNC** = TNC effectively degraded in the rumen, **SYND** = synchronous diet, **TNC** = total nonstructural carbohydrate.

INTRODUCTION

Despite the efficient synthesis of microbial protein from diets consisting of high quality pasture, preduodenal losses of N can account for up to 30% of ingested N (5). This loss of N occurs when concentrations of ruminal ammonia are high because of the rapid and extensive ruminal degradation of pasture N (5, 33) and may be exacerbated by an inconsistent diurnal pattern of DMI by intensively grazed dairy cows (26). A process to synchronize the rate of supply of N and energy yielding substrates with ruminal microbes has been suggested as a means to improve the capture of RDP (16, 21). Although the synchronization of supplemental energy and N could theoretically improve the utilization of N from high quality pasture (5, 24), this effect has not been well documented for lactating dairy cows on pasture.

Studies that have aimed to synchronize the ruminal degradation of N and energy in mixed diets have produced conflicting results. Yields of microbial N increased when different feedstuffs were formulated to match the extent or rate of degradable carbohydrate with that of CP (2, 9, 28, 29), but the effect on milk production remains unclear (1, 2, 10). Researchers using the same dietary ingredients to generate degrees of ruminal synchrony in vitro (20) and in vivo (8) have questioned the efficacy of ruminal synchronization to improve N utilization or microbial yield, which suggests that feedstuff composition might have been a confounding factor in some of the milk production studies.

The present experiment tested the hypothesis that a synchronized release of carbohydrate and pasture N to the rumen would increase the amount of pasture N retained by lactating dairy cows, which would enhance growth and milk production. Van Vuuren et al. (32) suggested that, for optimal utilization of pasture N, supplemental carbohydrate should theoretically have a degradation rate similar to that of pasture N (i.e., 8 to 14%/h). Two diets differing in the degree of synchrony, but not feedstuff composition or intake,

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were generated using a supplement based on ground corn that had an in situ degradation rate of total nonstructural carbohydrate (**TNC**) that was similar to that of pasture N. The carbohydrate was fed to cows in confinement either at the time that pasture was fed (synchronous diet; **SYND**) or 4 h after pasture was fed (asynchronous diet; **ASYND**).

MATERIALS AND METHODS

Experimental Design and Cows

Prior to the experiment, cows were adjusted from a total mixed diet to a diet based on pasture during 18 d of intensive grazing. During this transition, concentrate was fed at milking time (0700 and 1600 h). Cows spent 1 d readapting to barn feeding prior to the start of the experiment.

The experiment consisted of two 16-d periods arranged in a crossover design and was conducted during May and June 1994. Cows were allowed to adjust to the diets from d 1 to 6, milk production and composition were measured on 10 d from d 7 to 16, and data on total N balance were collected on 5 d from d 12 to 16. The crossover periods were separated by 1 d (d 17). Twelve Holstein cows were paired by milk production (35 ± 2 kg/d; $\overline{X}$ ± SE), BW (529 ± 15 kg), and DIM (90 ± 15 d) and were randomly assigned within pairs to two diets. Ruminal cannulas were previously fitted to 8 of the cows, 6 of which were primiparous heifers.

Two diets based on pasture that differed in the timing of ruminal TNC and N degradation were generated by the supplementation of a concentrate based on corn either at the time that pasture was fed (0900 and 1700 h; SYND) or 4 h after pasture was fed (1300 and 2100 h; ASYND).

The pasture and concentrate were fed separately, and, during the adjustment period, cows were trained to eat the concentrate under the two time regimens. To describe the feeding pattern, the proportion of cows standing and actively eating was recorded every 30 min on d 13 and 14 of each period. On these days, the consumption rate was estimated by weighing the pasture that remained in the feed bunk at 4 h after the initial feeding. The amount of concentrate fed was based on NRC (19) nutrient requirements. The finely ground concentrate consisted of 77.8% ground shelled corn, 9.8% cooked soybeans, 3.7% molasses, 2.8% Ren plus® (primarily meat and bone meal with blood meal and some feather meal; Mopac, Soderton, PA) 3.6% $CaHPO_4$, 1% NaCl, 0.7% MgO, 0.4% Se premix (600 mg/kg of Se), 0.2% Dynamate® (IMC-Agrico Co., Bannockburn, IL), 10,000 IU of vitamin A/kg of concentrate DM, 3500 IU of vitamin D/kg of concentrate DM, and 50 IU of vitamin E/kg of concentrate DM. A mean amount of 9.2 kg of concentrate DM/d was offered to each cow. Initial BW, milk production, and amount of DM consumed during the first 4 d of the experiment were used to determine concentrate and total DMI for individual cows. This level of DMI was maintained throughout the experiment, so that cows fed both diets would have similar DMI.

Pasture

Pastures were located at The Pennsylvania State University Dairy Cattle Research and Education Center (University Park) and had been established and grazed for 4 yr. The area was divided into 0.5-ha paddocks. Pasture with a herbage mass of 2791 ± 115 kg of DM/ha was harvested twice daily at 0730 and 1530 h. The regrowth interval between harvests was approximately 21 d. A flail harvester was used to cut pasture to a postharvest herbage mass of 1482 ± 43 kg of DM/ha, producing chopped pasture that was 10 to 15 cm in length. Preharvest and postharvest herbage mass (kilograms of DM per hectare) in each paddock was estimated using a rising plate meter. The plate meter was calibrated at the beginning of each period when 8 quadrants (0.268 m^2 per quadrant) of preharvest and postharvest pasture were cut to ground level and dried at 55°C. Pastures were fertilized with NH_4NO_3 (135 kg/ha) 3 wk before harvest.

Diet Composition

The fresh cut pasture was of good quality. The CP content was 22%, and the NDF content was 55% (Table 1). Pasture was predominantly orchardgrass (*Dactylis glomerata* L.) (78%) plus 8% Kentucky bluegrass (*Poa pratensis* L.), 6% white clover (*Trifolium repens* L.), 3% weeds, 2% other grasses, and 3% dead material. The concentrate fed contained 66.7% TNC and supplied 1.85 Mcal of estimated NE_L/kg of DM. The NE_L, NDF, and CP of the total diet consumed during the 10 d of milk collection were in accordance with concentrations recommended by the NRC (19). The nutrient composition of the fresh pasture that was used to determine in situ degradation kinetics was representative of the experimental pasture and contained 22.6% CP, 51.2% NDF, and 16.6% TNC.

Degradation Kinetics

Pasture and the concentrate supplement were evaluated in situ to determine ruminal availability and rate of degradation of OM, TNC, and N. The in situ procedure used in this experiment has been